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CCAFS

Situational analysis study for the agriculture sector in Ghana

July 2020

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Report

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

Agriculture is important for Ghana's economy and the livelihoods of the majority of the rural population even though its level of contribution to GDP is declining. Its importance is not only in terms of the contribution to food and nutrition security, but also in providing a basis for agro-industrial activities and for exports. It provides jobs and livelihoods to a significant proportion of the population especially in the rural areas. Farmers cultivate major staples such as maize, cassava, yam, plantain, sorghum and rice. The cash crops grown include cocoa, oil palm, cashew and rubber among others. Ghana's 2019 annual growth rate for agriculture was 4.6%. The crop sub-sector is the largest in the agricultural sector followed by livestock and fisheries.

The impacts of climate change on agriculture are not just projected but are real. The sector is currently contending against erratic rainfall patterns, water stress, desertification/ degradation of ecological systems/ forest degradation; increasing temperatures; and disruption of seasonality. Climate change affects agricultural activities in diverse ways including changes in the onset of the rainy season, increase incidence and frequency in some regions, increase in post-harvest losses of agricultural commodities, decline in the availability and quality of forage and high mortality and morbidity of livestock. Managing the impacts of climate change is important in addressing the challenge of enhancing productivity in the agricultural sector. It is a multi-dimensional challenge; hence solutions must emanate from the identifiable components of the environment. Agriculture is given a high priority in Ghana's political and socio-economic discourse with the President highlighting the agricultural programme of PFJ as the flagship of his government. The various national policy documents including the national development framework have underscored the importance of the agricultural sector. However, there is need to enhance policy coherence and strengthen policy implementation along the governance structures from the national through the regional to the municipal and district assemblies. Farmers and women must have stronger voices at the district level to articulate better their concerns. Besides, Ghana's national budgetary allocation to the agricultural sector is still below the target of the Maputo Declaration at about 9.7% currently. However, the on-going programmes such as

the PFJ and its constituent modules are likely to increase it. The funding from multi- and bi-lateral sources are also likely to increase agricultural expenditures.

The key recommendations proposed include creating an enabling legal, institutional and policy framework to create a favorable environment for enhancing policy coherence and strengthening policy implementation along the governance structures from the national to regional through to the municipal and district assemblies. It is also important to increase national budgetary and finance flows from bilateral and multi-lateral sources into the agriculture sector to promote widespread adoption of Climate Smart Agriculture (CSA). Investments should take into account gender and youth considerations, supported by a strong extension services system. Farmers' adoption of CSA is an important intervention area that economic planning must cater for. Market access and access to financial resources to finance their agricultural activities in crops, livestock, fishery and agroforestry, are crucial. Government must consider, adopt and implement this recommendation in collaboration with other stakeholders.

Keywords

Ghana; sciences; policies; partnerships; agriculture; climate change; food security.

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Contents

Acronyms

AEO	Agricultural Extension Officer
AfDB	African Development Bank
AFOLU	Agriculture, Forestry and Other Land Use
AgMIP	Agricultural Model Inter-comparison Project
AGNES	African Group of Negotiators Experts Support
AMSECs	Agricultural Mechanization Services
ANPP	Aboveground Net Primary Productivity
ASSAR	Adaptation at Scale in Semi-Arid Regions
BAU	Business-as-usual
BMZ	The Federal Ministry of Economic Cooperation and Development
CCAFS	Climate Change, Agriculture and Food Security
CGIAR	Consultative Group for International Agricultural Research
CIDA	Canadian International Development Agency
CMA	Chile Madrid Time for Action
COVID 19	Corona Virus Infectious Disease 2019
CSA	Climate Smart Agriculture
CSIR	Council for Scientific and Industrial Research
CSO	Civil Society Organisation
DFID	Department for International Development

DPAT	District Assembly Performance Assessment Tool
EPA	Environmental Protection Agency
EU-REACH	European Union Registration, Evaluation, Authorisation and Restriction of Chemicals
FASDEP	Food and Agriculture Sector Development Policy
GASIP	Ghana Agricultural Sector Investment Project
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMA	Ghana Meteorological Agency
GoG	Government of Ghana
GSS	Ghana Statistical Service
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
ICT	Information and Communications Technology
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IMS	Information Management Systems
INDC	Intended Nationally Determined Contributions
KNUST	Kwame Nkrumah University of Science and Technology
LTS	Long-Term Support
LULUCF	Land-Use Change and Forestry

M&E	Monitoring and Evaluation
MAG	Modernizing Agriculture in Ghana
MESTI	Ministry of Environment, Science, Technology and Innovation
METASIP	Medium Term Agricultural Sector Investment Plan
MMDAs	Metropolitan, Municipal, District Assemblies
MoFA	Ministry of Food and Agriculture
MRV	Measurement, Reporting and Verification
NCCP	National Climate Change Policy
NDC	Nationally Determined Contributions
NDPC	National Development Planning Commission
PERD	Planting for Exports and Rural Development
PESTELI	Political, Economic, Social, Technological, Environmental,
PFJ	Planting for Food and Jobs (PFJ)
SDGs	Sustainable Development Goals
SST	Sea surface temperature
STEPRI	Science and Technology Policy Research Institute
TORs	Terms of Reference
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WASCAL	West African Science Service Centre on Climate Change and Adapted Land Use

Introduction

Context

Ghana is situated on the west coast of Africa at Latitude 4^0 44' and $11^0$44' N and longitude $3^0$15'W and $1^0$12'E. The country covers a territorial area of approximately 238,540 square kilometers and has a population of about 27.67 million people as of 2015 (Ghana Statistical Service, 2020[1]). Ghana's climate is tropical with two main rainfall regimes: the north experiences a unimodal wet season from May to November; while the south experiences bimodal wet seasons, longer rainy season from March to July, and a shorter one from September to November.

The economy of Ghana is highly dependent on agriculture, employing about 42% of the workforce and contributing about 19.7% of the national gross domestic product (GDP) (SRID, 2016; World Bank, 2019; GSS, 2019). The sector is characterized by small-scale rain-fed crop and livestock farming systems with average farm size of less than 1.2 ha, accounting for about 80% of total agricultural production. Key agriculture subsectors in Ghana are: crops, livestock, fisheries and forestry. The major crops grown are maize, yam, cassava, rice, cocoa, oil palm, cotton, rubber, tobacco, sheanut, sugar cane and various varieties of fruits and vegetables based on the different agro-ecological zones. The production of cash commodities such as cocoa, sheanut and coffee is a major source of foreign exchange earnings. The main livestock are mono-gastrics (pigs and poultry), ruminants (cattle, goats, sheep) and non-traditional animals (snail, rabbit and grasscutter). The fisheries sub-sector comprises of marine, inland and aquaculture fisheries.

Climate change is threatening food production systems and therefore the livelihoods and food security of millions of Ghanaians who depend on agriculture. Climate vulnerability has significantly contributed to the high poverty levels, particularly in northern Ghana, which has remained the poorest part of the country (Al-Hassan et al., 2008). Analysis of long-term climate data shows a general increase in temperature in the country with a steady annual

[1] The Ghana Statistical Service is by law the statutory body responsible for publishing all statistics relating to the country. In this study, the authors will rely mostly on the statistics the GSS publishes rather than other organisations.

rise of 0.06°C per year and an overall increase by about 1°C over the past 40 years (Hansel *et al.,* 2012). Projections of future climate show that there will be an increase in temperature for all agro-ecological zones but changes in precipitation will vary considerably both spatially and temporally (World Bank, 2010).

Agricultural production will be substantially affected by the expected changes in rainfall patterns, temperature rise and other extreme weather events due to the excessive rainfed dependence of the sector. The frequency of days and nights that are considered 'hot' in the current climate is projected to increase, and the frequency of those considered 'cold' is expected to decrease (McSweeney *et al.,* 2013). Additionally, onset of the rainy season is expected to shift to later periods of the year, but the end of the rainy season and the total amounts of rainfall will remain largely unchanged (Van de Giesen *et al.,* 2010). Consequently, it is projected that the agricultural GDP will decline by 0.8% to 2.5% under climate change, with yield of maize and other major crops declining by 7% by the year 2050 (Ardnt *et al.,* 2015). Fish stocks appear to be on decline (Quansah and Ofori-Danso, 2016). It is further projected that in the next 100 years, due to sea level rise, shorelines will migrate by about 8km inland with far reaching impacts on coastal agriculture.

The Government of Ghana has put in place several policies and initiatives that set out the national priorities on agriculture and climate change. These include: The Coordinated Programme of Economic and Social Policies (2017 – 2024; The Ghana Shared Growth and Development Agenda (GSGDA) II; Planting for Food and Job (PFJ); Food and Agriculture Sector Development Policy (FASDEP II); Medium Term National Development Policy Framework; National Climate Smart Agriculture and Food Security Action Plan; Agricultural Sector Services Sub-Sector Investment Plan (AgSSIP); Ghana Poverty Reduction Strategy (GPRS) and National Climate Change Policy (NCCP) and the Nationally Determined Contribution (NDC) among others.

This situational analysis report assesses the current status and trends of the agriculture sector in Ghana and identifies opportunities to transform the sector towards low carbon and climate resilient development pathway. The report is organized into ten (10) chapters:

- Chapter 1 gives the introduction highlighting the rationale, methodology and limitations the study.

- Chapter 2 presents the status and trends of the agriculture sector.
- Chapter 3 discusses the impacts of climate change on agriculture and adaptation response measures.
- Chapter 4 discusses the mitigation potential of the agriculture sector.
- Chapter 5 examines the enabling policy environment.
- Chapter 6 deals with research, data and information management.
- Chapter 7 deals with governance and performance measurements.
- Chapter 8 provides the transformation agenda towards low carbon climate resilient development pathway.
- Chapter 9 examines finance and investments in agriculture.
- Chapter 10 provides the conclusion and recommendations.

Methodology of the study

Types of data and source

The study made use of both quantitative and qualitative data obtained primarily through extensive desk research and key informant interviews. Desk research entailed obtaining data from policy and related documents (e.g. sector policies, strategies, action plans and manuals), journal articles and other relevant materials. The desk research also collated available information on the impacts of climate change on agriculture.

Financial information was gathered on national and project investments relating to agriculture and climate change. Data on funding by international organisations such as the World Bank, AfDB, FAO, DANIDA, DfID and CIDA was also collected. The state of agriculture is conditioned by the policies and programmes implemented by the government, multi-lateral and bilateral organizations and non-state actors such as the local NGOs. Data in relation to these were also collected.

Key informant interviews were conducted with relevant and experienced individuals who were purposively picked from relevant government and non-government institutions to build and provide additional data to complement that from secondary sources. The main target institutions were the lead sector ministries such as the Ministry of Food and Agriculture (MoFA) and Ministry of Environment, Science, Technology and Innovation (MESTI). Annex III provides a list of the key informants.

The main sources of data included relevant national and sub-national agriculture ministries, departments and actors including regional and global agricultural institutions that are custodians of the different policies, strategies and frameworks relevant to Ghana; research publications as well as other relevant institutions e.g. CSA networks, climate change networks, etc).

Analytical framework

The PESTELI analytical framework was primarily used in this study though not exclusively. It enabled macro and micro analysis of the **P**olitical, **E**conomic, **S**ocial, **T**echnological, **E**nvironmental, **L**egal and **I**nstitutional dimensions of agriculture and climate change in Ghana. Table 1 illustrates the application of the framework in terms of the components and their respective elements. Each of the components provided perspectives for the analysis.

Table 1. The PESTELI Analytical Framework.

Component	Examples of Elements
Political	Governance system; Parliament; ideology; foreign policy; international alignments; mass media pluralism;
Economic	Market liberalisation; economic growth in sectors – agric., industry, services; value chain activities; export
Social	Demographics; Cultural trends; norms; societal attitudes
Technological	Production of goods and services; machinery and plants; Emerging technologies – ICT, robotics, AI; transport systems;
Environmental	Pollution of ecosystems; GHG emissions; climate change; forest degradation; deforestation; desertification; agro-ecologies
Legal	Laws; LIs; EIs; constitution; Judicial systems; Intellectual Property
Institutional	Public and private establishments; ministries; departments and agencies; NGOs; Civil Society; institutional linkages, collaborations and partnerships including FBOs and cooperatives.

The analysis here is not merely the description of the elements in the PESTELI components but also, more importantly, the interactions among the components and the extent to which there is coherence and synergy.

Limitations of the study

To the extent that this study relied extensively on desk research and some interviews with key informants, there are limitations. In-depth analysis could have been possible if interviews with farmers and field visits provided more accurate and timely primary data. The

restrictions associated with the COVID 19 crisis did not allow this; however, efforts were made to reduce bias.

Status and trends of agriculture sector

Overview

Ghana's 2019 annual growth rate of 6.5 percent is a slight improvement compared to the 6.3 percent in 2018 (Ghana Statistical Service, 2020)2. The Services sector recorded the highest growth rate of 7.6 percent, followed by Industry (6.4%) and Agriculture (4.6%) sectors respectively. The growth rates of these three main sectors reflect the corresponding shares of GDP. The services sector is the largest sector with its share of GDP increasing from 46.3 percent in 2018 to 47.2 percent in 2019. Two of the sub-sectors in this sector contributed more than 5 percent to the 2019 annual growth rates. These are the Information and Communication with a growth rate of 46.5% and a contribution of 1.0 percentage points (15.7%) to annual growth and the Trade; Repair Of Vehicles, Household Goods sub-sector (3.7%) which contributed 0.4 percentage point to annual GDP growth (Ghana Statistical Service, 2020). The Agriculture sector slackened in growth at 4.6 percent in 2019 compared to a growth rate of 4.8 percent in 2018. Its share of GDP declined from 19.7 percent in 2018 to 18.5 percent in 2019. Crops is the third largest economic activity in Ghana with a share of 13.8 percent of GDP. It contributed 0.7 percentage points to 2019 annual GDP growth. The Forestry and logging sub-sector contracted in growth at (-1.7 per cent) compared to 2.4% in 2018 (Ghana Statistical Service, 2020). The sectors' shares of the GDP and the respective growth rates provide a basis for discussing how their relative importance and roles in the country's socio-economic development.

Status and trends in agriculture sub-sectors

Crop sub-sector

The crop sub-sector of agriculture is considered the largest in the agricultural sector. Its importance is not only in terms of the contribution to food and nutrition security, but also in

2 The statistics provided in the cited publication are provisional figures which will be finalized in 2021 in line with the methodologies of the Ghana Statistical Service.

providing a basis for agro-industrial activities and for exports. It provides jobs and livelihoods to a significant proportion of the population especially in the rural areas. Farmers cultivate major staples such as maize, cassava, yam, plantain, sorghum and rice. As cash crops, the farmers cultivate cocoa, oil palm, cashew and rubber among others. Each of these crops have their value chains with the identifiable components including crop production, processing, transporting and marketing. Importantly, the value chains are dominated by smallholders generally producing on an average of about two acres. The men tend to dominate the production of the cash crops and some food crops such as yam and rice. Women dominate in some of the components such as small-scale processing of foodstuffs (e.g. maize and cassava) and marketing. Even though agricultural activities in Ghana is smallholder-driven, there are key large-scale crop producers, big commercial farmers and processors such as Volta River Estate Limited (a fair-trade banana producer and exporter), Golden Exotics Ltd., Twifo Oil Palm Plantation Ltd, Ghana Rubber Estates Ltd, and Blue Skies Ghana. These large-scale companies contribute significantly in employment and foreign exchange earnings. Most of the employees of these companies are the youth of the local communities.

The potential impact of agricultural activities on the environment through deforestation and forest degradation is depicted by the large hectares of farmland under cultivation. Maize and cassava grow in virtually all the agro-ecological zones in Ghana – Coastal Savanna, Guinea Savanna, Transition Belt and the Forests. The details of the ecological belts and how climate change impacts on them are discussed in section 2.2.4. The two crops currently cover about 20 million hectares of farmland as shown in Figure 1.

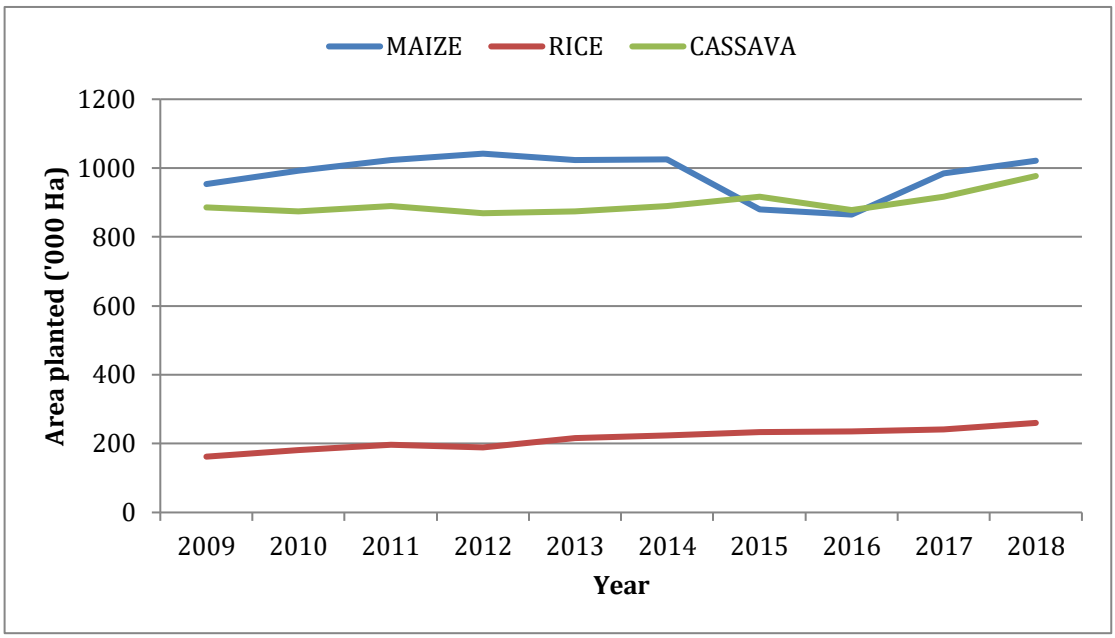

Figure 1. Annual Area Planted to Major Food Crops ('000 ha).

Source: Based on data from SRID, MoFA.

The significance of the increasing farmland of rice is the increasing importance of rice in food consumption in Ghana. The food preference of many Ghanaians have shifted from the traditional staple e.g. plantain, cassava, maize and yam, to rice. Annually, some $500 million is spent on rice importation. There are initiatives to locally produce rice to conserve foreign exchange. However, it is not only the issue of rice production but also the issue of acceptability of the locally produced rice for consumption. Local rice farmers quite often are faced with the challenge of preference for foreign imported rice and they have to struggle to find a market. The programme to boost local rice production has evolved into a holistic one with a drive towards promoting the acceptability of locally produced rice.

The production of food crops in Ghana is quite appreciable (Figure 2).

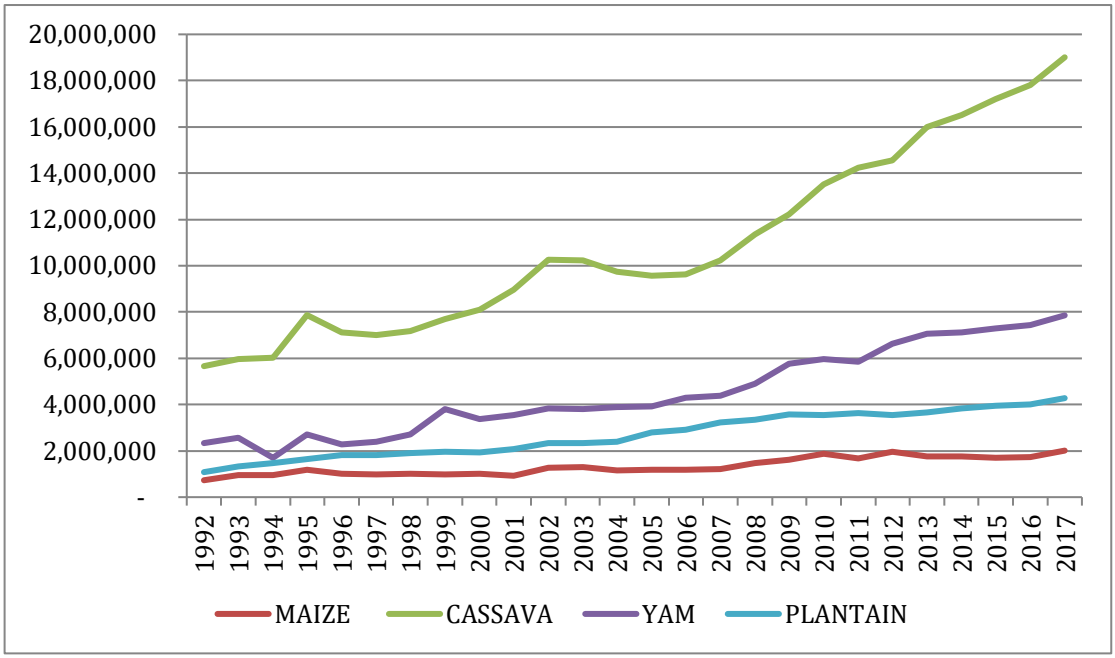

Figure 2. Annual Production of Selected Crops in Metric Tons - 1992 - 2017.

Source: Based on data from SRID, MoFA

In terms of quantity, cassava is the most heavily produced crop in Ghana with production increasing from about 6 million metric tons in 1993 to about 10 million metric tons to 14 million metric tons in 2010 to about 19 million metric tons in 2017. Cassava is a key staple used in various meals such as fufu, banku and gari. Processing cassava into the various food products e.g. dough (agbelima), gari and confectioneries, is a major occupation for women micro-processors. In recent years, cassava has become an industrial commodity as it is being processed in large-scale industries for industrial starch and beer. The production of yam has also seen similar increase though at a less remarkable rate. Maize and plantain have also experienced modest increases. Generally, the main drivers of the increases of these crops are the increases in demand for these staples and government policy emphasis on achieving food self-sufficiency and security. Though the predominant production scale was, and still is smallholder, farmers' hard work and dedication have translated into the increases observed. The current agricultural flagship programme – Planting for Food and Jobs (PFJ) – is likely to lead to further increases as more inputs e.g. fertilizer and agro-chemicals are extended to farmers.

Cash cropping is an important agricultural activity in Ghana. Among the tree cash crops, cocoa stands out as the most important crop. Cocoa has been the most important cash crop

for Ghana since it got established in the country in the early 1900s. It is at the centre of Ghana's economy and politics and it is a tool for social construction in the human settlements that have emerged over the years in cocoa farming communities (Ofori-Gyamfi and Essegbey, 2019). Successive governments have put in a number of interventions over the last 20 years such as the Cocoa Diseases and Pests Control programme (CODAPEC) in 2001, Cocoa High Technology (Hi-Tech) fertilizer application in 2003 and the re-introduction of the defunct cocoa extension delivery services to cocoa farmers in 2009 to resuscitate the industry. The interventions have led to a significant increase in cocoa production with the current production hovering between 850,000 and 950,000 metric tonnes (Ofori-Gyamfi and Essegbey, 2019). See graph in Figure 3.

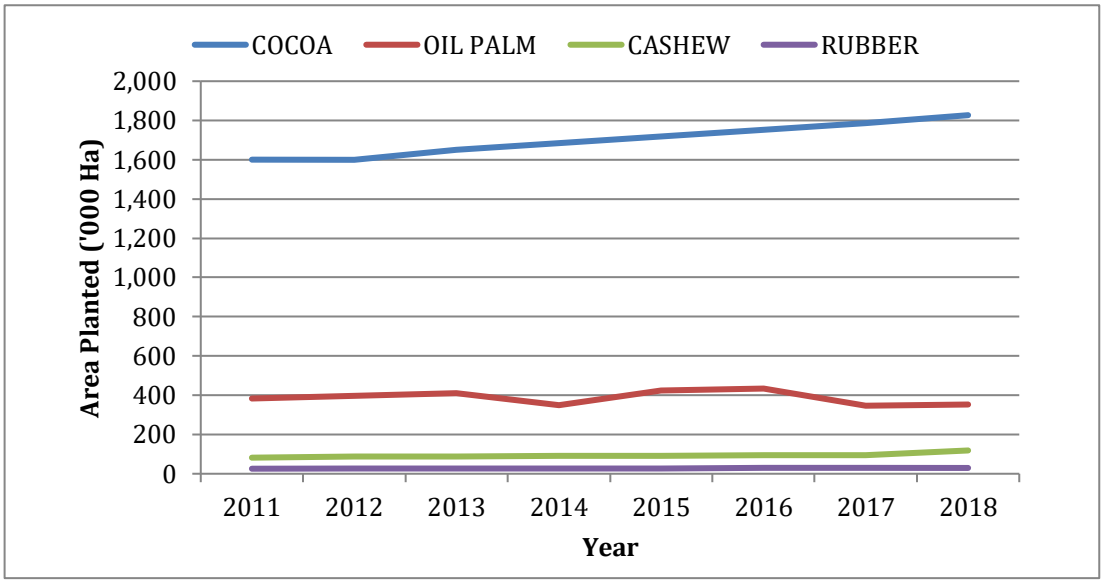

Figure 3. Annual Area Planted to Selected Tree Crops ('000 ha).

Source: Based on data from SRID, MoFA

Oil palm, cashew and rubber are some of the other tree crops of economic importance in Ghana. In comparison to cocoa, these are relatively less widely cultivated as depicted in Figure 4 and therefore less important. In fact cashew is one tree crop which is only being promoted on large scale in the last two decades. Rubber has been cultivated for more than fifty years in Ghana and was in the 1960s and 1970s an important crop. However, it is only beginning to make its ascendancy in the past ten years. Cocoa on the other hand has always maintained its importance through the particular attention it has attracted from successive governments. The Ghana Cocoa Board has over the years launched programmes to keep the

cocoa farms healthy with fumigation and spraying against cocoa pests and diseases and to promote replanting of farms. See Figure 4.

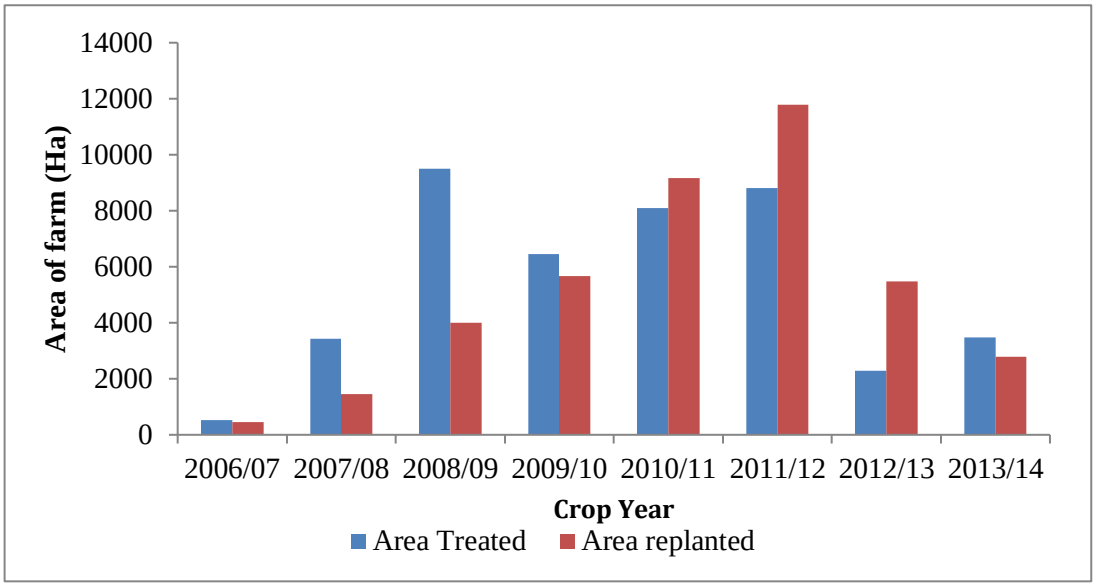

Figure 4. Area of coca farms treated and replanted (ha).

Source: Adapted from Ofori-Gyamfi and Essegbey, 2019

Ghana is the second most important producer and exporter of cocoa in the world after Cote d'Ivoire. Together, the two countries account for about 60% of global exports. Currently Ghana produces about 20% of the world's total export, and has managed to increase its share of free-on-board (FOB) export prices paid to farmers to about 70% of net FOB. For over a decade the producer price has increased nominally over the years even when real producer prices are not increasing (or possibly declining due to foreign exchange or inflationary trends). The government makes effort to reward cocoa farmers relatively well to ensure they maintain their cocoa farms. The tight monitoring and quality measures put in place ensures that Ghana's cocoa earns about 3-5% premium on international markets (Ofori-Gyamfi and Essegbey, 2019). The production of cocoa in the country is illustrated in Figure 5.

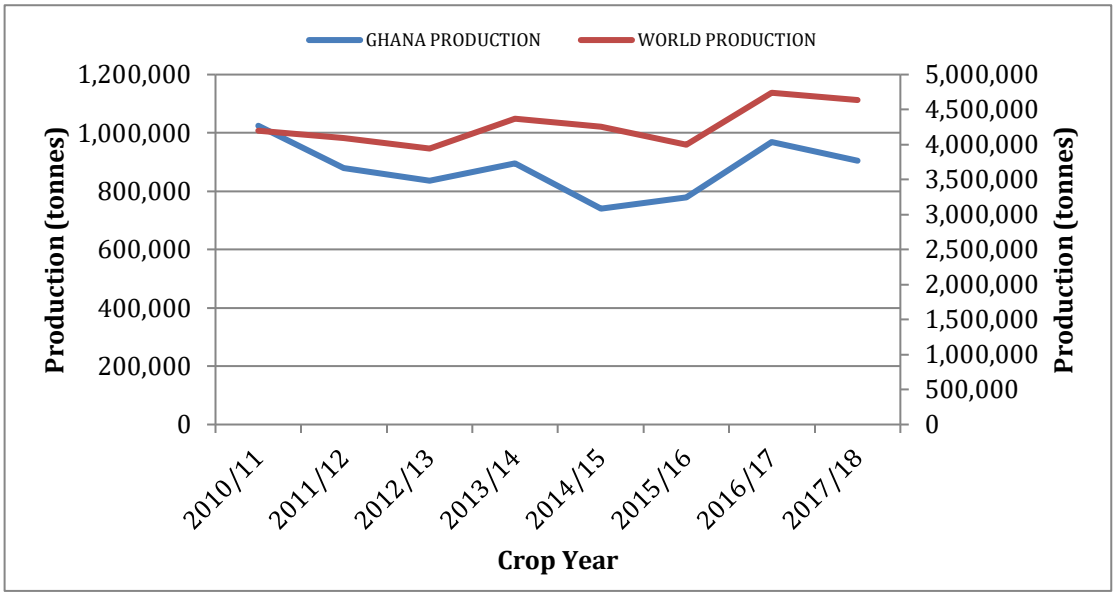

Figure 5. Total Cocoa Production in Ghana versus World Production.

Source: Based on data in Ofori-Gyamfi and Essegbey, 2019

An example of how government initiatives have boosted other tree crop farming is the Cashew Development Project financed by the African Development Bank concessionary loan of UA 9.89 million and a Government of Ghana contribution of UA 1.647 million. The actual implementation spanned a period of eight years to allow for the completion of feeder roads rehabilitation activities that were undertaken and also to ensure a more accelerated use of credit funds provided under the project (MoFA, undated). The Cashew Development Project aimed at production development, including provision of improved planting materials, cashew research, extension service delivery and training, and credit delivery to farmers and processors. The Project was able to reach out to 33,400 farmers to facilitate the establishment of 26,000 ha of new cashew plantations, promote canopy substitution and train farmers in GAP. Furthermore, 60MT of improved seed were procured and distributed to farmers and more than 30,000 improved planting materials (clones) were produced from the two central nurseries and successfully distributed to farmers (MoFA, undated). The project achieved the important feat of increasing cashew yield levels from 200 kg/ha at project inception to 550 kg/ha at project close (MoFA, undated).

Livestock sub-sector

There are two main livestock production systems; mixed farming which is predominant, account for about 95% of the production and is characterized by smallholder farmers. The second type is the pure livestock farming mostly practiced by commercial farmers. The latter is a more intensive system of production where farmers provide housing, veterinary services, feed (with prepared feed) and is usually practiced in peri-urban settings. Farming in the livestock sub-sector is mainly centred on cattle, sheep, goat, pigs and poultry. Smallholder farmers generally dominate except with cattle where large herds are reared by some cattle owners. The country's cattle population has increased from 1.145 million in 1990 to 1.302 million in 2000 to 1.454 in 2010 and to 1.815 in 2016 (Figure 6). It is the result of more farmers going into cattle rearing and the sub-sector becoming more lucrative.

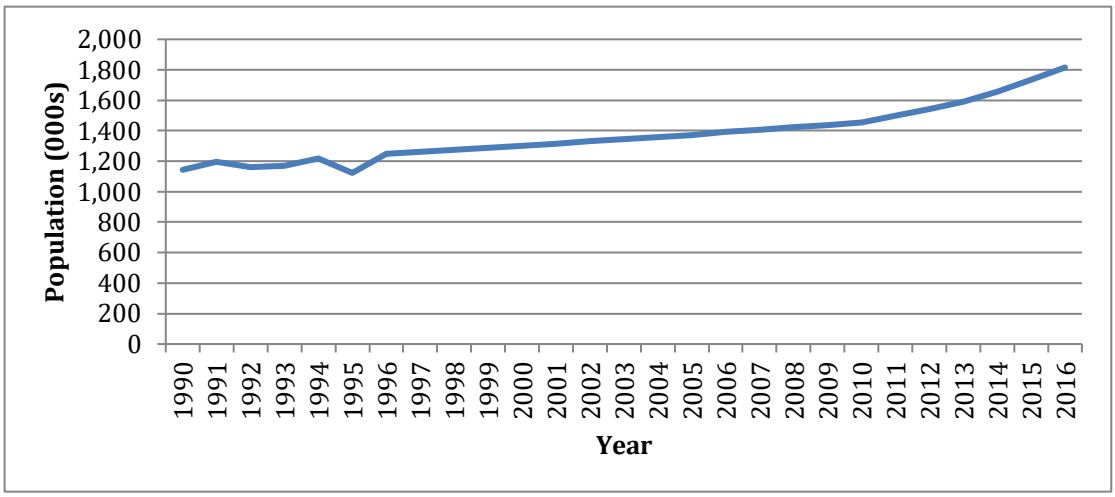

Figure 6. Population of Cattle in Ghana (000s).

Source: Based on data from the Ghana Statistical Service

Meat products from the cattle is supplemented by meat products from small ruminants such as sheep and goats. In 2016, there were 4.744 million sheep and 6.740 million goats in the country mostly held by smallholder farmers. The commonest cattle breeds are the Sanga, West African short horn, Ndama and their crosses. For sheep, there are the West African dwarf and the West African long-legged breeds. There are research programmes to breed to improve the genetic constitution of the animals to increase productivity and withstand environmental stresses. These are programmes going on in the knowledge institutions such as University of Ghana and the Animal Research Institute of the CSIR and the Animal Production Directorate (APD) of MoFA. The APD has six National Livestock Breeding Stations

located in various parts of the country to ensure that the breeding programmes respond to environmental influences in livestock production. Under the current Rearing for Food and Jobs (RFJ) programme, MoFA has imported some improved breeds of sheep and goats from Mali and Burkina Faso and distributed to farmers, not only to improve livestock production but also to improve the genetic stock. In a typical rural community, the men rear cattle and sheep whereas the women rear poultry and some goats. Apparently, the men go in for the livestock of relatively greater investment potential while the women are left with those with the smaller investment potential. A major constraint in the livestock sub-sector is the over reliance on community rangelands for grazing. Pasture development is low, there are seasonal variability in quantity and quality of feed available to livestock. Crop residues are often used in the dry season for feed, but these are often woefully inadequate. Additionally, patronage of veterinary services is low with smallholder farmers relying on indigenous knowledge to handle animal health issues. This has a serious implication for possible animal to human transmission of diseases with consequences for farmers' welfare and livelihood. Even though policies have identified these constraints and provided strategies to address them, implementation has not been adequate.

Poultry is a major livestock business venture. There is also the national policy of promoting poultry as a major source of employment generation and attraction of youth in agriculture. The policy is also meant to address the economic challenge of extensive importation of poultry products whereas the country has a virtually unlimited potential to produce more than enough to feed domestic demand and also export into the sub-region (Figure 7).

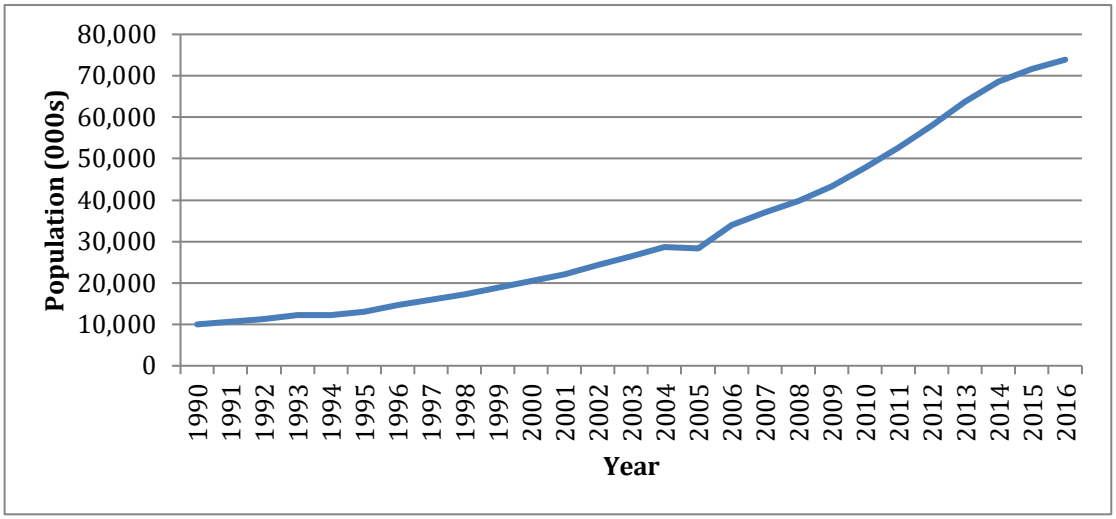

Figure 7. Population of Poultry in Ghana.

Source: Based on data from the Ghana Statistical Service.

Fisheries sub-sector

Fishing is an important economic activity for the coastal communities and those around the inland rivers and lakes. Apart from providing livelihoods and jobs, it is important for food and nutrition security. As shown in figure 7 fish landings are seriously decreasing for canoe artisanal fishers. These are the smallholder fishers whose households depend entirely on their fishing. This is a serious case of over-fishing in Ghana's marine waters by commercial fishing vessels, which are often foreign. Some engage in illegal fishing practices, which have detrimental effect on the fish stock in the marine waters. Artisanal fishers are then left with reducing fish stocks and hence the serious dip of the curve in Figure 8 illustrating the fish landings of the artisanal canoe fisher folks.

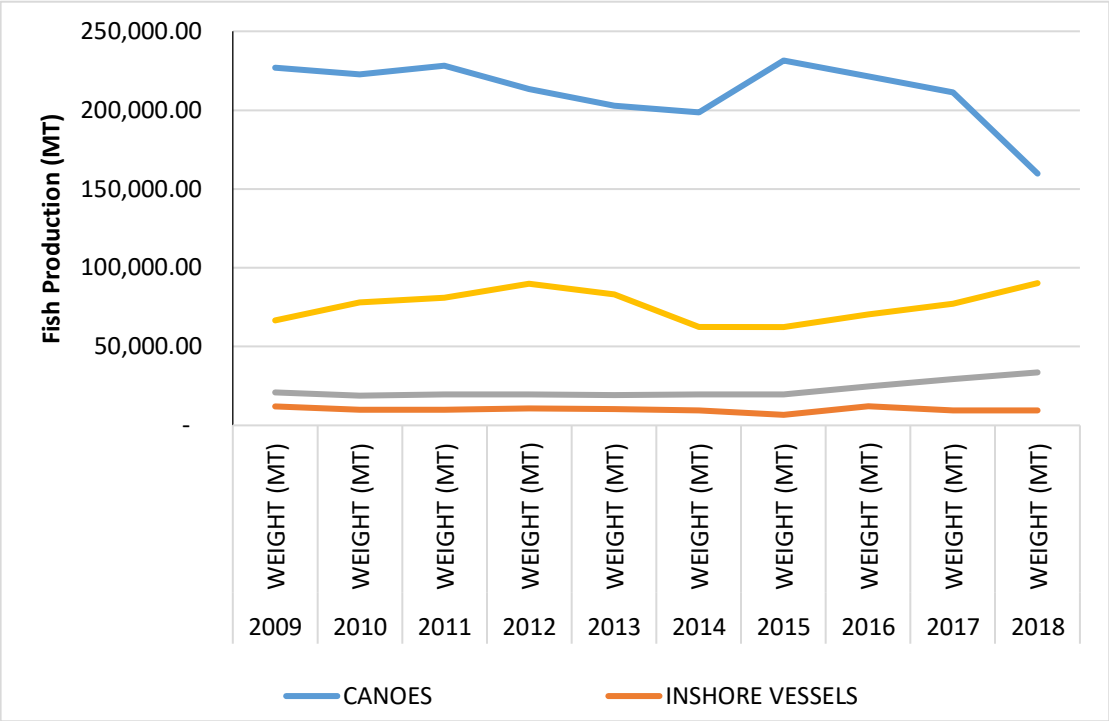

Figure 8. Trends in Fish Landing - 2009 - 2018.

Source: MoFA, 2019 based on data from the Ministry of Fisheries and Aquaculture Development

Aquaculture has become a lucrative business venture in Ghana. Most of the aquaculture ventures are on the Volta Lake with Tilapia being the dominant fish species produced. In 2013, almost 30,000 metric tons was produced. It increased to almost 49,000 in 2016 and to about 60,000 in 2017. In 2018, a total of almost 80,000 metric tons was produced. Catfish production is relatively low and shrimp aquaculture has virtually collapsed. See Figure 9.

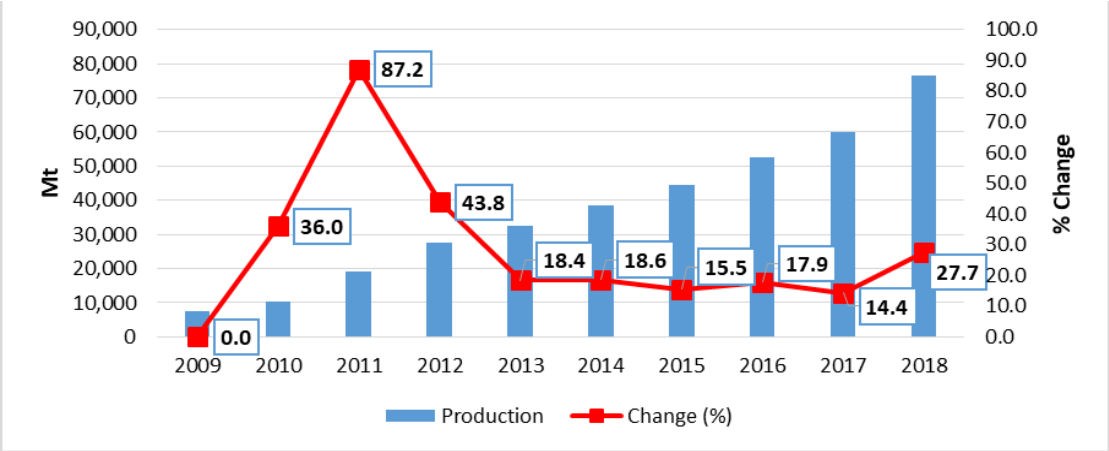

Figure 9. Aquaculture Production -2009 - 2018.

Source: MoFA, 2019 based on data from the Ministry of Fisheries and Aquaculture Development.

Landscapes and agroforestry

The main agro-ecologies in Ghana are the Coastal Savanna, Rain Forest, Semi-Deciduous Forest, Transition Zone, Guinea Savanna and the Sudan Savanna. These are spread across the 16 administrative regions of the country which until recently (in 2019) used to be 10 administrative regions and lend themselves to a diversity of agricultural activities. See map in Figure 10.

Figure 10. Map of Agro-ecologies in Ghana.

Source: Google

The forest ecologies comprise mainly of the rainforest and the deciduous forest. Ghana's rain forest is located in the South Western part of the country. The area experiences high rainfall of up to 2200 mm. It consists of tall and large trees that are mainly hardwoods thus serving as a source of timber. The rain forest is rich in biodiversity having a wide variety of flora and fauna including wild animals. The soils and the climate are a good combination for the production of tree, root and tuber crops and plantain. The deciduous forest zone is made

up of trees that shed their leaves at particular seasons and shrubs. It has diverse tree species and soil types and therefore it is suitable for all kinds of agricultural activities. Diverse cash and food crops are produced in the deciduous forest. The deciduous forest receives rainfall of approximately 1500mm annually. During the rainy season, [3] farmers take advantage of the rains to grow their crops. The rains are important in all the agro-ecologies as agriculture in the country is largely rain-dependent. Ghana's natural forest resources are rich in the variety of tree species including *Terminalia ivorensis* (Almond or Emeri)*, Terminalia superba* (African limba wood or Ofram), *Chrorophora excelsia* (Odum or Oroko)*, Albizia coriaria* (Kundro or Ati), *Funtumia elastica* (Ofruntum) *, Entandrophragma angolense* (Mahogany)*, Alstonia boonei* (Onyame Dua), *Pychantus angolensis* (African nutmeg or Ilomba) and *Triplochyton scleroxylon* (African white wood or Wawa). Many of these are logged and form the basis of Ghana's timber industry.

There is a national policy which addresses the primary challenge of the management of the forest ecologies. The Forest and Wildlife Policy of Ghana aims at conservation and sustainable development of the nation's forest and wildlife resources for maintenance of environmental quality and perpetual flow of optimum benefits to all segments of society. Ghana has by legislation established 282 forest reserves and 15 wildlife protected areas which occupy more than 38,000 km or about 16 percent of the country's land area. Outside the legally designated areas, an estimated 4000 km of forests still exist. Within the forest reserves, some 60,000 hectares of plantations have been established, while private interests and communities are planting trees on an increasing scale around the country (Forestry Commission, 1995). The policy places emphasis on reforestation initiatives towards restoring a significant proportion of the country's original forest cover. In this regard, **agroforestry** activities are very crucial. Thus, effort to increase public awareness and people's involvement in conservation of forest and wildlife resources, particularly where they directly affect the livelihood of communities and the stability of the environment, is a key strategy of the Forest and Wildlife Policy. Efforts will be directed at promotion and implementation of public education programmes to increase awareness and understanding of the role of trees, forest and wildlife and the importance of conservation. Also, there will be the promotion of

[3] There are two main seasons in Ghana. There is the rainy season and there is the dry season. The rainy season is from May to September in the North, April to October in the middle belt and April to November in the South.

agroforestry among farmers and cultivators to enhance food and raw material production and environmental protection (Forestry Commission, 1995).

Nevertheless, agroforestry is generally practiced in Ghana. Traditionally, farmers in local communities conserve the naturally growing economically useful trees. These trees provide a range of benefits including food ingredients, wood fuel, medicines and housing materials. For example, in the northern parts of Ghana, Dawadawa trees (*Parkia clapatoniana*) grow in the wild and provide unique food ingredients for the people of the region. Shea (*Vitellaria paradoxa*) is a tree that also grows wild. Its nuts are processed to obtain shea butter, which is used as food and cosmetics. The Shea tree provides important micro and small industrial processing opportunities for women in particular in the northern regions of the country. Both the Dawadawa and the Shea trees are now being planted by some farmers on farms along with the farmers' crops. The Mango tree (Mangifera indica) is a fruit tree which is also used in agroforestry with the fruits bringing additional incomes to farmers when sold. The branches can be pruned for wood fuel. The Neem tree (*Azadiracta indica*) grows in most of the agro-ecologies and farmers may leave them growing on the farm to provide shelter and become source of wood fuel. It is also used in medicinal preparations. Some trees are planted in woodlots in the agroforestry practices. Eucalyptus is planted in woodlots and so is teak (*Tectona grandis*). The trees are harvested from the woodlots for special uses such as the development of human settlements and construction.

Productive resources

Land resources

Land as a resource is critical to all agricultural activities. The country has a total land area of 23.8533 million hectares with a total coastline of 535 km. (MoFA, 2019). About 57% of the land is Agricultural Land Area (A.L.A.) though it is 50% of the total land that is cultivated. The irrigated land is less than 5% and this illustrates the extensive reliance on rainfall in agriculture in the country. Land use in Ghana is summarized in Table 2.

Table 2. Summary of Land Use in Ghana.

Type of Land Use	Hectares	(%)	Percentage formula definition
1.0 Total Land Area (T.L.A.)	23,884,245	100.00	
2.0 Agric. Land Area (A.L.A.)	13,600,000	56.94	(2.0/1.0)
2.1 Area under cultivation (2018)	6,763,500	49.73	(2.1/2.0)
2.1.1 Total area under irrigation (2018)	222,978	3.18	(2.1.1/2.1)
3.0 Area under inland waters	1,100,000	4.61	(3.0/1.0)
4.0 Others (forest reserves, savannah Woodland etc.)	8,746,021	36.62	(4.0/1.0)

Sources: Table presented in MOFA, 2019

Note: Percentages will not add up to 100 because Area under cultivation is part of Agric. Land Area, while area under irrigation is part of area under cultivation.

The issues of ownership, accessibility and typology are what fundamentally translate into challenges for farmers irrespective of the type of farming they are engaged in e.g. crop, livestock and agroforestry. The challenges are complex and multi-dimensional.

The land tenure system in Ghana is rooted in traditional custom and practice. Ownership of land is determined by various types of title to the land such as the allodial title, customary freehold, freehold and leasehold. About 80 per cent of the land in the country is held by chiefs occupying stools or skins, families and clans. It means that one has to deal with these traditional owners of lands to engage in farming or any agricultural venture requiring land. In many traditional areas, women are disadvantaged in land ownership as the customary practice might disallow female ownership of land. Aware that the land tenure system in Ghana is a major constraint to modern economic development, there are projects for reform. For example, the Land Administration Development Project implemented under the auspices of the Lands Commission was designed to better define ownership of the land and enhance access for economic activities including agriculture. Yet, much of the traditional land tenure systems remain and settler farmers have to strike a bargain with landowners concerning crop sharing on the lands they farm. Communities are not able to optimize on the land resources to the advantage of their development (Appiah and Nyarko, 2015).

In the urban areas the sprawling development of houses and estates has led to the situation where agricultural lands are being sold to property developers. Clearly the planning done at the Lands Commission with green belts designed for the cities are no more applicable

leading to the loss of farmlands as well as greenery. This is a major policy failure in the country.

Soils

Soils differ generally in relation to the agro-ecological location. On the whole, much of the available soils lend themselves to various types of agricultural activity. Table 3 summarises the types of soils available in the agro-ecologies.

Table 3. Fertility Status of Soils in the Ecological Zones of Ghana.

Ecological Zones	Soil pH	% Organic matter	% Total Nitrogen	Available Phosphorus (mg/kg soil)	Cation Exchange Capacity
Coastal savanna	4.4-9.5	0.00-8.00	0.07-0.37	0.00-6.62	0.00-9.28
Deciduous Forest	4.4-9.5	0.00-13.83	0.00-0.52	0.00-3.48	0.00-9.62
Moist Evergreen*	4.4-7.7	0.69-13.83	0.00-0.37	<0.02	0.00-1.21
Wet Evergreen*	4.4-7.7	0.69-13.83	0.00-0.37	0.00-8.19	0.00-1.21
Transitional	4.1-7.7	0.00-10.3	0.00-0.52	0.00-2.00	0.00-9.62
Guinea Savana	4.1-7.4	0.00-6.74	0.00-0.14	0.00-7.60	0.00-7.85
Sudan Savana	4.1-7.4	0.54-5.89	0.00-0.1	0.00-3.62	0.00-7.72

Source: MoFA, 2019 based on data from CSIR-Soil Research Institute; *The Evergreen forest is the Rainforest.

As shown in Table 3, the soils differ in acidity, percentage organic matter, nitrogen and phosphorus content. Generally, the more organic matter, nitrogen and phosphorus in the soil, the more conducive it is for agricultural purposes. Still, each of the agro-ecologies has its particular crops that can be suitably cultivated.

Water resources

The country is endowed with rivers, lakes and lagoons that support agricultural activities including Rivers Volta, Birim, Pra and Densu, the Volta Lake and Sangor Lagoon. There are various wetlands in the country, which currently are under threat from human settlement.

Constraints to agricultural development and growth

There are a number of constraints to agricultural development and growth in Ghana. In analyzing the constraints it is best to come from the perspective of the underlying philosophy that is driving agricultural policies and programmes currently. That, agriculture is

business that must profitably impact on the lives of the farmers and all those who are engaged in it. In this regard, the PESTELI tool is applied to analyse the constraints and generate options for agricultural development and growth and cutting across all sectors including crops, livestock and fisheries.

Table 4. The PESTELI Analysis of Ghana's Agriculture.

Component	Specific Elements	Key Constraints
Political	Democratic, parliamentary governance system; decentralization of political power to MMDAs; mass media pluralism; commitment to international agreements e.g. Paris Agreement, CAADP, UNFCCC, ECOWAS protocol	MMDAs still handicapped politically; farmers not participating in decision-making; weakness in enforcing international agreements
Economic	PFJ is the biggest flagship programme of government; agric considered key priority sector for food, jobs & exports; national budgetary allocations for agric programmes; climate finance inflows from multilateral and bilateral sources	Market dysfunctions; post-harvest losses; land tenure constraints; farmers' limited access to financial resources
Social	Farmers organized in FBOs; largest segment of population youth; socio-cultural emphasis on agriculture as means of livelihoods e.g. farming, fishing, livestock rearing; harvests celebrated in festivals and rituals; women disempowerment & social disadvantages	Youth migration to urban areas; youth disinterest in farming; unfavourable land ownership arrangements; women not able to own land in some communities; weak extension services
Technological	Government emphasis on modernization of agric; provision of tractor services and machines; promotion of improved seeds e.g. maize, rice, cowpea, agro-chemicals; promotion of CSA	Limited adoption of technologies and farming inputs e.g. pesticides for many farmers; inadequate knowledge of CSA
Environmental	Pollution of ecosystems e.g. through illegal mining of gold; climate change effects e.g. unreliable rainfall, flooding, high temperatures, depletion of fish stocks; forest degradation; deforestation	Degraded farmlands; loss of land to non-farm activities; soil erosion and loss of fertility; pollution.
Legal	Constitutional protection of chieftaincy and traditional authorities; legislations for businesses and investment in agriculture; free zone legislation to boost exports; environmental laws	Abuse of land ownership traditional authorities e.g. sales of farmlands to illegal miners; lack of enforcement of laws
Institutional	MoFA and relevant agencies set up; MESTI for climate change; NGOs & civil society active in agric and climate change; collaborations and partnerships	Weak institutional linkages among public institutions.

As shown in the table 4, there are several constraints that emerge across the PESTELI components relating to the agricultural sector. The following are the highlights:

- Limited adoption of modern technology
- Inadequate provision of extension services
- Weak linkages among public institutions
- Weak linkages in the agricultural value chains
- Aging farmers and limited interest of the youth in agriculture
- Dysfunctional markets
- Post-harvest losses
- Inadequate access to financial resources

Each of the PESTELI components highlights some important constraints that need attention in the development of the agricultural sector. For example, in the political component, even though decentralization has brought some decision-making powers to the district level of governance, the MMDAs are politically handicapped in formulating their local policies and programmes as they need to situate these in the national policy framework and within the limits of available budgetary resources. Economic dysfunctions also manifest in the economic component. Especially in the agricultural sector, market failures abound and farmers during bumper harvests of perishables e.g. vegetables and fruits, incur huge losses as they sell their produce at ridiculous prices. In the social component, unfavourable land ownership is a major constraint especially where women are concerned. Traditionally, land ownership in most Ghanaian cultures are male-dominated. In that sense, women disempowerment is a gendered constraint. Technologically, the extension system has weakened with the decentralization of the public extension system to the MMDAs, which are not able to mobilise resources to operate the kind of extension system that caters for the majority of farmers in the municipalities and districts, to enhance the diffusion of technologies. Institutional weaknesses manifest in the weak linkages between organisations working towards common goals. For example, the Department of Feeder Roads, which is under the Ministry of Roads and Highways does not link effectively with MoFA to build the needed feeder roads into the hinterlands where the bulk of agricultural produce comes from. Even though there is the constraint of financial resources to build the roads, strong

linkages between the relevant institutions can address the challenge of feeder roads to boost agricultural value chains.

Indeed, it is important to note that the constraints inter-lock. The inadequate access to financial resources and the lack of means for many farmers connect with their inability to adopt modern technologies such as machines for agricultural activities. For example, there are districts where tractor services are available and yet farmers would still stick to their hoes and cutlasses to prepare their farmlands because they are unable to afford the fees to access tractor services. Post-harvest losses abound because farmers lack the technologies or warehouse facilities to properly store grains and legumes or to process produce such as tomatoes, mangoes, oranges and water melons. It illustrates the weaknesses in the linkages in the value chains and the ineffectiveness in policy implementation to achieve set goals and objectives to enhance efficiencies in the agricultural activities and increase productivity. For the overall goal of making agriculture profitable business for the benefit of the youth and the nation, the constraints have to be addressed effectively and innovatively.

The next sections in the report will go into details of analysis of e.g. the impacts of climate change on agriculture and the adaptation response measures, climate financing and MRV among others. What is important is to enable the generation of recommendations for addressing the constraints to agriculture development and growth in the context of the national vision of attaining an upper middle-income status.

Impacts of climate change on agriculture and adaptation response measures

Overview

Climate change is causing increased temperatures and unpredictable rainfall patterns in Ghana with negative impacts on agriculture and the people's livelihoods Ghana is already experiencing higher average annual temperature of 1°C and decrease in monthly rainfall by about 2.4% per decade since 1960. The declining rainfall amount is most severe in the southwestern regions of the country while the rest of the country is experiencing more prolonged and severe dry seasons (De Pinto *et al.,* 2012). Climate scenarios indicate an

increasing trend in temperature, especially in the northern regions. Various models have revealed that the mean annual temperature in Ghana will increase by 1.0°C - 3.0°C and 1.5°C - 5.2°C by 2060 and 2090 respectively. Such changes will be more pronounced and severe in the northern region of the country. It has been estimated that climate change and variability will cause decline in household consumption and gross domestic production by 5-10% and 1.9-7.2% respectively in Ghana by 2050 (Nelson *et al.,* 2009).

The Ghanaian agricultural-dependent economy is expected to suffer severe economic consequences from climate variability and change. The sensitivity and vulnerability of the agriculture sector to climate change is based on the fact that it is largely rain-fed with minimal technological inputs (Naab *et al.,* 2019). Limited use of irrigation only 0.89% of the total cultivated land in Ghana exacerbates the problem. The sector is already struggling to contend with erratic rainfall patterns, water stress, desertification/degradation of ecological systems/forest degradation; increasing temperatures; and disruption of seasonality as well as rising prevalence of crop and livestock pests and diseases (Arndt *et al*., 2015). The effects of climate change are more felt by more than 70% of the country's population who depend directly or indirectly on smallholder agriculture thus raising the poverty gap (Adu-Boahen *et al.,* 2019).

Agriculture sector in Ghana is also a source of emissions and with great mitigation potential. The sector is the second largest contributor of emissions after the energy sector. Major emissions from the agriculture sector are: nitrous oxide (NO_2) and methane (CH_4). As demand for agricultural products continues to increase, emissions from Ghana's agricultural sector will likely increase as well (De Pinto *et al.,* 2012) unless appropriate adaptation and mitigation actions are implemented.

Impacts of climate change on agriculture sub-sectors

Crop sub-sector

The projected increase in warming and droughts will lead to reduced water availability; drop in soil fertility due to increased decomposition of soil organic carbon and increased incidence of pests, diseases and weeds, thus decline in crop yields (Abubakari and Abubakari, 2015; C. Kyei-Mensah et al., 2019). Analysis of recent rainfall conditions in West Africa, including Ghana indicates long-term change in rainfall patterns within the semi-arid and sub-humid

zones, with reduced rainy days (Ndamani and Watanabe, 2015). Effects of variability in climate are highly felt in smallholder rain-fed crop production systems which account for a large percentage of the total crop production in Ghana (Kyei-Mensah *et al*., 2019).

Some of the major crops in Ghana are currently experiencing major yield gaps. For instance, cassava, maize, sorghum, rice and yam currently have yield gaps of 57.5%, 38%, 40%, 33.33% and 40%, respectively. Despite their current state of low yields, these crops are expected to experience further decline in productivity due to climate change (Knox et al., 2012; Issahaku et al., 2014). Cocoa which is one of the major export crops in Ghana has recorded a drop in its foreign exchange earnings; it accounted for over 40% of the total foreign exchange earnings in 1970s which has dropped to the current 18%. This is partially attributed to effects of climate change including variations in temperature and precipitation (Wiah, 2017). The effects of diseases such as Cocoa Swollen Shoot Virus Disease (CSSVD) and pests such as the capsid pests have long constrained cocoa production. However, climate change impacts also are affecting cocoa production. Projections indicate that suitable areas for cocoa production will shift and this will mainly affect the southern area of Brong Ahafo, and Western regions in Ghana by 2030, thereby reducing area suitable for crop production.

There is a likelihood of a shift in suitable production areas for some crops due to shifts in climatic zones due to climate change. A study by Bunn and Castro (2018) also illustrated a spatial distribution of suitable areas for cocoa production by 2050. The southern part of Brong-Ahafo, small sections of the Northern parts of Ashanti and Volta regions will no long be suitable for cocoa production and hence will require transformational changes due to a change in climatic zone (Figure 11). Western, part of Central and Volta regions will experience the weakest climatic change and, hence, will require incremental adaptation to maintain cocoa production.

The yields of major food crops have varied annually mainly due to variability or erratic rainfall distributions (Amikuzunu and Donkor, 2012). A study by MacCarthy et al. (2017) indicated maize yield gaps of between 59 and 75 for Northern Ghana, could be reduced to between 29 and 59% with improved fertility management, appropriate plant density and use of certified seeds. The PFJ initiative introduced about three years ago is, however, closing the yield gaps through availability of agro-inputs at subsidized prices.

A number of studies have also reported on the projected changes in yields of cereals, legumes and tubers (Table 5). Cassava yields are expected to reduce by 13.5% and 53% in the years 2050 and 2080 respectively (Asante and Amuakwa-Mensah, 2015). Yields of rice are also expected to reduce by between 8 to 20 % (Asante and Amuakwa-Mensah, 2015; Oort and Zwart, 2017). Freduah et. al. (2019) also projected reduction in the yields of maize among smallholders in the interior savannah of Ghana. Groundnut productions are however largely projected to increase due mainly to carbon dioxide fertilization (Adiku et al. 2015; De Pinto et al. 2012).

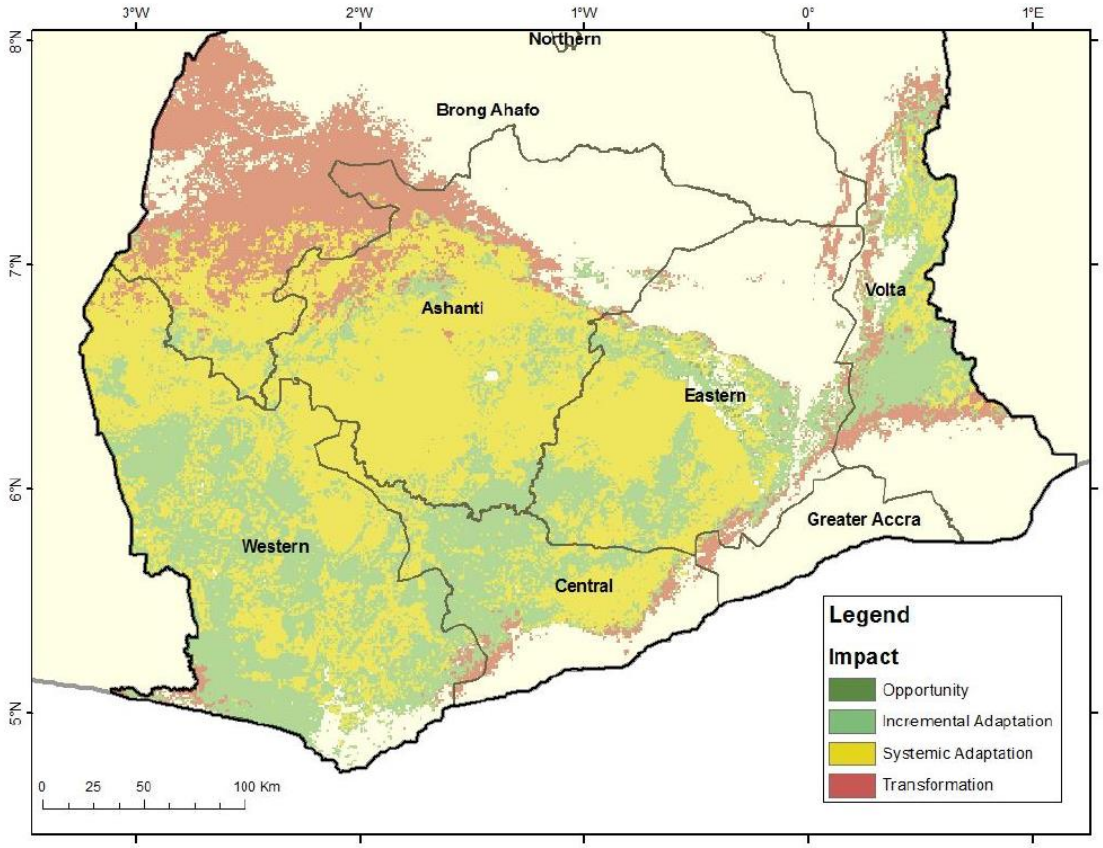

Figure 11. Zones of most likely climate impact on cocoa suitability by the 2050s relative to 1950-2000 in Ghana. The scenario was obtained by choosing the most frequent change observed among the 19 climate projections.

Source: Bunn and Castro, 2018.

Table 5. Projected changes in yields of some crops.

Crop	Projected changes (2050)	Projected changes (2080)	Location
Cassava	-13.5	-53	Asante and Amuakwa, 2015
Yam	-29.6	-64	Asante and Amuakwa, 2015
Maize	-18 to -33		MacCarthy et al. 2019
Rice	-8 – to -20	-20	Oort and Zwart, 2017
Groundnut	+5 to +19		Adiku et al. 2015
Millet	-7 to -11		MacCarthy et al. 2019
Sorghum	+4 to -9		Adams et al., 2020

Over the years, smallholder farmers have tended to increase cultivated land instead of intensification as a coping mechanism to deal with low yields (Issahaku et al., 2014). Increasing agricultural production through land expansion is not sustainable as land is a finite resource. While crop intensification is the most appropriate approach for enhancing crop yields, this would require adoption of appropriate climate smart technologies and practices. Unfortunately, most of the smallholder farmers do not have access to climate smart technologies and inputs such as fertilizers, pesticides and improved seeds (Branca et al., 2013) making it difficult to transform their farming practices. This situation triggered the PFJ initiative where agro-input have been supplied to farmers at heavily subsidized prices for the past three years and has changed drastically.

Livestock sub-sector

Most farmers practice mixed crop-livestock farming. Livestock such as cattle, goats and pigs serves as a means of capital investment. However, some poultry and livestock farmers do operate on commercial scale. Climate change and variability has negative impact on livestock systems in the country. Thornton et. al (2015) indicated that Aboveground Net Primary Productivity (ANPP) in rangelands which is a good proxy for livestock productivity is projected to decrease by as much as 47.9% in Ghana by 2050. Consequently, climate change has both direct and indirect effects on livestock sector through: extreme weather events; increased droughts and floods; productivity losses (physiological stress) owing to temperature increase; feed quality, quantity and access; heat stress; water availability and access; prevalence of livestock pests and diseases together with disease vectors and biodiversity. Reduced biomass productivity due to projected reduced rainfall amounts

The sensitivity of livestock production to climate change and extremes is more pronounced in the rural set ups characterized by extensive and free-range livestock keeping systems. Pastoral households and other livestock keepers in these systems experience complex and localized impacts of climate change, mainly because of their constrained adaptive capacities. Further climate change and variability is anticipated to increase the susceptibility of the livestock industry and exacerbating impacts on livestock systems, incomes and food security in Ghana (Thornton *et al*., 2015; Sarkwa *et al.,* 2016). The main feed resources in communities that rear livestock are crops residues (groundnut haulms, cowpea hay, pigeon pea residue (mixture of pods and leaves), rice straw, sorghum heads, yam and cassava peelings), and natural pasture. Agro-industrial by-products like corn mill waste flour, brewers' spent grain, maize bran, and rice bran were found. Also, few households had stands of browse trees like *Leucaena leucocephala*, pigeon pea (*Cajanus cajan*), *Gliricidia sepium*, acacia and mango trees (Konlan *et al*., 2014). Decline in feed resources due to declining grazing lands is one major constraint in the livestock production systems especially in the northern part of the country (Oppong-Anane, 2013; Konlan *et al*., 2014). The feed challenge together with high incidences of diseases and mortality contribute significantly to low livestock productivity. Other constraints are poor housing, perennial water and feed shortage in the dry seasons. In the savanna zone of northern Ghana, bush fires and decline in nutritive value of fodder resulting from senescence makes it difficult for livestock to meet their nutritional requirement in the dry season under the existing extensive and free range management systems practiced by most smallholder farmers (Konlan *et al.*, 2014).

Fisheries sub-sector

Ghana's current fish production stands at approximately 400,000 metric tons a year from its marine fisheries, inland waters and aquaculture. Lake Volta is Ghana's single most important source of inland fish catch, and hosts about 140 fish species and provides livelihood for millions of Ghanaians who live around the lake. The predominant fishing gear used in the artisanal fishery includes seines, set nets, draft gill nets and hook and line. Changes in weather patterns, namely rainfall, relative humidity, winds, temperature and light intensity and period have undoubtedly affected fisheries and aquaculture in Ghana. Climate change has both direct and indirect influence on fisheries and aquaculture. Direct implications of climate change are on physiology and behaviour of the fish that affect growth, reproduction,

mortality and distribution (Williams and Rota, 2011; Asiedu, *et al.,* 2017). Some of them include water surface temperature rise, sea level rise, increasing water salinity and ocean acidification. The indirect impact affects the productivity, structure and composition of the ecosystem in which the fish depend on for food. Changes in biophysical characteristics of the aquatic environment and frequent occurrence of extreme events significantly affect the ecosystems that support fish (Essam & Uraguch, 2013). These direct and indirect effects of climate change have contributed to reduction of fish stocks in the freshwater and marine ecosystems in Ghana (Asiedu, *et al.,* 2017).

Aquaculture, especially in Volta Lake and river, is one of the fastest growing animal food producing sectors offering employment and food security to the ever increasing human population in Ghana (Asiedu *et al.,* 2015). Aquaculture production in Ghana has increased from 5,000 tons in 2000 to 38,547 tons in 2017 with annual per capita fish consumption of 28 kg (Asiedu, *et al.,* 2017). Aquaculture production systems in Ghana include: earthen ponds, tanks, cages, pens and raceways depending on the culture system being adopted, and can also be in the freshwater and marine environs (Asiedu *et al.,* 2015). Climate change impact can negatively affect these ventures as water availability becomes challenged or that the constituents of the water bodies are varied due to climate change (Asante and Amuakwa-Mensah, 2015).

Landscape and agroforestry

In Ghana, little literature exist on the impact of climate change on landscape and agroforestry. There is, however, evidence that changes have been taking place in the Ghanaian landscape. Predictions indicating that increase in climate warming will have profound impacts on forest ecosystems and landscapes in Ghana due to rise in temperature and alteration and disturbance of ecosystems and regimes. These are largely attributed to anthropogenic factors such as clearing land for agriculture (Braimoh and Vlek, 2005) and biophysical factors (Kleemann et al. 2017). Other studies have also reported negative impacts of climate change on landscapes. Any changes in climate parameters will alter the composition of vegetation in a given landscape, the hydrology, carbon sequestering capacity of the landscape. Land degradation occurs largely due to the mismanagement of land and results frequently from a mismatch between land quality and land use. Activities that can degrade land are over grazing, in appropriate mechanized farming, over grazing, bush/forest

fires among others. Land degradation in semi-arid and sub humid areas can result in desertification thereby resulting in the diminishing soil productivity, food production decreases and vegetative cover is lost. Climate change has been associated with frequent bush fires resulting in changes in the composition and densities of vegetation especially in the northern savannahs and savannah-transition zones. Thus, forest biodiversity and the ability of forests to provide soil protection, habitat for species and other ecosystem services will be severely affected due to their direct exposure to the biophysical effects (UNDP, 2020)

Productive resources

Land resources

Climate change has created conflict over land access and utilization across various users especially between pastoralists and farmers. Rising sea level resulting from climate change affects low-lying coastal areas with large populations, leading to increased risk of conflict over scarce land and water resources. According to Asante and Amuakwa-Mensah (2015), there has been a continuous increase in forest and grassland conversion rate thereby resulting in increased carbon dioxide emissions. The Environmental Protection Agency (2008) reported that an estimated 35% of the total land mass in Ghana has become a desert area. This desertification is estimated to be proceeding at a rate of 20,000 hectares per annum, explaining why the LUCF sector is contributing more to greenhouse gases emissions in recent times (EPA, 2008). Projected increases in temperatures are expected to drastically affect the suitability of current cocoa growing areas by 2050. Based on the projections of CIAT for 2030, suitable areas for cocoa production will start shifting and this will mainly affect the southern area of Brong Ahafo, and Western regions in Ghana. Further, conditions similar to the current climates of high temperature will remain only in the areas between Central, Ashanti and Eastern regions (Asante and Amuakwa-Mensah, 2015). Within the 1900s, forest cover was estimated to be 33% of the country. However, this percentage declined by 78% (to 1.8 million ha) in the 1980s, and forest areas are now uncommon. Considering the current trend of decline of the forest cover, degradation is projected to increase to 65.5% of the area by 2050 and this clearly increases the risk of desertification (Stanturf et al. 2011). Similar dramatic shifts occurred in the Forest-Savanna Transition Zone. The effects of climate change are already evident in Ghana. These are manifested the change in species composition and increasing presence of invasive species in forests and

farmlands as well as increased wildfire threats and extension of the forest transition zone further down south (UNDP, 2020)

Soils

Soils play important functions such as serving as a source of food and biomass production, soil organic carbon pool, storing, filtering, transforming, and recycling, as well as habitat and gene pool (Hamidov et al 2018) which are all sensitive to climate change parameters. The soils in Ghana are very prone to climate change processes with the most vulnerable agro-ecological zone to land degradation being the interior savanna, which covers about 50% of the total land area of the country (Osumanu et al. 2016). Our soils are further prone to a number of agricultural practices that affects its capacity to provide the needed ecosystem benefits in a sustainable manner. Some of the effects of farming system practices and their associated effects on soils are illustrated in Table 6 below. It must be mentioned that the use of slash-burn as a mode of land preparation has significantly declined with the adoption of agricultural machinery such as tractors. The practice however still pertains to a small extent especially in the forest and transitional zones. Asante and Amuakwa-Mensah (2015) also stated substantial loss in top soil which was attributed to wind and water erosion in the northern savanna zones, thus further deteriorating the fertility of the soils. Climate change influences soil moisture levels by direct climatic effects (precipitation, temperature effects on evaporation), climate induced changes in vegetation, plant growth rates, rates of soil water extraction by plants and the effect of enhanced CO_2 levels on plant transpiration (Pareek, 2017). Because soils are part of the C and N cycles and C and N are both important components of soil organic matter, the organic matter content of soils will be influenced by climate change (Brevik 2013).

Table 6. Effects of some farm practices in different farming systems on soils.

Type of farming system in Ghana	Farming practice	Effects on soil
Rotational bush fallow system	Slash and burn. Fallow periods. With or without fertilizer	Destroy vegetative cover. Expose the soil to erosion. Leaching of soil nutrients
Permanent tree crop system	Slash and burn but provide tree cover	No serious soil loss consequence identified in this system. Good forest cover

Compound farming system	Ploughing with or without fertilizer/ manure. Grazing livestock	Soil loss as a result of erosion, leaching of soil nutrients, compaction from livestock
Mixed farming system	Ploughing with or without fertilizer/ manure	Soil erosion and nutrient depletion
Special horticultural farming system	Ploughing with fertilizer/ manure And chemical Application	Soil erosion, eutrophication and acidification of the soil as a result of fertilizer and chemical application

Water resources

Water resources in Ghana are already affected by climate variability and are highly climate vulnerable. Climate change impacts include alterations in the quantity and quality of water available for human consumption and agricultural production systems across the country. Temperature increases may decrease river runoff, and changes in precipitation may affect both runoff and groundwater recharge. Other potential impacts of climate change include lowered water tables, reduced stream flows, and diminished availability of water in lakes and reservoirs, and salinization of estuaries and aquifers due to sea level rise. A study by Kankam-Yeboah et al (2013) on stream flow in two river basins namely White Volta and Pra projected reduction in stream flow by 50 and 46 % respectively by 2050. Surface runoff is said to be sensitive to changes in rainfall distribution and amount as well as temperature. Thus a reduction in annual river flows will result in reduction in annual total runoff. If the runoff from rainfall that flows into rivers and streams is affected by changes in temperature, so too is the water underground storage will be impacted. According to a study by Water Research Institute, 30-40% reduction is projected for river flow and underground water recharge by 2050 (WRI, 2000). An assessment of the impacts of projected climate change on water availability and crop production in the Volta Basin and the southwestern and coastal basin systems of Ghana show that all water demands (municipal, hydropower, and agriculture) cannot be simultaneously met currently, or under any of the climate change scenarios used, including the wet scenarios Amisigo et al. (2015). Climate change has also resulted in heavy rainfall events over short time frame resulting in flooding. The 5 northern regions and parts of Western regions have mostly been affected by flooding events (UNDP, 2020).

Adaptation measures being undertaken

A number of adaptation measures have been pursued (Table 7). The list of adaptation options listed were collated from studies in the country. These adaption strategies are classified into short and medium terms. Most of the short-term strategies are rather immediate and do not require investments from policy makers while the long-term strategies require policy interventions. The government has put in place enabling environment to support adoption of adaptation measures through the Planting for Food and Jobs (PFJ), Livestock Development Policy, Fisheries and Aquaculture Policy and the Ghana Fisheries and Aquaculture Development Plan. Farmers across the country have embraced various climate adaptation options including: growing drought-resistant crops, use of crop insurance mechanisms, irrigation, and adoption of soil and water conservation measures; crop diversification, varying crop varieties, changing planting and harvesting dates, use of water and soil conservation techniques and livelihood diversification away from farming (Nhemachena and Hassan, 2007; Issahaku and Abdulai, 2019). Various farm management practices can enhance soil carbon stocks and encourage soil functional stability. Farmers have also adopted conservation agriculture technologies (minimum soil disturbance, cover crops and crop rotations including legumes), soil conservation measures (e.g. contour farming) and nutrient replenishment strategies to restore soil organic matter (Pareek, 2017). There are differences between female and male farmers' adaptation strategies. The age of a farmer determined the type of adaptation practices that are adopted (Lawson et al. 2020). Whilst men are more into on-farm agronomic practices, women are interested and utilize more off-farm adaptation strategies especially petty trading, in addition to the on-farm agronomic practices. Adzawla et al (2019) reported that the differences are mainly in the level and intensity of adoption of the practices rather than differences in the options adopted by the different gender groups.

Table 7. List of adaptation practices being implemented in the agricultural sector.

	Short-term options	Mid- to long-term options
Dealing with risk and uncertainty	▪ Weather and climate information services and early warning ▪ Crop/livestock insurance ▪ Raising of awareness and access to information ▪ Participatory planning or collective	▪ Climate modeling, impact and vulnerability assessment ▪ R&D on improved seeds and farming technologies ▪ Strengthening seed systems

	action ▪ Flood control measures	
Farming practices and technologies	▪ Soil and water conservation measures – composting, dynamic kraaling ▪ Use of drought/flood -tolerant and early maturing crops ▪ Crop diversification and specialization ▪ Improved crop varieties (maturity duration) ▪ Improved crop practices and production technology ▪ Pest and disease control (crops & animals) ▪ Fodder banks (animal feed) ▪ Adaptive water management and moisture control ▪ Appropriate soil conservation and erosion control measures ▪ Efficient Fertilization ▪ Rain water harvesting technologies ▪ Moisture conservation, e.g. mulching ▪ Ridging ▪ Row planting ▪ Extension services and training ▪ Intercropping ▪ Dry season gardening ▪ Shift in planting dates ▪ Ground water irrigation ▪ Cultivating high value crops ▪ Integration of beneficial trees in farming practices. ▪ Cropping moist valley bottoms. ▪ diversification from crops into livestock rearing	
Off-farm practices and strategies	▪ Improve post-harvest, ▪ food storage practices ▪ Empower communities and females ▪ Improve access to credit ▪ Enhancing food security measures by storing food in national banks ▪ Alternate livelihoods (e.g. Apiculture) ▪ Migration ▪ Extraction of natural resources ▪ Village Savings and Loan Associations (VSLA)	▪ Improve access to land or tenure rights ▪ Migration ▪ Disease prevention ▪ Long-term credit
National development policy	▪ Climate Smart Agriculture Action Plan ▪ Planting for Food and Jobs Program	

There are a number of barriers in the adoption of these practices. Some of them are lack of access to credit facilities and finance to purchase inputs such as improved varieties and

fertilizers, inadequate capital to engage labour for some of the practices like; ridging and row planting. A key barrier to adaption among women farmers was land access and ownership. Some farmers have embraced agroforestry through incorporation of trees (*Acacia albida*, *Gliricidia sepium*, *Leuceana leucocephela*, *Albezia lobeck*) into farming system as a way of restoring degraded soil which can boost food production (for humans as well as animal feed) and provide alternatively sources of nutrition or income when crop yields are low. Various livestock management practices have also been embraced including livestock diversification and feed conservation strategies. Aquaculture is widely growing in Ghana as promising approaches for addressing fish need gaps in the country as a result of dropping fish stocks in the wild.

Mitigation potential of the agriculture sector

Overview

Mitigation and adaptation are both essential aspects of dealing with climate change, but adaptation becomes costlier and less effective as the magnitude of climate change grows. Consequently, when mitigation objectives are affordably achieved, adaptation requirements are reduced and the ultimate result is less stress. The strategies for reducing emissions (mitigation) also have significant synergies with adaptation. Therefore, pursuing synergies between mitigation and adaptation in the context of increasing agricultural production and reducing poverty will be particularly important in building resilience to the effects of climate change.

Global technical mitigation potential in the agricultural sector is high – at between an estimated 5.5 and 6.0 gigatons (Gt) of carbon dioxide equivalent per year by 2030. The majority of these emission reductions can be achieved through effective changes in agriculture management practices that increase soil carbon, reduce methane emissions from flooded rice fields and improve nitrogen fertilizer usage.

Agriculture, Forestry and Other Land Use (AFOLU) sector is the largest source of GHG emissions in Ghana, accounting for 54.4% of the overall national emissions of 42.2 MtCO2e (Figure 12). The total GHG emissions in Ghana recorded a growth of 7.1% between 2012 and

2016, with the AFOLU sector indicating an increase of about 4% within the same period (Ghana GHG Inventory Report, 2019). The emission trends in the AFOLU sector indicate that land category is the main source of emissions in the AFOLU sector at 30% (12.9 MtCO2e) of the total national emission. It accounts for 46% of the overall AFOLU emissions, declining by 0.7% since 2012 due to the carbon stock enhancement interventions in degraded areas. Within the land category, cropland, grassland and forestland were responsible for most of the emissions. The emissions from "aggregated sources and non-CO2 emission on land" was the second highest in the AFOLU sector. Its levels were 6.6 MtCO2e in 2016, making 16% of the national emissions and represented 3% increment compared to the 2012 levels. The "direct N_2O emissions from managed soils" formed a large share to the tune of 63% of the total C emissions. Livestock emissions were 3.03 MtCO2e and made up 8% of the total net emissions. The emissions increased by 18% between 2012 and 2016. There are more emissions associated with enteric fermentation than manure management (Ghana GHG Inventory Report, 2019).

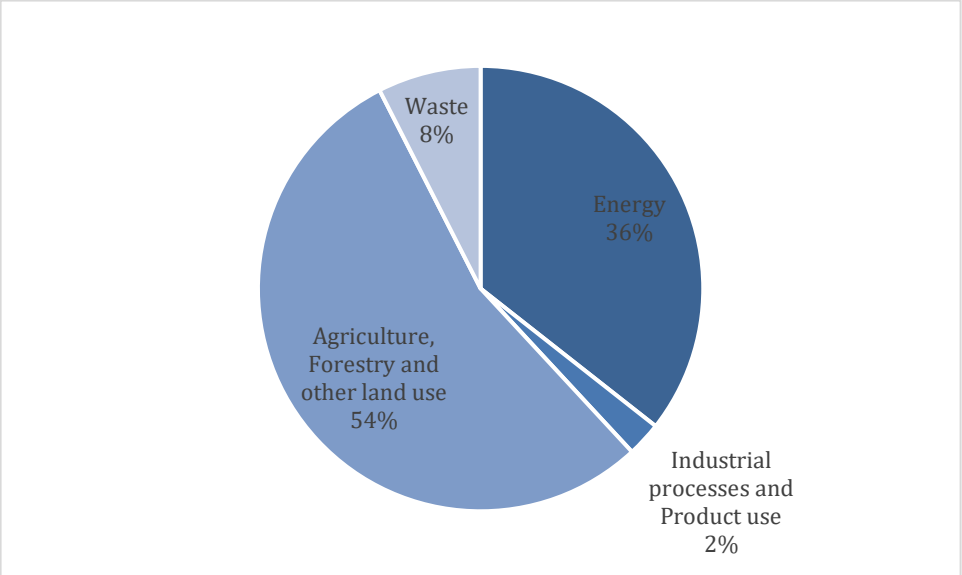

Figure 12. Greenhouse Gas Emission by source.

The top 6 largest emitters are shown in figure 13. A number of mitigation options are available for the agriculture sector in Ghana such as: adoption of no till or reduced tillage; agroforestry; use of cover crops; use of crop residues for mulch; improved water management for irrigated crops; any Most of these options would not only have great potential for carbon sequestration but also promote a sustainable increase in productivity by increasing soil organic carbon. Adoption of these approaches among the Ghanaian farmers

could store about half million tons of carbon per year in the soil, which, in the presence of functioning carbon markets, could generate up to $6 million per year (De Pinto et al., 2012; Ghana GHG Inventory Report, 2019).

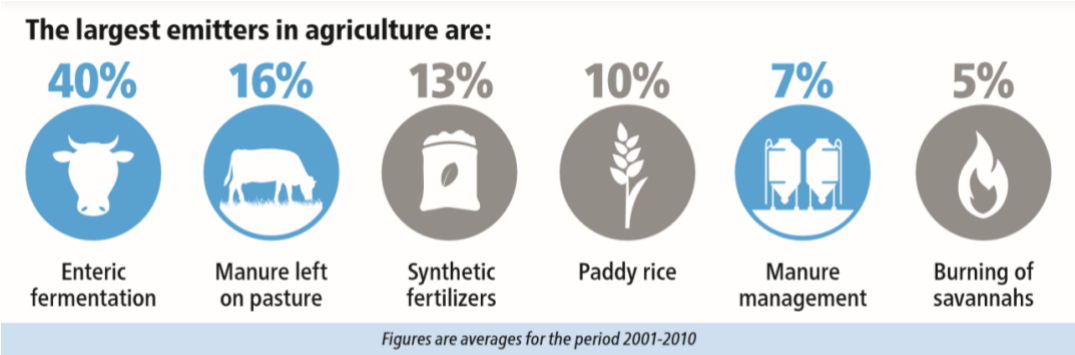

Figure 13. Major contributors to greenhouse gas emission in the agriculture sector.

Source: Ghana GHG Inventory Report, 2019

Adaptation co-benefits and mitigation potential of the agriculture sub-sectors

Crop sub-sector

The conversion of forestland to cropland and poor land use practices are the main sources of CO_2 emissions in cropland. According to the Ghana GHG Inventory of 2019, Cropland was the second largest source of net CO_2 emission in the land category contributing net 8.8 $MtCO_2$ to the total land emission of net 12.87 $MtCO_2$ of which forest-cropland conversion through deforestation was the biggest contributor. This is observed across the country with varied degrees of intensity.

There are various mitigation options are available to support mitigation efforts for the crop sub-sector in the country. These can be classified largely into two systems; upland and lowland/flooded. include: appropriate use of chemical and organic fertilizers; use of improved crop varieties that allocate more biomass underground; rotations with legume crops that reduce the need for nitrogen fertilizer; use of agroforestry; adoption of reduced/improved tillage, use of cover crops; use of crop residues for mulch and improved water management for irrigated crops and Improved crop residue managements. Most of the agronomic practices contribute to building of soil organic matter inputs to soil (crop residue management, organic fertilizers and agroforestry) thus increasing mitigation potential through increases in soil organic carbon stocks, regardless of soil type (Richards et

al. 2019). Irrigated rice production is an important source of GHG emissions. At the global level, it contributes about 10 % of the emissions in the agriculture sector. It is important to note that data on actual measurements on emission are lacking. Rather emission factors (which are often not calibrated to our conditions) are usually used to estimate emission from the various sectors.

Table 8. Management practices in the cropping sector with mitigation potential.

Cropping system	Practices
Upland	Integrated soil fertility management
	Crop residue retention in soils
	Agro-forestry
	Use of improved varieties
	Crop rotation legume-cereals
	Minimum/improved tillage
Flooded systems	Type, quantity and method of fertilization
	Water management (continuous, intermittent)
	Use of appropriate crop varieties
	Soil: organic matter, tillage practices

Livestock sub-sector

Almost half (50.6%) of the total methane gas in 2016 was emitted from the AFOLU sector mostly from livestock rearing. Enteric fermentation and manure management contributed a whopping 77.3% of the total methane emissions produced within the AFOLU sector in 2016. Livestock rearing is associated with the emissions of nitrous oxide (N_2O) and methane (CH_4). The type of animal husbandry system and the management practice influence the levels of emissions. The livestock emissions are mainly associated with enteric fermentation and manure management. The factors that influence emissions associated with enteric fermentation include, but not limited to animal feed (quantity and quality) and digestive processes (e.g. animal weight, excretion rate). Emissions from manure management estimates depend on the various livestock management systems (mainly pasture/range/paddock, dry lot, liquid/slurry etc.) and the rate of utilization (Ghana GHG Inventory Report, 2019). Another potential source of GHG emissions in this sector is the activities (such as waste management, management of holding facilities for animals) in the slaughter houses.

Methane production is dependent on animal population, weight and age of the animals as well as the quantity and quality of feed (Getabalew et al., 2019). The type and efficiency of the animals' digestive system also influence methane production. The quantity of Methane production in ruminant livestock is more than that produced by non-ruminant livestock. The total emission generated from enteric fermentation in 2016 was 2.41 MtCO2e. This amount represents 69.1% of the overall emissions from Livestock. Enteric fermentation in 2016 shows an increasing trend with 64% increase from 2000 and 20% from the last reporting period of 2012. Emissions in the manure management category are mainly methane and nitrous oxide from the management of livestock. Manure management systems included in this inventory were: paddock and pasture, slurry dry lot and poultry with or without litter. Ghana accounts for both CH_4 and N_2O emissions from manure management for cattle, sheep and goats and CH_4 emissions for horses, donkeys, swine and poultry. Manure management accounts for 30.9% of the aggregate livestock emissions (Getabalew et al., 2019; Ghana Government, 2019).

A number of mitigation options are available in the livestock sub-sector that can also enhance productivity. These can be placed into three main categories (i) efficient and productive breed selection, (ii) improved feeding and (iii) improved manure management. These include:

- The choice of adapted animal types and breeds will result in less non-productive animals in a herd hence, reducing GHG emission.
- Adoption of agro-forestry systems with leguminous fodder shrubs as a diversification option and also sequester carbon.
- Use of dual-purpose legumes as intercrop/rotations to serves as feed for livestock. Better feeding increases production and lowers the greenhouse gas production per kg of animal produce.
- Use of feed management strategies that contribute to sustainable intensification are key strategies in mitigating GHG emissions.
- Grazing and range land management.
- Improved processing and storage of manure to reduce methane and nitrous oxide emissions while increasing crop yields
- Enhanced management of wastes from slaughter houses and animal holding facilities

Fisheries sub-sector

Unlike other sectors, mitigation options in fisheries sub-sector are limited (Magawata and Ipinjolu 2014) and are rather aimed at the inputs, equipment and methods employed in fishing and fish processing activities that can contribute to reduction of GHG emission (Zougmoré et al. 2016). Some of the available mitigation options include:

- improving fuel efficiency through switching to more efficient gear types or vessels;
- switching to sails or changing fishing practices;
- removal of fuel subsidies (disincentives for energy efficiency);
- increasing consumption closer to the source (reducing travel distance);
- Use of more stable fishing vessels of all sizes to allow for fishing further away from the coastal area to follow targeted species and resist inclement weather;
- Improved feeds and feeding practices that are more ecosystem friendly;
- Promotion of the use of improved stoves for processing (smoking) fish.

Aquaculture in Ghana is mainly based on Nile tilapia, *Oreochromis niloticus* and the African catfish, *Clarias gariepinus* of which tilapia forms about 80% of aquaculture production (Asiedu, Asase, Iddrisu, & Ayisi, 2016; FAO,2005). Adaptation strategies to cope with the impacts of climate change, 32% planted trees around ponds to serve as shade to reduce evaporation, 20% raised the banks of ponds to prevent loss of fish when there is heavy rainfall that could result in flooding, 16% dug bore hole near ponds to serve as a water source during the dry and low rainfall seasons, 12% constructed ponds close to water bodies and stocked favourable species whereas 8% adjusted stocking time to meet rainy season (Figure 14).

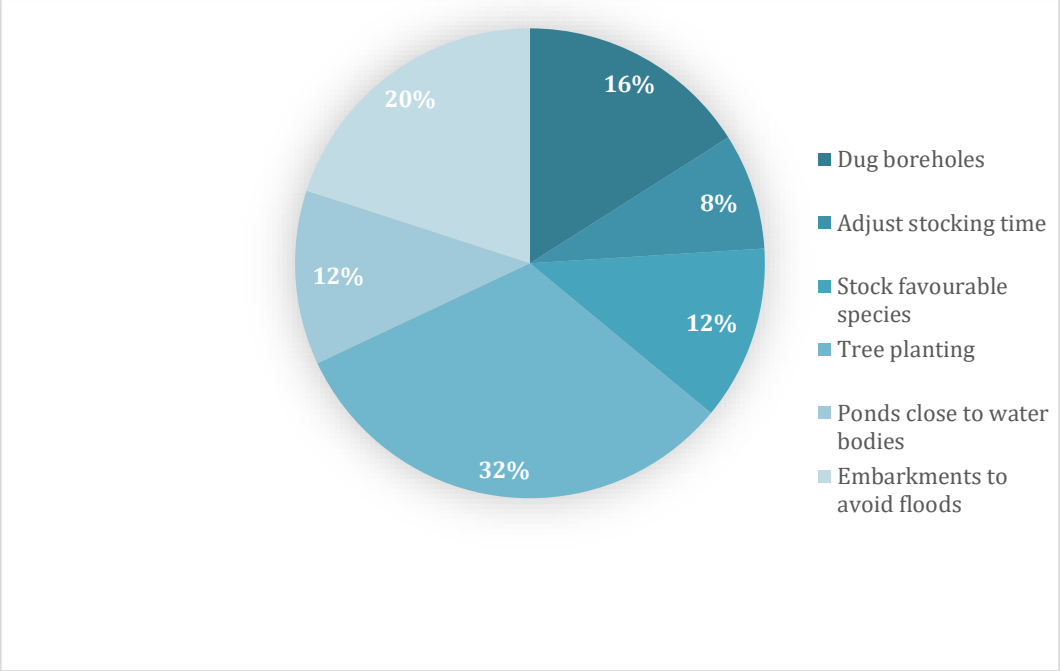

Figure 14. Adaptation strategies to cope with climate change in aquaculture operations.

Landscapes and agroforestry

Land degradation

A number of integrated soil land management (SLM) practices have been documented to positively impact on soils in Ghana. There is however, limited knowledge on the extent to which these practices contribute to mitigating GHG emissions except for few instances in which emission factors were used to estimate impacts of certain farm management practices. This is mainly due to the unavailability of the appropriate equipment to analyse GHG. Hence measurement have been limited to laboratories to the neglect of the fields. Land degradation results in the loss of topsoil profile which has high capacity to hold soil organic carbon (SOC) (World Bank, 2006; Diao and Sarpong, 2007). Studies have illustrated the benefits of improved farm management practices to maintaining the integrity of soils (Table 9).

Table 9. Benefits of farm management practices in different agro-ecological zones on soil and its productivity.

INTERVENTION	ECOLOGICAL ZONE	RESULT
1. Cover crops Mucuna	Transition/Semi deciduous forest	Controlled weeds and increased soil nitrogen by 0.14% to 0.18%, increased maize grain yield over control by 86% (Osei Bonsu et al. 1995; Agyenim Boateng, 1997)

Groundnut	Guinea Savanna	Reduced soil loss by 94% and run off by 70% (Bonsu 1980)
	Semi deciduous forest	Reduced soil loss by 66% and run off by 24% (Quansah et al. 2001)
Bambara nut	Semi deciduous forest	Reduced soil loss by 57% and run off by 38%
Cowpea	Semi deciduous forest	Reduced soil loss by 79% and run off by 38% (Quansah et al. 2001)
2. Strip Cropping **Maize-cowpea** **Maize-groundnut**	Transition zone	Reduced soil loss by 92% and run-off by 70% (Quansah et al. 2001) Reduced soil loss by 80-99% and run off by
3. Zero Tillage	Sudan savannah Transition, Semi deciduous Forest	76-99% (Bonsu and Obeng 1979 50% higher yield compared to traditional
4. Zero Tillage **With weedicide**	Sudan savannah Transition, Semi deciduous Forest	Slash and burn, with net financial benefit of 58-98% (Boa-Amponsem et al. 1998)
5. Mulching	Guinea Savanna Transition Semi deciduous Forest	Reduced soil loss by 90% (Bonsu and Obeng 1979; Quansah et al 1997)
6. Contour/ Vegetative barriers	Semi deciduous Forest	Controlled soil erosion and conserved moisture to increase maize yields (GGDP 1993)
7. Liming (Acid soils)	High rain forest	Reduced soil loss when liming rate increased from 1 ton/ha to 5ton/ha (Bonsu 1979)
8. Organic Matter	Guinea Savanna Transition	Reduced soil loss and increase crop yields (Bonsu and Obeng 1979; Quansah et. al 1997)
9. Crop rotation **Groundnut maize, Cowpea maize,**	Semi deciduous Forest Guinea Savanna	Yield for maize increased from 1.94 ton/ ha to 3.16 ton/ha Reduced soil loss and increased yield (Sauerborn et al. 2000) Increased the yield of maize from 2.11 ton/ha to 4.82 ton/ha and 4.75 ton/ha, respectively
10. Intercropping **Groundnut maize, Cowpea maize**	Guinea Savanna & Transition	Yield for maize, soybean and groundnut by 48, 32 and 9 % respectively increased from 1.94 ton/ ha to 3.16 ton/ha Reduced soil loss and increased yield (Sauerborn et al. 2000) Increased the yield of maize from 2.11 ton/ha to 4.82 ton/ha and 4.75 ton/ha, respectively
11. Use of rice husk biochar & inorganic fertilizer in irrigated rice	Coastal Savanna	Rice yield increase by between 12 and 29%, increase carbon storage by between 17 and 32% (MacCarthy et al., 2020)

Agroforestry

Agroforestry is often considered a cost-effective strategy for climate change mitigation (Appiah and Nyarko, 2015). Tree-based farming systems store carbon in soils and woody biomass, and they may also reduce greenhouse gas emissions from soils (Smith and Olesen, 2010). Agroforestry establishment can be an adaptive strategy to temperature rise, with shade trees lowering understory plant temperature and providing income diversification; yet some of the most common agroforestry trees are vulnerable to warmer and dryer conditions (de Sousa et al., 2019). Water availability reduction may prevent shade tree establishment over the area most affected by climate change, in Northern Ghana (Schroth et al., 2017). Findings from West Africa and South America indeed exhibit a greater resilience to extreme drought stress of full-sun cocoa and coffee over shaded systems (Abdulai et al., 2018; Padovan et al., 2015).

Progressive yield decline or tree mortality may lead farmers to adopt unshaded cultivation or shift to annual crops, which would be detrimental to on-field carbon stocks. Thus, planting of new agroforestry trees in this area should take into account potential climate changes and select tree species that can better adapt to it and provide the largest benefits to the crops beneath. Agroforestry systems maximize co-benefits when they feature various types of agroforestry trees and companion crops fulfilling different roles, such as shade provision, soil fertilization, fruit production, or timber value, because they provide diversified habitats, income sources, and allow alternative adaptation strategies.

Productive resources

Land resources

Land is the primary resource for any agricultural activity. Chapter 2 of this report presented the state of Ghana's land use with respect to agriculture generally. Crop farming in particular demands extensive land use except that the current emphasis on intensification agriculture enables more crop production per unit area. In livestock farming, land as a key resource is exemplified in the fodder banks.

Ghana has established fodder banks in the past and continues to establish them presently. In 2013 fodder banks were built in the Afram Plains such as at Wawase, Forifori, Mem-chemfre

and Amankwakrom on 872 hectares of land. It was intended to promote cattle rearing but also to control the large influx of Fulani cattle. The funding came from part of the 32.5 million dollars Afram Plains Agriculture Development Project (Ghana News Agency, 2014). It is to enable the Kwahu Afram Plains North and the Kwahu Afram Plains South District assemblies to collect revenue from the cattle owners and also prevent the cattle from destroying farm produce. The fodder banks had been fenced and provided with dugout water for the cattle. There is also an on-going project for the development of a multispecies fodder bank that concentrates the species with forbs, grasses and fast-growing fodder legumes has been identified as an opportunity for ensuring sustainable all-year-round fodder production and availability. Fodder banks are known to constitute an innovative approach to improving livestock nutrition during dry seasons and fodder scarcity period (CCAFS, 2020).

Soils

Within the AFOLU sector, direct and indirect N_2O emissions from managed soils accounted for 86% of the N_2O emissions in 2016. Soils are known to be an important source and sink for atmospheric carbon (C). Conserving and improving soil organic matter through judicious soil use and land management can help to mitigate climate change (ISRIC, 2020). Land management practices that can contribute to carbon storage in the soil help sequester C, thereby reducing GHG emission. Land management practices in the agriculture sector that can enhance the potential of soils to mitigate climate change impact include efficient crop residue management; conservation tillage; crop rotation; cover cropping; surface mulching; use of appropriate landforms to reduce soil C and nutrient loss.

Water resources

The practices that are relevant to the agriculture sector include irrigation. Drainage of agricultural lands in humid regions can promote productivity (and hence soil carbon) and perhaps also suppress N_2O emissions by improving aeration. Any nitrogen lost through drainage, however, may be susceptible to loss as N_2O. Applying more effective irrigation measures can enhance carbon storage in soils through enhanced yields and residue returns, but some of these gains may be offset by CO_2 emissions from the energy used to deliver the water.

Adaptation co-benefits and mitigation realized

Mitigation strategies in agriculture can be categorized in three ways: carbon sequestration into soils, on-farm emission reductions and emission displacements from the transportation sector through biofuels. Sequestration activities enhance and preserve carbon sinks and include any practices that store carbon through cropland management “climate smart practices”, such as no till agriculture or that slow the amount of stored carbon released into the atmosphere through burning, tillage and soil erosion. Sequestered carbon is stored in soils, resulting in increases in soil organic carbon (SOC). Many on-farm management practices can raise SOC. Such practices include livestock and manure management, fertilizer management improved rice production, reducing the amount of bare fallow, restoring degraded soils, improving pastures and grazing land, adopting irrigation, crops and forage rotation and adopting no till practices. Finally, the production of liquid fuels from dedicated energy crops. However, the extent to which biofuels can offset carbon emission hinges on the type of land cover that their cultivation would replace. The conversion of land from higher carbon value, such as forest land to cropland, would release CO_2 into the atmosphere.

The Government of Ghana (GoG) has given high priority to addressing land degradation through integrated landscape management in targeted watersheds and forest lands. In the Northern Savannah region, the Government has been successfully implementing the GEF financed Sustainable Land and Water Management Project (SLWMP), where it has already benefitted some 39,000 farmers by bringing about 15,000 ha of land under sustainable management, reforestation of 1,000 ha, 72,000 ha under forest management plans and more than 600,000 ha of land under Community Resource Management Areas (CREMAs).

In the cocoa producing high forest zone landscapes, the Government has been engaged in addressing deforestation and forest degradation through the Forest Investment Program (FIP), the REDD+ Program, the Voluntary Partnership Agreement (VPA), AFR100, the Forest Plantation Development Program, Multi-Sectoral Mining Integrated Project (MMIP) and policy reforms on Tree Tenure and Benefit Sharing Schemes. These contribute directly to the action areas “creating climate-resilient landscapes” and “promoting climate smart agriculture” as envisaged in the WBG’s Africa Climate Business Plan. The Project directly contributes to the policy action areas “Promote Sustainable utilization of forest resources

through REDD+" as envisaged in the in the country's NDC commitments to mitigation in the AFOLU sector.

Table 10. Interventions with mitigation potential and adaptation co-benefits being implemented.

Interventions	Mitigation/adaptation co-benefits
Reduced tillage	Improved crop yield, reduce GHG emissions
Agro-forestry system	Improved productivity and carbon storage
Manure management practices	Reduce emission of GHGs and crop productivity
Improved water management in irrigated rice systems	Reduce energy use in irrigation, improve water use efficiency
Improved fertilizer management	Improved crop productivity and lose to the environment
Crop rotation	Improves crop productivity and builds soil carbon storage
Improved crop residue management in lowland rice systems	Reduce GHG emissions while improving yields
Ridging and contour	Reduces soil loss and increases yields

Enabling policy environment

Overview

Climate change is undoubtedly the most severe challenge facing our planet during the 21st century. Human interference with the climate system has increased the global and annual mean air temperature at the Earth's surface by roughly 0.8oC since the 19th century (IPCC, 2013). This trend of increasing temperatures will continue into the future: by 2100, the globe could warm by another 4oC or so if emissions are not decisively reduced within the next decades (IPCC, 2013). There is broad agreement that a warming of this magnitude would have profound impacts both on the environment and on human societies (IPCC, 2014a), and that climate change mitigation via a transformation to low emissions, climate resilient development pathways and societies has to be achieved to prevent the worst of these impacts (IPCC, 2014b).

The global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, with a view to

accelerating the reduction of global greenhouse gas emissions. Combating climate change would require substantial and sustained reductions in GHG emissions which, together with adaptation can limit climate change risk.

Global frameworks

UNFCCC

The United Nations Framework Convention on Climate Change (UNFCCC) is an intergovernmental treaty developed to address the global challenge of climate change. The Convention, which sets out an agreed framework for global response to climate change was adopted in June 1992 in Rio de Janeiro, Brazil at the Rio Earth Summit. The UNFCCC entered into force on 21 March 1994. The ultimate objective of the Convention is to *"stabilise greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system"* and which *"should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner".*

Developed countries listed in Annex II (a sub-set of Annex I) are expected to provide finance, technology and capacity building support to the developing countries. Since it is a framework instrument to operationalize its provisions, other instruments have to be established. Since then two instruments have been established the Convention, namely: Kyoto Protocol (1997) and Paris Agreement (2015). Ghana is a signatory to the UNFCCC).

Climate change, biological diversity and desertification are intricately related on the social, economic and environmental fronts and the nationally determined contributions/national adaptation plans (NDCs/NAPs), national biodiversity strategies and action plans (NBSAPs) and national action programmes (NAPs) are the implementation tools, respectively. In December 2009, the UN General Assembly noted the need for enhanced cooperation among the Rio Conventions and in July 2012, UNGA adopted "The Future We Want", encouraging coordination and cooperation between multilateral environmental agreements (MEAs).

Action at the national level represents an important opportunity to establish synergy, coherent policy instruments and cost-effective ways for implementation. Synergies are

found when addressing problems caused by climate change, biodiversity conservation, land degradation and drought (DLDD), such as:

- Forestry, sustainable land management (SLM), rural development, other land use sectors and agricultural production, reducing emissions from deforestation and forest degradation (REDD+);
- Adaptation through ecosystem approach, resilience capacities; and
- Training and education, awareness raising, information and science.

Kyoto Protocol

The Kyoto Protocol (KP) was adopted in 1997 and came into force in 2005. The main objective of the Protocol is to reduce emissions of Annex I countries by at least 5% below 1990 levels (and in some cases 1995 levels) in the period 2008-2012. Individually, these countries had separate commitments. The European Union countries were collectively expected to reduce their emissions by 8%, the USA by 7% and Japan by 6%. Australia, Iceland and Norway were allowed to increase their emissions. The remaining countries were allowed varying levels of reduction. The Protocol identifies policies and measures that can be taken by countries (Art. 2) and quantified commitments for Annex B countries on six GHGs.

The Protocol established three flexible mechanisms: joint implementation (JI, Art. 6) with crediting among the developed country Parties; Clean Development Mechanism (CDM, Art. 12) which aims at enabling projects in developing countries to achieve sustainable development, contribute to the ultimate objective of the Convention and assist developed countries in complying with their quantified emission reduction and limitation commitments; and the emission trading (ET, Art. 17) among themselves. The mechanisms were founded on division of a budget of permissible emissions among countries (cap and trade system). Those countries that do not use their complete share may sell the unused portion to those who need them. The assigned amounts (or quotas) were allocated to the developed countries and the quotas were equivalent to their emission reduction commitments. The underlying rationale of these co-operative mechanisms is to ensure that global emissions of greenhouse gases are reduced in a cost-effective manner. The first commitment period of KP started in 2008 and ended in 2012.

The Doha Amendment to the KP adopted in 2012 established the second commitment period for developed countries to reduce their GHG emissions by at least 18% by 2020 below 1990 levels. Unfortunately, to date the Doha Amendment are yet to attain the requisite number of countries that have ratified it for it to come into force. The effect of this is that the KP and its Doha Amendments will come to an end at the end of this year (2020).

That notwithstanding, the KP made some useful achievements. These include introduction of a multinational carbon market; delivery of new rules for reporting, accounting and verifying emissions; support to poorer countries through the establishment of the Adaptation Fund; incentivizing green investments in the developing world; and the institution of rules-based architecture.

Paris Agreement on Climate Change

The Paris Agreement on Climate Change was adopted at COP21 in 2015 in Paris, France and came into force in November 2016. The purpose of the Agreement is set out in Article 2 to enhance implementation of Article of the Convention and to strengthen the **collective global response to climate change**. The three elements underpinning the purpose are:

- Holding the average global temperature to well below 2^{o}C above pre-industrial levels and to ensure that efforts are pursued to limit the temperature increase to 1.5^{o}C;
- Enhancing adaptation and resilience and synergies between adaptation and mitigation; and
- Making finance flows consistent with low emissions, climate resilient development pathway.

Adaptation is recognized as a key component of the long-term global response to climate change and an urgent need of developing countries. Article 7 of the PA establishes an aspirational global goal on adaptation (GGA) to enhance adaptive capacity, strengthen resilience and reduce vulnerability to climate change (Art. 7.1). The importance of continuous and enhanced support for adaptation efforts of developing countries particularly vulnerable to the adverse effects of climate change are also recognized. The PA provides that adaptation should follow a country-driven, gender-responsive, participatory and transparent approach that takes into account the interests of vulnerable groups,

communities and ecosystems. Adaptation action should be based on and guided by “the best available science and, as appropriate, traditional knowledge, knowledge of indigenous peoples and local knowledge systems, with a view to integrating adaptation into relevant socioeconomic and environmental policies and actions, where appropriate”. Each developing country is required, as appropriate, to engage in adaptation planning processes and the implementation of actions, plans and policies such as, for example, formulating national adaptation plans (NAPs), assessing climate change impacts and vulnerability and building resilience (Art. 7.9). **Means of Implementation (finance, technology and capacity building**) are crucial for supporting developing countries to transition low emissions, climate resilient development pathways.

Sustainable Development Goals (SDGs)

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. The SDGs replaced the Millennium Development Goals (MDGs). The MDGs established measurable, universally agreed objectives for tackling extreme poverty and hunger, among other development priorities. The 17 global goals are a blueprint to achieve a better and more sustainable future for all. All these goals are so closely interconnected that success in one, affects success of others. Adoption of the SDGs coincided with two other historic agreements, the Paris Agreement on Climate Change and the Sendai Framework for Disaster Risk Reduction (DRR).

Ghana through the NDPC has adapted and adopted the SDGs within the framework of Ghana's development priorities. SDGs are in line with Ghana's Medium-term Development Agenda (GSGDA II), the National Climate Change Policy and the 40-year Socio-economic Transformational Plan. Ghana is therefore committed to aligning its development priorities with the SDGs to deliver sustainable development co-benefits, and ensure local ownership (UNDP, 2017). The country has enhanced integration of SDGs into the Medium-Term Development Plans (MDTDPs) and MMDAs.

Sendai Framework on Disaster Risk Reduction

The Sendai Framework on Disaster Risk Reduction 2015-2030 was adopted in 2015. The Framework outlines seven clear targets and four priorities for action to prevent new and reduce existing disaster risks: (i) understanding disaster risk; (ii) strengthening disaster risk governance to manage disaster risk; (iii) investing in disaster reduction for resilience and (iv) enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction. The Framework aims to achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries for the period up to 2030.

Ghana is located in one of the world's most complex climatic regions that are strongly affected by the climatic forces of the Sahel and two oceans. Different models and projections for climate change have indicated that the country's vulnerability to intense weather conditions will increase as a result of global warming and climate change (UNDP, 2017). The country is historically exposed to natural hazards such as earthquakes, floods, coastal erosion, droughts, tropical storms and wildfires. In more recent times, the country's susceptibility to floods, droughts, disease epidemics and wildfires, has increased, particularly in the Northern Savannah portion of the country. The frequency and complexity of some of these disaster events are also increasing, especially flooding.

Ghana has established the National Disaster Management Organization (NADMO) to coordinate disaster management among governmental and non-governmental actors and build the capacity of communities to respond effectively to disasters. The country has also set up the Ghana Plan of Action for DRR (Dazé and Echeverría, 2016; UNDP, 2017). Further, the country through the support of the World Bank has established the Disaster Risk Management (DRM) Country Plan to support strengthening of flood forecasting as well as advocacy and capacity building on DRR.

Regional Policies

Continental framework

The African Union's Agenda 2063

The Africa's Agenda 2063 is a strategic framework for socio-economic transformation of the continent by 2063. It builds on and seeks to accelerate the implementation of past and existing continental initiatives for growth and sustainable development. It identifies agriculture as one of the sectors of economy the needs to be transformed in order to achieve the needed sustainable development across the continent (AU, 2017).

The Comprehensive Africa Agriculture Development Programme (CAADP)

The Comprehensive Africa Agriculture Development Programme (CAADP) was adopted in 2003 in Maputo. The African Union under the Maputo Declaration on Agriculture and Food Security in Africa made the first declaration on CAADP as an integral part of the New Partnership for Africa's Development (NEPAD). Therefore, CAADP is a pan-African framework to allow countries to review their progress towards agricultural transformation, wealth creation, food security, nutrition and inclusive economic growth. It identifies four key pillars to accelerate agricultural growth, reduce poverty and achieve food and nutrition security including: sustainably increase the areas cultivated and served by reliable water control systems; improve rural infrastructure and trade capacities to facilitate market access; increase food supplies, reduce hunger, improve responses to food emergencies; and improve agricultural research, dissemination and adoption of technologies. The Maputo Declaration included the decision to commit at least 10% of national budgets to agriculture. It also aimed at an annual agricultural productivity growth of 6%. In 2014, the AU Summit adopted the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods that reaffirms the central commitment of the Maputo declaration on 10% national budget allocations for agriculture. It also specifies more commitments such as increased irrigation, mechanization and reducing post-harvest losses (AU, 2014).

Ghana has made substantial efforts to align the agriculture sector policies, plans, strategies and investment programs to the CAADP and Malabo declaration. Ghana signed the CAADP

compact, committing to make agriculture a central pillar of development and strive to achieve recommended targets of a 6% annual growth in agricultural GDP and minimum budget allocations of 10% for the agricultural sector. The country has recorded a steady increase in the share of actual expenditure devoted to agriculture: over the decade 2001-11, from an average of 6.4% during 2001-03 to 9% during 2004-07, then reaching or exceeding 10% during 2008-11 (World Bank 2013). Ghana has also made great strides in reducing the incidence of extreme poverty, which has focused attention on the fact that remaining poverty is increasingly concentrated in the agricultural regions of the north of the country (Poulton et al., 2014).

Sub-regional

Ghana is a member of the Economic Community of West African States (ECOWAS), The ECOWAS has put in a place ECOWAS Common Agricultural Policy (ECOWAP). A key target area of the ECOWAP is increasing productivity and competitiveness of agriculture. With respect to trade, ECOWAP focuses to deepen the regional market for agricultural products and differentiated border protection policy. As a result of commitment to the ECOWAP, Ghana like other member countries has recorded significant increase in public spending in sector over the past ten years. The ECOWAP has supported improvement in trade on agricultural products (mainly livestock, cereals, market gardening, roots and tubers) among member states, playing an important role in regional integration.

Another important initiative in the West African region is the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL). It is a large-scale research-focused Climate Service Centre designed to help tackle this challenge and thereby enhance the resilience of human and environmental systems to climate change and increased variability. WACAL strengthens the research infrastructure and capacity in West Africa related to climate change and by pooling the expertise of ten West African countries and Germany (WASCAL, 2020). The CCAFS programme of West Africa connects with some research and development (R&D) initiatives in individual countries including Ghana to address community action to climate change at the district level. The goal is to strengthen the countries' capacity in addressing climate change for enhanced agricultural productivity and food security (CCAFS, 2020).

National policies

The Government of Ghana has put in place macro and sectoral policy instruments particularly on agriculture and climate change. These policies identify priority areas towards the development of a climate resilient and compatible economy while achieving sustainable development through equitable low-carbon economic growth for Ghana, including agriculture and food systems. The point needs to be made that the implementation of these policies sometimes suffers from lack of coherence and inadequate synergy. Probably, this is inevitable as most policies are formulated and championed by particular ministries and public institutions. The lack of effective coordination among these institutions leads to inadequacies in policy implementation. Yet, the spectrum of policies in the agricultural sector and relating to agriculture, underscore Ghana's commitment to agricultural development and the national efforts to address the key constraints.

Macro-economic policy framework

The Ghana Shared Growth and Development Agenda II identify agriculture as a major component of the country's economy that needs to be transformed to realize economic growth. It outlines various strategic interventions including: promoting agriculture mechanization; promoting science, technology and innovation application; promoting seed and planting material development; strengthening access to extension services and agriculture training; enhancing institutional coordination for agriculture development; improving post-production management; and rehabilitating and improving the irrigation systems in the country (Government of Ghana, 2015).

The Medium-Term National Development Policy Framework (MTNDPF) 2018-2021 has laid foundation for actions to support the Government's flagship projects and programmes. Within this framework, the policy on Investing for Food and Jobs was formulated in line with both CAADP and SDGs 1 and 2. This has supported agriculture sector programs mainly: Planting for Food and Jobs; Aquaculture for Food and Jobs; One-Dam Project; the One-District-One-Warehouse Project; Planting for Export and Rural Development; and Rearing for Food and Jobs.

The Ghana's 2020 Budget Statement and Economic Policy the government presented on the theme "Consolidating the gains for growth, jobs and prosperity for all" (Government of

Ghana, 2020). A major highlight in the Budget Statement, is the Government's agriculture modernisation programme aimed at improving production efficiency, achieving food security, and profitability for our farmers, and significantly increasing agricultural productivity as the basis for industrialization, job creation and export. The modernization agenda was being executed through the key flagship project of Planting for Food and Jobs (PFJ) under the following modules; Food Crop Production; Planting for Export and Rural Development (PERD); Rearing for Food and Jobs (RFJ); Greenhouse Technology Development as well as Mechanization for Food and Jobs. The necessary budgetary resources were earmarked accordingly.

Relevant sectoral policies

Investing for Food and Jobs (IFJ): An Agenda for Transforming Ghana's Agriculture (2018-2021)

It has been developed to support operationalization of the vision of the Government of Ghana as indicated in the Medium-Term National Development Policy Framework (MTNDPF). It also domesticates international development frameworks such as the SDGs at the global level; CAADP-Malabo declaration at the continental level; and the ECOWAP at the regional level (Government of Ghana, 2018). One of the key government flagship agricultural programme under the IFJ is the Planting for Food and Jobs, which is designed over a four-year period (2017 – 2020) and costing US$ 723,538,502. It was launched with the commitment to increasing the productivity and thereby catalyzing a structural transformation in the economy through increased farm incomes and job creation. The overall aim is to motivate the farmers to adopt certified seeds and fertilizers through a private sector led marketing framework, by raising the incentives and complimentary service provisions on the usage of inputs, good agronomic practices, marketing of outputs over an E-Agriculture platform. PFJ revolves around five pillars namely: Seed access and development; Fertilizer access and fertilizer systems development; Extension Services; Marketing; E-Agriculture (MoFA, 2017).

National Climate Smart Agriculture and Food Security Action Plan – 2016 – 2020

It provides the implementation framework for an effective development of climate-smart agriculture in the country. This action plan in consistent with the policy objectives of the

focus area of the Agriculture and Food Security in the NCCP. It outlines specific strategies for developing climate-resilient agriculture and food systems for all agro-ecological zones, as well as the human resource capacity required for a climate-resilient agriculture promotion in Ghana. It translates to the ground level the broad national goals and objectives in climate-smart agriculture (MoFA, 2015; Essegbey et al., 2015). The Action Plan is an attempt to analyse and define activities that take into account the three pillars of CSA simultaneously. It focuses on the smartness of the following: weather information, energy, water, nitrogen within the Ghanaian agriculture and food system; and effectiveness of institutional (policy and finance) collaboration under climate change. The CCAFS Science-Policy Dialogue Platforms has set up various district platforms to contribute to climate change action in the district to promote CSA and climate change adaptation generally.

Ghana Strategic Investment Framework (GSIF) for Sustainable Land Management (SLM) 2011–2025

The dominant smallholder farmers in Ghana are face with the several challenges including declining soil fertility, land degradation, and low levels of technology that result in lower productivity and output, farm incomes, and food security. The GSIF-SLM 2011–2025 was established as a step to address the low agricultural productivity and environmental problems. It aims to support conservation of agricultural land resources and reducing rural poverty. The GSIF-SLM is based on understanding that promoting productive and efficient use of arable land and other resources is an important policy issue that is essential for sustainable food production and poverty alleviation in the country and that SLM practices contributes to enhanced productivity and efficiency, as well as carbon sequestration (Issahaku and Abdulai, 2020).

Agriculture Sustainable Land Management Strategy and Action Plan

Under this plan, there is ongoing Sustainable Land and Water Management project for enhanced food security and increased resilience of the beneficiary communities to climatic variability. The agricultural landscape and the corridor areas under SLWM have been made productive through farming techniques such as contour bunds, zero tillage, crop rotation, intercropping with legumes, composting, mulching, protecting buffer zones and planting

trees along river banks. Forest fringe communities will continue to be trained on wildfire management and volunteer fire squads equipped with field equipment.

The Ghana Livestock Development Policy and Strategy 2016 - 2025

It seeks to address the myriad of issues affecting the development of the Ghana livestock sub-sector such as the excessive importation of livestock and livestock products especially poultry, increased incidence of emerging and re-emerging animal diseases, inadequate supply of vaccines and veterinary pharmaceuticals, inadequate livestock infrastructure, transhumance, financing , research and technology dissemination in the livestock industry, among others.

The Ghana Fisheries and Aquaculture Policy (the Policy) and the Ghana Fisheries and Aquaculture Development Plan (the Plan)

Bot are valuable tools in the management of the fisheries sector. They establish strategic pillars on which the development and management of fisheries in Ghana will be built and the principles that will be applied to guide this process. As part of its commitment to combating illegal, unreported and unregulated (IUU) fishing, Ghana's Fisheries Commission has installed Vessel Monitoring System (VMS) on all industrial Ghana-registered trawl fishing vessels as well as on all Ghanaian large-scale tuna fishing vessels. The requirement for VMS as a condition for fishing vessels proceeding to sea and fishing is required under Ghana's statutes.

National climate change policies

The National Climate Change Policy launched in 2014 (NCCP) spells out the vision, goals and objectives of the national efforts to address climate change. It outlines the strategic areas of focus and the identifiable plans for addressing climate change. The vision of the NCCP is to *"Ensure a climate-resilient and climate-compatible economy while achieving sustainable development through equitable low-carbon economic growth for Ghana."*

Ghana's National Adaptation Plans (NAPs) provide the enabling framework for the planning and implementation of adaptation actions as enshrined in the National Climate Change Policy (NCCP) (2013), the National Climate Change Adaptation Strategy (NCCAS) (2012) and the Nationally Determined Contributions (NDCs) (2015), all done within the context of

sustainable development. Improving adaptation planning through the NAP process will help build local adaptive capacity to address climate change, reduce poverty thereby enhancing livelihood opportunities (Government of Ghana, 2018). All these tools identify agriculture a key component of the country's economy. For instance, The NCCP and the NCCAS aim to develop effective mechanisms for managing climate change, including climate-resilient agriculture and food systems, and disaster preparedness and response.

Nationally Determined Contributions (GH-NDCs): Ghana prepared and submitted the first GH-NDCs to the UNFCCC secretariat in 2015. It sets out key priority adaptation and mitigation actions. Through the priority actions, the country aims to unconditionally reduce its GHG emissions by 15% relative to a business as usual scenario emission of 73.95MtCO2eq by 2030 and additional 30% conditional emission reduction alongside an adaptation goal of increasing climate resilience and decreasing vulnerability for enhanced sustainable development. The National Planning Development Commission (NDPC), Ministry of Environment, Science, Technology and Innovation (MESTI) and the National Climate Change Steering Committee (NCCSC) are already playing major roles in the planning and coordinating the implementation of the GH-NDCs in the country. The NDPC's medium-term planning framework offers a unique opportunity to incorporate the GH-NDCs into national plans.

REDD+ Strategy: The Ghana REDD+ Strategy was formulated for a period of some twenty years from 2016 to 2035. There is the National REDD+ Secretariat (NRS) which oversees the implementation of the strategy. Before the strategy was put in place, through a partnership with the Forest Carbon Partnership Facility (FCPF), Ghana commenced REDD+ readiness activities in 2008 with the submission and acceptance of the country's REDD+ Readiness Plan Idea Note (R-PIN). Already the implementation of the strategy promises to provide multiple benefits that will safeguard the country's forest and wildlife resources and ensure that there is optimal and sustainable flow of benefits to all segments of our society. The goals set by Ghana for REDD+ implementation are to:

- Significantly reduce emissions from deforestation and forest degradation over the next twenty years, while enabling carbon stock enhancement through sustainable forest management and forest restoration strategies such as forest plantation establishment;

- Preserve Ghana's forests in order to sustain their ecosystem services, conserve biological diversity, and maintain a cultural heritage for generations to come;
- Preserve Ghana's forests in order to sustain their ecosystem services, conserve biological diversity, and maintain a cultural heritage for generations to come;
- Transform Ghana's major agricultural commodities and Non-Timber Forest Products (NTFPs) into climate-smart production systems and landscapes;
- Expand platforms for cross-sector and public-private collaboration and sustainable economic development;
- Generate innovative, substantial and sustainable economic and non-economic incentives and benefits to improve livelihoods across all regions of Ghana.

Ghana defines its forest as any piece of land with a minimum area of one hectare, with a minimum canopy cover of 15% and with trees that have the potential to reach or have reached a minimum height of 5 metres at maturity in situ. In terms of implementation of forest monitoring, Ghana intends to use an approach that combines remote sensing technology with ground-based sampling on appropriate stratification and sampling methodologies. The key threats to the country's forestry sector are the uncontrollable illegal mining and logging, wildfires, unsustainable farming practices and infrastructure development. These are the activities primarily driving forest degradation and deforestation in Ghana.

The national REDD+ strategy therefore outlines large-scale sub-national interventions that seek to address the key drivers of deforestation and forest degradation within the jurisdictional coverage of the selected programmes. Ghana has transitioned from REDD+ readiness to an intermediary stage where REDD+ demonstration activities (under the Forest Investment Programme) and development of Ghana's first sub-national REDD+ programme (i.e. the Ghana Cocoa Forest REDD+ programme) are being concurrently undertaken. These advances have contributed greatly to a clearer understanding of the form that REDD+ implementation will take in Ghana and have also shaped thinking on the key approaches to be adopted for addressing the drivers of deforestation and forest degradation in a manner consistent with national circumstances. Through an extensive consultative process and focus group discussions, a national and two sub-national programmes have emerged as the

priority REDD+ programmes for Ghana. These are the Emission Reductions Programme for the Cocoa Forest Mosaic Landscape (The Cocoa-Forest REDD+ Programme); the Emission Reductions Programme for the Shea Landscape of the Northern Savanna Woodland (The Shea Savanna Woodland Programme); Ghana's Programme for Policy and Legislative Reforms on Tree Tenure and Carbon Rights (Policy and Legislative Reform Programme). See Government of Ghana, 2016; Lonescu, 2018).

Regional and district level

Ghana has formulated various policies and strategies such as the Decentralization Policy Framework and Second National Decentralization Plan. These are supporting the devolution of agriculture alongside other sectors to the country's 260 MMDAs. This enhances outreach, mobilization and participation of community members/ smallholder farmers in various agricultural programs (Resnick, 2018). At the regional level, Regional Agricultural Development Units (RADUs) perform supervisory roles over programming in agriculture. RADUs comprise personnel from all directorates, include information management and monitoring and evaluation specialists, and are managed by the Regional Director of Agriculture. At the district level, agricultural programming is managed by Departments of Agriculture under the decentralized system. The Department of Agriculture in a district consists of the District Director of Agriculture (DDA), subject matter specialists, field officers, and support staff. District-level officers are divided into District Agricultural Officers (DAOs) and Agricultural Extension Agents (AEAs) (Moore et al., 2015).

Research, data, knowledge and information management

Overview

Investment in the development and dissemination of new scientific evidence and technologies is the primary driver of agricultural productivity growth. The Council for Scientific and Industrial Research (CSIR) is the country's leading public agricultural research and development (R&D) agency. The universities, and precisely the public universities such as Kwame Nkrumah University of Science and Technology (KNUST), University of Ghana,

University of Development Studies and University of Cape Coast (UCC) all have priority focus on research and the science faculties and departments carry on research as a core mandate of their activities. However, the key challenge has been the weak linkage between the research system in Ghana comprising the research institutions and the end-users of the outputs of research i.e. the technologies and innovations. The private sector in particular is not able to adopt the technologies and innovations from the research system for various reasons including lack of awareness of these outputs and inability to afford them. Over the years, the institutions in the research system have been challenged to find solutions to these problems and the challenge still remain.

Agricultural research, data, knowledge and information management

The Council for Scientific and Industrial Research (CSIR), which is the country's leading public agricultural R&D agency operates thirteen food and agriculture research institutes. CSIR provides the main research institutional framework for agricultural technology development and innovation in the country. Other agricultural research institutions outside of the CSIR include the Cocoa Research Institute of Ghana (CRIG), Biotechnology Nuclear Agricultural Research Institute (BNARI) and the Marine Fisheries Research Division (MFRD). The CRIG, a subsidiary of the Ghana Cocoa Board (COCOBOD), employs researchers and studies cocoa and other tree crops, such as kola and cashew. Ghanaian universities and technical schools also conduct agricultural research and development.

Research spending accounts for about 0.7% of agricultural output (excluding cocoa), above the SSA average of 0.5%, but below the rates of regional leaders, such as Kenya (1.4%) and South Africa (2%), as well as the African Union target of 1%. Moreover, many research projects are not geared towards solving the most urgent constraints faced by farmers. In addition, human-resource constraints are serious and growing. Nearly 40% of agricultural researchers in Ghana are over 50 years old, and only about one-third hold doctoral degrees. It is estimated that less than 4% of the CSIR budget is available to finance new operations. As a result, researchers are almost totally dependent on donor funding, which is unpredictable and allocated according to donor objectives that are not necessarily consistent with those of the government or with the interests of farmers.

Specifically, on funding of agricultural research in Ghana, the Science and Technology Policy Research Institute (STEPRI) and the International Food Policy Research Institute (IFPRI) have been collaborating in the Agricultural Science and Technology Indicator (ASTI) Survey. In the 2015 ASTI Survey of thirteen agricultural research institutes and five public universities in Ghana the study revealed that, total public agricultural R&D expenditure had increased by 59% from 42.5 million (2005 PPP) dollars in 2000 to 67.7 million (2005 PPP) dollars in 2011 and with an average expenditure of 54.1 million (2005 PPP) dollars per year (Asare and Essegbey, 2016). The total expenditure by Council for Scientific and Industrial Research (CSIR) with its thirteen research institutes, constituted about 50 per cent of the total agricultural research expenditure in Ghana. The study however, showed a drastic decline in capital investments from 6.7 per cent in 2000 to 0.1 per cent in 2011 of the total government funding with operational cost following similar declining pattern (Asare and Essegbey, 2016). Still, when considering the totality of funding including salaries and wages, government support is the main source of funding for agricultural R&D in Ghana (85%) with donors (7.3%), sale of goods and services (6.7%) and others serving as complementary sources. Nevertheless, though there have been considerable government investments in agricultural R&D in CSIR over the period, impact on operational and research activities has been minimal as the chunk of it went into payment of salaries and wages. The fundamental challenge in agricultural research, is funding the very important operational and research activities which lead to technology development and innovation (Asare and Essegbey, 2016).

There is almost no private sector participation in agricultural research in Ghana. The cocoa sub-sector for example, has significant private sector actors purchasing cocoa and processing. However, the lead R&D institution for cocoa is the state-funded Cocoa Research Institute of Ghana (CRIG). Private firms import hybrid seeds, fertilizers, pesticides, and new livestock breeds, but Ghana lacks the strong biosafety and regulatory framework necessary to take full advantage of biotechnology and transgenic. Conducting timely evaluations of emerging genetic traits would enable them to be rapidly approved and inserted into existing commercial crop varieties. Currently, private firms that import sophisticated productive technologies tend to focus on export-oriented cash crops, such as oil palm, while technological uptake among smallholders who produce cereals, tubers, and other food crops remains limited. Adopting more stringent labelling rules would help to improve quality

control along the seed supply chain, and authorities should facilitate joint ventures between multinationals and local seed companies. Furthermore, easing of regulations related to importation of foundation seed, and easing of restrictions related to intellectual property rights would help to develop a more competitive seed domestic sector, capable of supplying quality seed which is critical for productivity growth.

Aragie et al (2019) puts the whole subject of technology development and innovation to enhance agriculture in Africa in sharper analytical perspective with reference to the Comprehensive African Agricultural Development Program (CAADP) through the adoption of the Malabo Declaration (AU 2014). The declaration included commitments to reduce hunger and poverty, boost intra-regional trade, enhance resilience to climate variability, and, to continue allocating to agriculture at least 10% of government expenditure. Despite this long-standing spending commitment, Ghana's agricultural budget share has remained well below 10% during the last decade. Ghana's relatively weak agricultural performance during the period from 2007 to 2017 may be linked to low levels of spending. The assessment of Ghana in the African Agricultural Transformation Scorecard (AATS), which was launched by the African Union (AU) in 2018, was not satisfactory and Ghana's development partners called for an increase in funding allocated to the agriculture sector at the national Joint Sector Review for Agriculture in June 2019 (Aragie et al, 2019).

The MoFA has a directorate known as Statistics, Research and Information Directorate (SRID), which work for the generation of agricultural data and statistics including production data of agricultural commodities, market prices, export and import data. The outputs of SRID have fed into the work of relevant institutions such as the Ghana Statistical Service and the work of individual researchers. There are also institutions whose work contribute to generation of data and knowledge for agricultural activities in Ghana. For example, under the CSIR, there is the Institute for National Scientific and Technological Information (INSTI) which information management system to support socio-economic activities. There is the Ghana Agricultural Information Network System (GAINS), which has created the Ghana Agriculture Information (GHAGRI) database with about 10,000 records on agricultural scientific research and ventures for all kinds of users.

The main constraint facing the sustainability of Ghana's agricultural research systems is the declining public funding. Government budget accounts for over 85% of the R&D funding and there has been an increasing gap between budgeted and actual expenditure. As such available funding has largely been used to pay salaries without the provision of requisite financial resources for the necessary research and development: infrastructure equipment, staff development, and information systems. Maintenance, rehabilitation and operation of infrastructure such as laboratories, offices and equipment for R&D have also become a major challenge (Brief, 2017). Also, the agricultural research tends to be highly fragmented among many small, externally financed projects with limited coordination and minimal private sector involvement.

The challenges affecting the R&D systems in Ghana are also reflected in the seed system which is largely public-sector driven, with a legal and regulatory framework that imposes some restrictions on the participation of the private sector. Ghana's seed sector has undergone some significant changes in the past few years, with approval of the new seed law and regulations (Plant Breeders Law, 2013), the appointment of the National Seed Council, and the emergence of a more diversified commercial seed sector. However, while the new legal framework promises new incentives to spur the seed industry, the direction of the seed system development is determined by the agronomic and economic considerations and that there are several important issues that policymakers need to address if Ghana's commercial seed sector is to progress. Three of these are related to the implementation and enforcement of regulations (for variety release, seed certification, and consumer protection) that come under the responsibility of the National Seed Council; management of CSIR's agricultural research institutes; price related issue. All these issues have implications on the development of the seed systems and the associated productivity which determines the rate of return of research and development system (Brief, 2017).

Climate information systems (CISs)

The Ghana Meteorological Authority have over the years, generated information to guide farmers' activities including land preparation, planting and harvesting. Information about rainfall in particular has improved over the years and most people these days take weather warnings from the GMA seriously. Access to climate information through CIS is critical where small-scale agriculture is an integral part of livelihoods and is threatened by climate change

and climatic variability like in the case of Ghana. CIS assist small-holder farmers, amongst others, to improve their understanding of climate change and variability. This allows them to assess the impact of climatic factors on agricultural production and their livelihoods.

In recognition of the importance of CIS, the Government in partnership with development partners such as CARE International and FARM Radio International has established Climate Information Centres (CICs) in some districts in the country. The purpose of the CICs is to use the development of radio broadcasting in hard-to-reach, rural areas of Ghana so as to provide smallholder farmers with a range of climate information relevant to cultivation practices. Weather forecasts, farming best practices, tips on the appropriate period for cultivation and other information is broadcast to farmers, helping them reduce the vulnerability of their activities to adverse climate change conditions. CICs use Participatory Scenario Planning (PSP) and are community managed, with technical support from GMET and Farm Radio International. In addition, CICs link broadcasts to mobile phones for call-in programmes as well as general weather information dissemination from GMET and other services (such as ESOKO) (Brief, 2017). The climate information generated through the PSP are circulated to the end users (farmers) through SMS, radio broadcasting, brochures as well as informal meeting.

Agricultural advisory services, extension and outreach

The provision of public extension and advisory services in Ghana falls under the umbrella of the MoFA. Governmental extension offices and personnel operate in all 16 regions and are present in all 254 districts. Structurally, MoFA is divided into eight directorates: crop services, plant protection and regulation, animal production, veterinary services, agricultural engineering, women in agricultural development, and agricultural extension. The Directorate of Agricultural Extension Services (DAES) is directly tasked with providing public extension and advisory services in Ghana. While the Directorate of Policy, Planning, Monitoring, and Evaluation (DPPME) creates extension policy, DAES is responsible for the implementation of these policies through operational planning, the coordination of extension activities, and provision of direct technical support to Ghanaian farmers. DAES also coordinates with other MoFA directorates, primarily the Directorates of Animal Production and Crop Services, in the provision of agricultural extension services.

To expand access to private extension services, the government should develop a new framework for collaborating with agricultural input companies, distributors and dealers, transport and logistics providers, food processors and retailers, and telecom operators. Whereas public extension services are typically focused on the supply side, private services are usually driven by the quality and scale demands of agro-processors, wholesalers, and exporters. Under a fully private extension system, the costs of extension services are financed by the efficiency improvements they generate. As farmers adopt new technologies, marginal yields increase, output quality improves, economies of scale develop, and new opportunities for value addition arise. If these efforts are successful, improved farmer productivity and the elaboration of agricultural value chains will more than offset the cost of providing extension services (Brief, 2017).

The RADU oversees the extension activities of districts within the region, provides operational support to district offices, facilitates training and resource dissemination, and manages region-wide data and reporting. This synchronism suggests that effective communication mechanisms do exist between district and regional levels. However, the decentralization policy has somehow brought a disconnect between the main AESD operations in the ministry and the agricultural extension services in the districts and municipalities since the district and municipal assemblies are supposed to be responsible for agricultural extension services in their administrative jurisdictions.

There is little contact between researchers and extension agents, and technological-adoption studies are rare. Promoting technology transfer is often the most cost-effective way to boost agricultural productivity, yet Ghana has made little progress in encouraging the adoption of improved technologies. Many agricultural innovations remain underutilized despite their proven productivity benefits, such as the improved cassava varieties developed with support from the World Bank-financed West Africa Agricultural Productivity Project (WAAPP). Overcoming this apparent problem by encouraging farmers to adopt existing technologies will require more effective extension services. However, these services are inherently expensive, and expanding public agricultural extension may be infeasible in the context of the ongoing fiscal consolidation. The government should therefore explore innovative strategies for encouraging private sector engagement in agricultural extension and forge new PPPs in the agricultural sector. The innovative strategies include providing

extension services via mobile phone. This is already being done in some communities. For example, Farmerline disseminates information to farmers in nine local languages, digitizing the work of extension agents in certain localities. Some 5,000 farmers receive information on weather forecasts, market prices, agronomic and financial tips. Indeed, an assessment of mobile phone-based dissemination of weather and market information in the Upper West Region of Ghana concluded among other things that improvements in the mobile phone networks and related services will enhance the utilization of mobile phone-based weather and market information (Etwire et al, 2017). In other words, infrastructural development to effectively support the service is critical. This calls for some policy innovation on the part of government. Mobile telecommunication operators have responsibility to invest in infrastructural development insofar as it creates opportunity for profit-making in their operations. However, in the remote and poor regions, the public policies must provide incentives for the private sector operators to carry out the necessary infrastructural development. Public-private partnership arrangements can be designed for such regions.

Governance and performance measurements

Overview

The agriculture sector in Ghana is multi-faceted with Ministry of Food and Agriculture, Ministry of Fisheries and Aquaculture Development (MFAD), and the Ministry of Lands and Natural Resources serving the sector. Agricultural governance in Ghana is organized under the Ministry of Agriculture and Food (MoFA) with departments responsible for the agriculture subsectors including crops, livestock, with responsibilities overlapping with or crosscutting agriculture, such as water resources management, food, local government and rural development, microfinance and rural enterprise. These higher level institutions are supported by sub-regional and community level structures. The performance of agriculture sector is based on its ability to cope with the contemporary challenges like rising population, changing demand pattern of food and agri-product, climate change, resource scarcity and many more uncertainties. The sustainable livelihood and quality of life of rural population is consistently linked to the performance of agriculture sector. The MoFA has developed sectoral tools and frameworks to guide performance assessment of the agriculture sector in the country.

Governance of the agriculture sector

National level

The governance structure (Figure 15) of the agriculture sector is decentralized from the national to the metropolitan, municipal, district and community levels with various actors working to ensure effective governance. At the national level, the sector ministry which is the Ministry of Food and Agriculture (MoFA), works closely with other related ministries such as ministry of Finance (MoF), Ministry of Science, Technology and Innovation (MESTI), Ministry of Local Government and Rural Development (MLGRD) and Ministry of Fisheries and Aquaculture Development (MFAD). The Environment and Climate Change Unit (ECCU) of the Crop Services Directorate (CSD) under MoFA is responsible for all climate change activities related to agriculture and the unit is led by a management level officer (Directorate grade). The head of the ECCU reports to the Chief Director of MoFA and works closely with other relevant sector ministries, Research Institutions, Universities, Development partners, NGOs and other relevant stakeholders to ensure effective coordination, implementation and reporting of climate change activities in the Agriculture sector. Figure 15 illustrates the relationships between the governance structures as they relate to the agricultural sector.

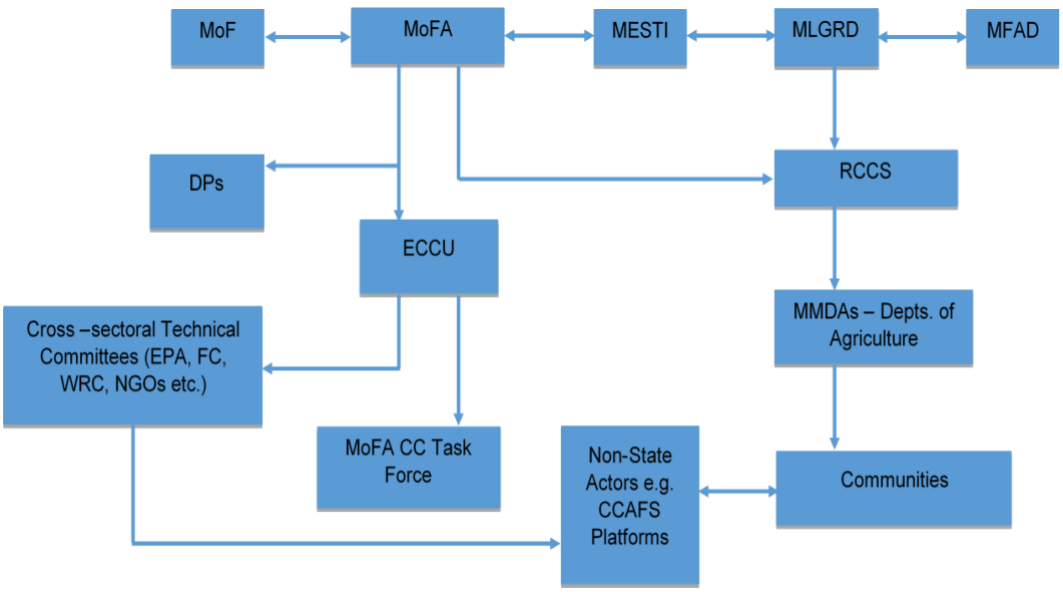

Figure 15. Institutional Relationships for Agriculture and Climate Change.

Source: Adapted from MoFA, 2017

Sub-national/regional/district

Decentralization as enshrined in the 1992 constitution is an integral component of public administrative architecture of government. This allows for development planning and consultations on policy frameworks at the local level. This is enhanced by the Local Governance Act (Act 936) of 2016 and The District Assembly Performance Assessment Tool (DPAT) as well as The National Popular Participation Framework. Currently there are Metropolitan, Municipal and District Assemblies (MMDAs) fostering local governance in all the sixteen regions in Ghana. The Departments of Agriculture of the Regional Coordination Councils are responsible for technical support to and coordination of activities of the MMDAs within their jurisdiction.

At the district level, the Department of Agriculture collaborates with and coordinate activities of relevant Civil Society Organizations (CSOs) to ensure synergy and achievement of economies of scale. This is done through awareness creation, farmer training and demonstration of best practices. The MMDAs are to ensure that adequate budgetary provisions are made to fund activities on annual basis. The planning of activities and budgeting are supposed to be participatory with the involvement of people at the local level. To the extent that the assemblies give opportunities for social and economic actors within the units of local administration to participate in decision-making at the respective level of governance, a wide range of stakeholders including farmers, small-scale entrepreneurs, traders, teachers, women and youth.

At the community level, farmers and farmers' groups are responsible for the implementation of activities on their management units. Community leaders including traditional authority and political leaders (Assembly Members) are responsible for leading community level activities and serve as liaisons between their communities and external actors. Although the MMDAs have responsibility for agricultural planning and implementation of agricultural programmes within their respective administrative areas, there are no clear structures on the linkage with national policy and planning processes leading to policy incoherence (Essegbey, 2014).

Performance measures

Monitoring and Evaluation (M&E)

Monitoring and Evaluation (M&E) tools and structures for performance of the agriculture sector in Ghana are critical. M&E enhances the effectiveness of agricultural institutions and provides increased accountability and transparency in implementation of agriculture policy, programmes and plans. The agriculture sector's M&E system is institutionalized at the national and decentralized units (Figure 16). Regular data collection is implemented at the district level through District Agricultural Development Units (DADU) offices, under the technical guidance and backstopping of Statistics, Research and Information Directorate (SRID) and technical directorates. In each district, there are Special Duty Extension Officers, specialized AEAs (livestock, perennial crops, etc.) that collect a series of data that is reported on monthly, quarterly, seasonal or annual basis.

Within decentralized MoFA, data are consolidated and sometimes analysed by the district MIS officer (DMISO) and submitted to the District Director of Agriculture (DDA) for review. The DDA sends the district report through the Regional Director of Agriculture to the Regional M&E officer at RADU. The Regional M&E officer consolidates all district reports into a regional report, incorporating data from decentralized directorates, special studies and sometimes agriculture projects and programmes. This report is sent quarterly and annually through the RDA to Chief Director of MOFA and Director, Policy, Planning, Monitoring and Evaluation Division (PPMED). The M&E systems are designed to respond to the results framework of METASIP and they serve as input to the NDPCs annual progress reports.

As illustrated in Figure 16, there are 5 line Directorates, 7 Technical Directorates, 3 Subvented Organisations, 16 Regional Directorates which all report to the Chief Director. At the regional levels, governance is further decentralized to the district directorates who report to their respective regional directorates. At the regional level, PPMED prepares the overall MoFA report by gathering reports from each region and from each directorate, agriculture related boards and authorities, and by incorporating data from agricultural project and programme reports and from special studies. MoFA report is then validated by the Chief Director and distributed within decentralized MoFA, NDPC and shared with other users including the development partners. Most of the disaggregation of data is based on

administrative boundary (region and district) and commodity. However, only few of them have gender dimension.

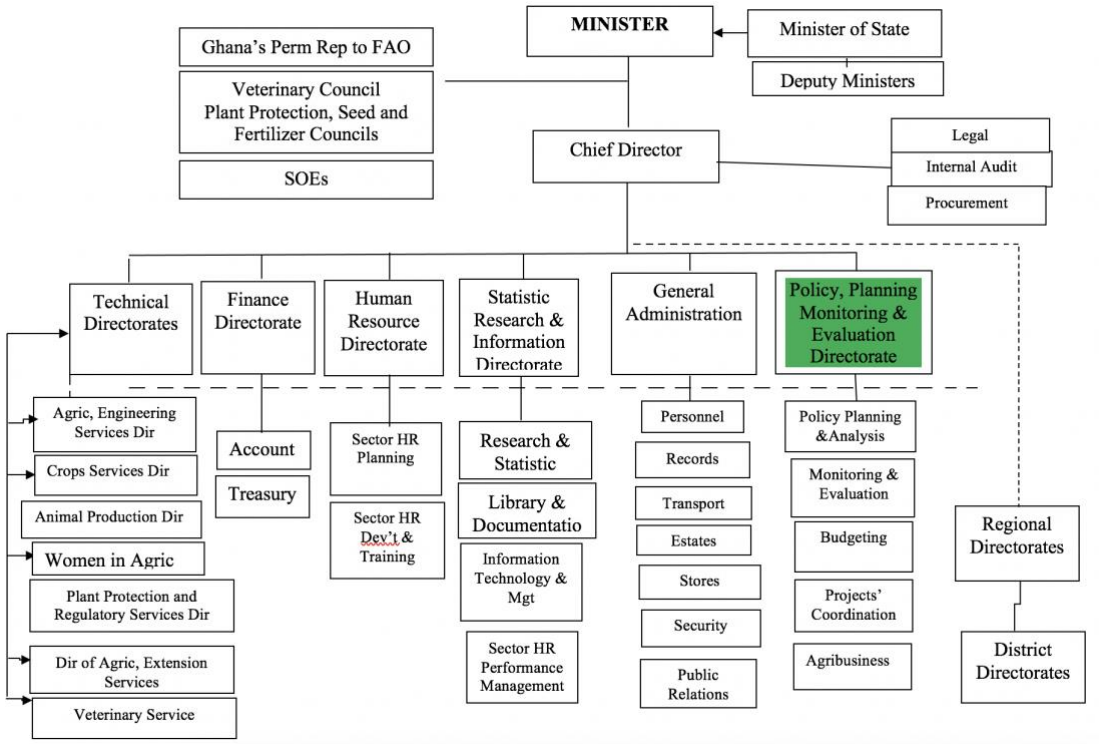

Figure 16. The Organs of the Ministry of Agriculture.

Source: MoFA

At the national level, the Policy, Planning, Monitoring and Evaluation Directorate (PPMED) is one of the line directorates of the Ministry of Food and Agriculture. The functions and services of the line directorates cut across or feed into the operations of the technical directorates of which there are seven in MoFA including the Crops Services Directorate, the Animal Production Directorate and the Women in Agricultural Development. The PPMED was established with the vision of a well-coordinated and harmonized agricultural policy environment leading to increased agricultural growth and income. It has the mission to ensure the development of effective policy and programmes and coordination of the agricultural sector for higher productivity and reduced poverty. Among its functions broadly aimed at the formulation and analysis of agricultural policies and programmes and assessment of impact on both producers and consumers are the following:

- Coordination of the preparation of MoFA's Annual Plan and Budget;
- Facilitating the release of funds to Cost Centres;

- Monitoring financial expenditures;
- Monitoring and Evaluation of agricultural sector programmes, projects and expenditures;
- Provision of technical support in project appraisal, mid-term and project completion evaluations of programmes and projects under the ministry (MoFA, 2020).

Indeed, the PPMED is at the heart of the ministry's effort to track progress of policy and programme implementation and generate the evidence for this. In this respect it is linked not only to the various organs of the ministry but also of the relevant ministries and institutions in the country such as the Ministry of Finance and the National Development Planning Commission. However, the PPMED is constrained in the delivery of its services in some ways. The major constraint is the limited budget, which though is systemic and therefore affects other directorates and public institutions, invariably impacts negatively on the operations of the directorate. The decentralization policy that transfers the District Agriculture Departments to the MMDAs also has created some problems for the operations of the PPMED. Once these departments are within the structures of the MMDAs and are expected to be financed by the MMDAs, their responses to the demands for submissions to the PPMED at the national offices of MoFA are not as when they were directly within the structures of MoFA. These and other constraints militate against the effective performance of the PPMED.

Measurement, Reporting and Verification (MRV)

Ghana's domestic MRV system for tracking and reporting on climate action operates at three different levels (national, sectoral and project). This process started in 2015 as pilot with mainly the mitigation sectors with an objective to fully operationalize the system in 2020 as part of the full implementation of the NDCs. The idea is to roll on board adaptation tracking and reporting unto the MRV system to cover all the NDC actions. Tracking of the NDC actions from the NDC sectors is planned to use the existing National Development Planning reporting system coordinated by the NDPC so that Ghana does not create parallel reporting systems. There are three (3) main levels of indicators for the NDC reporting including national, sectoral and district using the annual progress reporting (APR) system. MESTI/EPA team with support from the UNDP is working closely with the NPDC on how to integrate the

NDC tracking and reporting into the existing national M&E system. The existing MRV system together with the roadmap for deployment is shown in Figure 17.

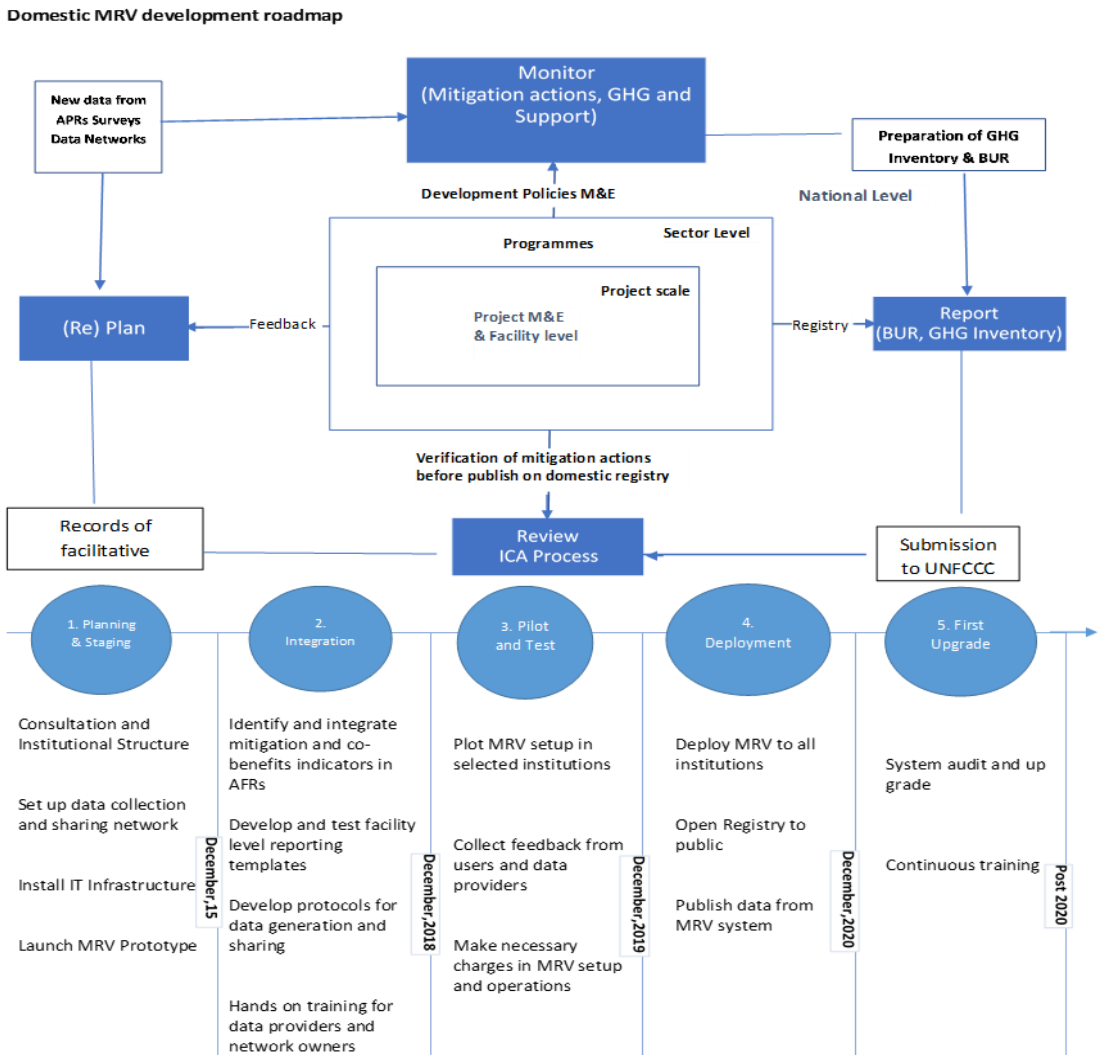

Figure 17. Diagram of the MVR Systems in Ghana

Source: BUR2 for Ghana, 2019

Mitigation tracking and measurement have seen continuous improvement in Ghana but same cannot be said about adaptation. Adaptation initiatives may be placed into three broad categories: addressing the existing 'adaptation deficit'; managing incremental changes in climate-related risks; and proactively addressing the more profound longer term manifestations and impacts of climate change by transforming or replacing existing systems and practices.

These shortcomings in existing adaptation practices and associated results frameworks highlight a need for new approaches that:

- Assessing adaptation using indicators of development outcomes, when the timescales associated with climate change impacts may be too long for such indicators to give a representative picture of adaptation outcomes.
- How to assess adaptation against a changing climate-risk baseline that will require either normalization or contextualization of development outcome indicators with respect to change exposure to risk, or the use of other indicators such as those representing vulnerability rather than development outcomes.
- How to assess different time scales and permit a range of responses from addressing current climate variability, through climate proofing existing development, to transformational change to address more challenging manifestations of climate change within the NDC sectors.

Transformation agenda: Towards low carbon, climate resilient development

Overview

Ghana is endowed with areas of high agricultural production potential that can support the growing of a wide-range of commodities. For example, the Northern Savannah Ecological Zone (NSEZ), Afram plains, the Accra plains, and other high agricultural potential areas are endowed with abundant and fertile land to produce a wide range of commodities. Given its vast size, low population density and availability of water resources, the NSEZ is considered to have one of the highest potentials for agricultural production in Ghana. The existing agricultural potential of the NSEZ is estimated to attract between US$1.9 and US$2.3 billion of private investment in agriculture. This includes downstream processing and irrigation infrastructure which could create over 400,000 permanent jobs along the targeted value-chains.

Both macroeconomic and agriculture policies recognize agriculture as a primary source of growth in the country. They also recognize the value women and youth who are the majority of the population could bring to agricultural transformation. The country has great potential to increase crop production through yield increases because farm level yields are several

times below what is obtained at research stations. The yields of almost all the food crops are significantly below the on research station yields. Areas that have potential of catalyzing agricultural growth include use of improved inputs including seed, stocking and planting materials; adoption of sustainable land water management practices and ICT. Agricultural growth is needed to leverage rapid growth in the larger agri-food system, including agro-processing and trade.

Agricultural growth potential and sources of growth

Over the last decade the relative size of the agriculture sector in Ghana has more than halved, amounting to 15.3% of nominal GDP as of the second quarter of 2019, down from 31.8% in 2009. Nonetheless, the sector retains its strategic importance as a major employer, comprising 44.7% of the labour force. Varying estimates put the percentage of households owning or operating a farm at between 44.1% and 51.5%, amounting to approximately 7.3m individuals. Given agriculture's crucial role in providing jobs for Ghana's growing population, the government has embarked on significant modernization efforts since 2017, the most important being the Planting for Food and Jobs initiative. The implementation plan; "Investing for Food and Jobs" was launched in 2018, and it focused on agriculture, food security and rural development. There are several opportunities that can be explored to increase growth in the agriculture sector. These include:

- Large gaps exist between current crop yields and attainable yields that need to be addressed to improve productivity and enhance farmers' livelihoods.
- Income growth in many Asian countries is likely to create fresh demand for Ghana's traditional agricultural exports, and high world food prices combined with rising domestic demand through urbanization and income growth should offer new market opportunities for staple crop producers (Al-Hassan et al. 2008).
- There is increasing demand for staple crops such as rice and soybean which currently are largely imported. The rising demand is attributed to increasing urbanization and income growth thereby creating the opportunities for market that should be exploited. While domestic rice production is on the rise, imports still account for about half of the country's rapidly growing demand (World Bank 2018).
- Better design and implementation of sector strategy in line with the new flagship program—the Planting for Food and Jobs. Its implementation is anchored on five pillars:

(i) provision of improved seeds; (ii) supply of fertilizers; (iii) provision of extension services; (iv) marketing arrangements and reduction of post-harvest losses; and (v) an electronic platform to capture and monitor program implementation.

- Growing the poultry industry. As with rice, the poultry needs of the country are met by large import bills.
- Significant irrigation potential of the NSEZ of 23 large and medium sized dam sites which can be developed for multiple uses such as hydropower generation, irrigation development, flood control, aquaculture. Some of these dams are estimated to be able to serve 209,000 to 547,000 hectares of irrigable land. There are also an estimated 104 small dam sites across 95 catchment areas with potential to harness over 104,000 hectares under irrigation.

Indicative priority adaptation and mitigation action areas

Well targeted investments in the agriculture sector are capable of uniquely deliver mitigation and adaptation benefits as well as economic, environmental and social co-benefits, often simultaneously.

Priority adaptation action areas

Key adaptation action areas include:

- Actions that enhance resilient, productive and sustainable agricultural systems;
- Adoption of crop varieties and cultivars that are drought/flood tolerant;
- Adoption of climate resilient livestock breeds;
- Promoting adoption of conservation agriculture and ecologically compatible cropping systems;
- Promoting sustainable management of rangelands and pastures;
- Promoting irrigated agriculture by encouraging irrigation systems that use water sustainably;
- Promoting and encouraging agricultural diversification, and improved post-harvest handling, storage and value addition;
- Improve climate information system and its use by farmers; and systems for conveying timely climate information to rural populations to enhance the resilience of agricultural systems to the impacts of climate change; and

- Develop innovative climate risk management tools such as insurance schemes.

Priority mitigation action areas

Assessment of Ghana's contribution to GHG emissions had indicated that AFOLU is the second highest emitter of the GHG emissions in the country after the energy sector. This indicates the need and appropriateness of for mitigation actions in the country (Government of Ghana, 2016). Potential mitigation actions include: adoption of climate-smart agriculture (CSA). Examples of CSA practices include: sustainable land management (SLM); conservation agriculture (minimum soil disturbance, mulching and crop rotation); integrated soil fertility management (e.g. cover crops, mulching); agro-forestry (e.g. intercropping staples with nitrogen-fixing plants or trees). In the livestock sub sector, this could be achieved through zero grazing and the use of livestock waste for household biogas production; improving pastoral livestock keeping practices (e.g., improved breeds and feeding regimes) and rehabilitation and restoration of rangelands. Other mitigation action areas include (1) forestry (afforestation, reforestation, restoration, and avoided deforestation); (2) perennial cropping systems (e.g. cocoa); (3) promotion of wetlands conservation and restoration and (4) increased access to alternative energy sources (e.g. biogas, liquid petroleum gas (LPG)).

Climate finance and investments in the agriculture sector

Overview

Ghana is still experiencing serious challenges and inadequacies with regards to agriculture sector financing. This results to limited average acreage of cultivated farmlands and thus impeding agricultural growth with consequences at both micro and macro economies across the country. These challenges are attributed to weak credit appraisal by banks and high risks associated with agriculture; covariance of agricultural production, market, and price risks; limited expertise in managing agricultural loan among financial institutions. Currently (2020), Ghana allocated 2.1% of the national budget to the food and agriculture sector. The percentage of budget allocated to Agriculture as captured here is much lower that what

actually it benefits since several other ministries such as roads and Highways overseas road infrastructure to connect production areas to markets. Its worthy of note that the figures reported for the Ministry of Agriculture excludes figures of Fisheries and Aquaculture Development which is a Ministry on its own. Financing to the agriculture sector also come from international development partners and multilateral facilities.

Public expenditure through the national budget

Over the last ten years, Ghana's National Budget contribution to Agriculture has increased from GHS 202.632 M in 2009 to GHS 1186.521 M (PWC, 2019). The both budgeted and released funds to the ministry in 2018 and 2019 were significant compared to the previous years mainly because of the implementation of the planting for food and job program, with a budget overrun in 2018 due to over subscription of inputs for the PFJ (Figure 18).

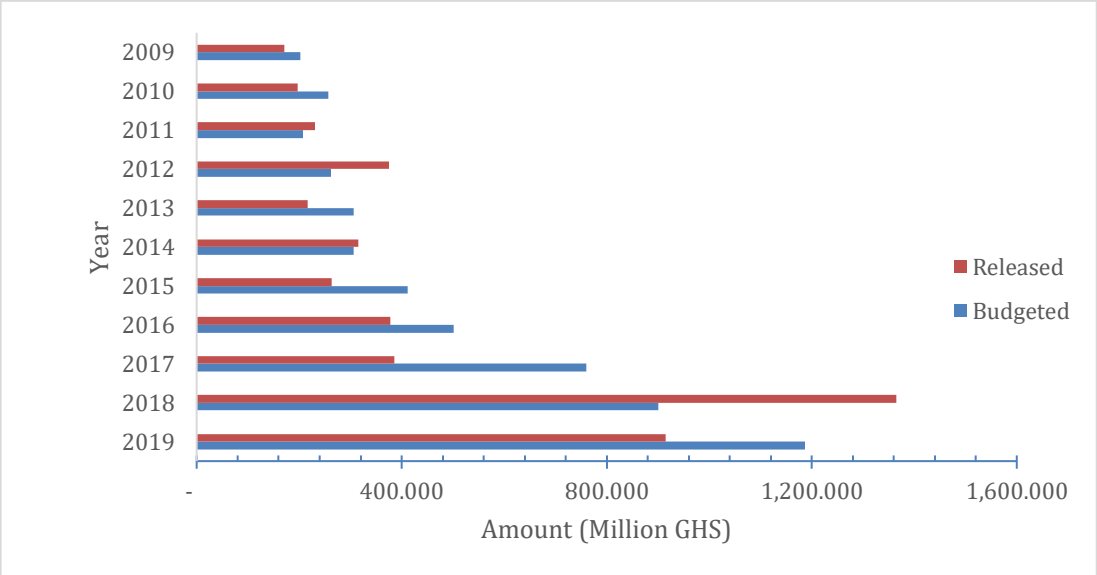

Figure 18. Annual amount of funds budgeted from the National budget compared to amount released (2009 - 2019).

Source: Finance Directorate of MoFA

Overseas Development Assistance (ODA) and Foreign Direct Investments

Overseas Development Assistance

Over the years, various international development agencies have partnered with the government of Ghana to provide financial support for the agricultures sectors, largely

through projects and programs. Some examples of the major programs by development partners are identified:

- ***The Outgrower and Value Chain Fund (OVCF)*** funded by the German Financial Cooperation to provide medium-long term refinancing vehicle for investments related to outgrower schemes as well as technical assistance to outgrowers. It was aimed at reducing rural poverty through creation of jobs along agricultural value chains. The fund led to enhanced integration of smallholder farmers into commercial agricultural development.
- ***The Financing Ghanaian Agriculture Project (FinGAP,*** a USAID funded program aimed at improving financing and investment in agribusinesses operating in the maize, soy, and rice value chains in the north of Ghana. Since its inception in 2013, it has enabled agribusinesses to access funds from financial institutions to over USD 85 million, with majority of funds going to agro input dealers, processors and farmers.
- ***The Rural and Agricultural Financing Program (RAFIP)*** collaboratively funded by IFAD and DANIDA aimed to increase sustainability in access to financial services among rural and agricultural population through enhanced outreach, sustainability and linkages. It aimed at strengthening rural financial systems by providing series of capacity building trainings, including technical training on finance and credit operation, as well as management and governance on bank operation, to staff of rural/community banks and microfinance institutions. It also strengthened linkages between financial and agricultural/agribusiness sectors to promote agribusiness investment.
- **The World Bank** extended a credit facility of USD 50 million to Ghana in 2018 to execute Ghana Commercial Agriculture Project (GCAP) aimed at increasing the area under irrigation by about 8,000 hectares, including providing additional 1,500 hectares of new land under irrigation. Over 14,000 farm families and agribusinesses particularly in the Northern Development Authority area (Northern Region, Upper East and Upper West regions) and the Accra plains are expected to benefit from this financing (World Bank 2018).
- **The Resilience Against Climate Change: Social Transformation Research and Policy Advocacy (REACH-STR)** project began in January 2019 with the broad aim of addressing pertinent issues in climate change in the north of Ghana. The International Water

Management Institute (IWMI) is leading this six-year REACH-STR project in Upper West and Northern Region, in partnership with University of Development Studies (UDS), the Centre for Migration Studies of the University of Ghana and the Science and Technology Policy Research Institute of the CSIR. The general objective of the project is *more inclusive and sustainable economic growth policy and programming approaches undertaken in Northern Ghana by 2025* (Osei-Amponsah, 2019) Thus, at the end of the project it is expected that the local, regional and national decision-makers better understand the social transformation conditions that will enable sustainable and inclusive rural economies, thereby promoting the implementation of climate change adaptation practices in development plans and strategies in these regions. The project is funded by the European Union under the productive investment for agriculture programme, with support from the Deutsche GIZ, through the Competitive Cashew initiative, and supported by the CGIAR Research Program on Water, Land and Ecosystems (WLE) which works toward sustainable food systems that address gender, migration and urbanization challenges. IWMI with its partners will focus on three research streams namely: 1. Methods and strategies for achieving resilience at a community level in case study communities; 2. Migration and youth-specific issues of transformation in the northern region focus areas; 3. Evidence-based gender research focusing on key constraints to positive transformation, and the means to enhance equality and expand economic opportunities for rural women and young people. The research streams will complement other project activities such as capacity building and national dialogues to result in more inclusive and sustainable economic growth policy and programming in Ghana by 2025. The University of Ghana and UDS will train graduates at the master's and doctoral levels. The total budget for this project is 22 million euros.

- **The Ghana Agricultural Sector Investment Programme (GASIP)** is one of the key projects in the agricultural sector currently. GASIP's goal is to contribute to sustainable poverty reduction in rural areas of Ghana and its development objective is to enhance the profitability and climate change resilience of agribusinesses and smallholders. MoFA is implementing the programme over a six-year duration made up of two cycles of three years each. The programme started in May 2015 and is scheduled for closure on 31 December 2021. A Programme Coordination Unit (PCU) located in Accra supported by

four Zonal Coordination Offices (ZCOs) is responsible for overall implementing GASIP. At design GASIP was expected to reach 86,400 farmers by the end of the second cycle, working through 4,000 FBOs organised under value chain clusters. An IFAD loan of US$ 36.6 million and an ASAP grant of US$ 10 million financed the first cycle of the programme (MoFA, 2020). GASIP follows a value chain development approach. It assists in developing secured marketing linkages between FBOs and agribusinesses referred to as value chain drivers (VCD). The FBOs and the VCD sign agribusiness partnership agreements before the production season with the VCDs committing to purchase the crops produced by the FBOs based on quantity, quality and cost parameters agreed in the agribusiness agreements. GASIP supports the implementation of these agribusiness agreements by strengthening the FBOs, providing matching grants to support crop production activities and strengthening value chain infrastructure. GASIP also promotes the adoption of climate change resilient practices (MoFA, 2020). As of December 2019, GASIP has partnered with 53 VCDs which in turn have partnered with 1,200 FBOs mainly for producing rice, maize, soya, cassava and some vegetables across all the major agroclimatic zones in the country. GASIP has supplied $13.6 million as matching grant support to the beneficiaries to ensure their access to quality and timely inputs through the VCDs. GASIP's Crop Yield Surveys have suggested that the beneficiaries have experienced over 70% increase in yield due to good quality and timely access to the inputs followed by regular technical guidance by the VCDs and government extension staff during the season. Smallholder farmers benefited from training in Climate Smart Agriculture technologies and weather information services. GASIP installed ten (10) automatic weather stations across the programme beneficiary Districts in the northern zone. The installation of the automatic weather stations provided smallholder farmers with real-time weather information services (MoFA, 2020).

Foreign Direct Investments

There are opportunities to leverage corporate commitments from private actors in Ghana's most important valuable commodity chains -namely cocoa, oil palm, rubber, and timber- towards climate change mitigation. Some examples of private sector commitments and funds dedicated to climate change mitigation and adaptation through forest protection and regeneration include the following:

The Cocoa and Forest Initiative (CFI): A commitment led by the governments of Ghana and Cote d'Ivoire with the world's top 35 cocoa and chocolate companies to eliminate deforestation in the cocoa supply chain. Individual company actions plans outline the resources allocated towards internal and collaborative actions to stop deforestation and support reforestation.

The RSPO Smallholder Strategy (RSS): The Roundtable on Sustainable Palm Oil is the leading palm oil certification body whose members include the world's largest palm oil producers and food and consumer product brands. RSPO holds its members to industry leading environmental and social standards and uses funds from member dues to monitor and enforce compliance.

Agroforestry Palm Oil: In Daboase, Wassa East District, Western Region, the NGO "Building Business with Values, Integrity, and Dignity (BBOVID)" is developing a sustainable, social approach to palm oil production that depends on an extensive network of outgrower farmers and agroforestry, in stark contrast to the business-as-usual plantation model. BBOVID's model uses organic farming and agroforestry techniques on smallholders farms, aimed at reducing environmental and soil degradation, and preserving existing vegetation and surrounding forests. This scheme has been lauded by the United Nations and received USD $5 million in funding from French impact investors, The Moringa Fund.

Production-Protection Agreements: With partners Benso Oil Palm Plantations and the Pro-forest Initiative Africa, Partnerships for Forests (P4F) will introduce sustainable production-protection contracts that aims to "bring 20,000 ha under sustainable land use" and "reduce pressure on the local landscape," accomplished with an anticipated USD$15 million in private investment funds.

Satelite Monitoring of Forests: In July 2020, Nestle launched a forest protection and reforestation project aimed at protecting the Cavalley forest in Ivory Coast from deforestation tied to cocoa production. This project is part of Nestle's commitment to "eliminate deforestation from all supply chains and achieve net zero emissions by 2050". This project lends itself to replication and scaling in Ghana- particularly because it relies on satellite imagery of the selected forest, and high-quality imagery is already available through Lindt's satellite monitoring activities.

Landscape Management Boards (LMBs): The Rain-Forest Alliance, in partnership with Olam, P4F, and the Ghana Forestry Commission and COCOBOD, will establish LMBs in cocoa producing communities who are tasked with protecting 155,000 ha of the Sui Forest from deforestation through protected areas, sustainable farming practices, and biodiversity and resource management. This project will rely on around USD $35 million in investment from cocoa licensed buying companies, including Olam.

There also a number of projects that are ongoing that contributes to the Nationally Determined Contributions Pre-2020 Reporting. The scope of coverage, the sub-theme under which they are being operationalized among others are indicated in Appendix 1.

Private sector investments

The private sector has an important role to play in the development of the agriculture sector in Ghana. This relates to the fact that the financing from the public expenditures is inadequate. Much of private sector investments are in the large-scale commercial farming of high-value crops such as of pineapples, mangoes and other horticultures as well as tree crops such as cashew. Agro-processing businesses also attract private sector funding. There is generally low private sector investment in smallholder agriculture mainly due to lack of profitable opportunities; high business risks that cannot be mitigated in a cost-effective manner; poor infrastructures such as bad roads that hinder effective transportation of produce from the rural areas to various markets, resulting in high post-harvest losses; inadequate macro-economic policy environment; poorly coordinated agricultural value chains among others (Mhlanga, 2010). The private sector participation and investment is largely strong in cocoa production (through smallholders) and investment and processing (through large international companies) (Norman et al., 2016). Usually the totality of private sector investment is difficult to compute given that they are diverse and embedded in the respective businesses.

Climate finance

Multilateral sources

Multilateral climate finance is a key component of the climate funding inflows for Ghana. The multilateral sources comprise of the World Bank, the Global Environment Facility, the

United Nations Environment Programme and other UN agencies. The funding from these sources are discussed in the subsequent sub sections.

Green Climate Fund (GCF)

Green Climate Fund is the largest international climate finance fund. It partners with the business world to mobilise institutional investors at scale to fund climate action, and to encourage local private sectors in developing countries to deliver climate solutions. It has supported various development programs, especially in the agriculture sector in Ghana. The GCF grant of USD 50 million for the project entitled "Resilient Landscape for Sustainable Livelihoods" that to be executed by the Ministry of Food and Agriculture with the UN Environment as the accredited entity has gone through evaluation process and is yet to be approved. The project will focus on supporting conservation agriculture techniques; agroforestry; fire management; and riverbank stabilization. Vulnerable communities are trained on post-harvest management approaches (e.g. post-harvest storage, processing and financial management) that optimize the benefits accrued from on-field interventions. The project targets to facilitate a widespread and sustained behavioral transformation in smallholder farming communities.

Program on Affirmative Finance Action for Women in Africa (AFAWA)

Financing Climate Resilient Agricultural Practices in Ghana which has a cross-cutting focus on Ghana's NDC commitments. The program aims to empower vulnerable women groups in this most vulnerable agro-ecological zone through Line of Credit (LoC) and through Technical Assistance (TA) to participate in low-emission climate resilient agricultural (CRA) practices in the country. In 2018, the country together with Uganda and Nigeria benefited from Acumen Resilient Agriculture Fund (ARAF), under the GCF. Acumen aims at supporting pioneering and early-growth stage innovative agribusinesses that enhance the climate resilience of smallholder farmers. This funding focused on adaptation with emphasis on food and water security areas. UNEP also accessed funds in 2019 from GCF to develop a NAP adaptation process that will produce a costed adaptation strategy for the country and provide the tools, mechanisms, system and information with which to replicate the NAP process at regular intervals and to mainstream the adaptation strategy into sector and District development plans.

Global Environment Facility (GEF)

The GEF has continuously provided financial support to the agriculture sector and climate change projects in Ghana. Financial and technical support towards the preparation of Ghana's BUR2 was provided by the Global Environment Facility (GEF) via the UN Environment (BUR2, 2020). In 2016, with the World Bank as the as the implementing agencies and the Ministry of Environment, Science, Technology and Innovation (MESTI) as the executing agency. It has extended additional facility to fund a project "*Sustainable Land and Water Management*, (SLWM) which aimed at expanding the area under Sustainable Land and Water Management Practices in Selected Watersheds by supporting adoption of adoption of the sustainable land and water management practices for reducing land degradation and enhancing maintenance of biodiversity (Table 12). In this regard the project focuses on: capacity and monitoring for SLWM; implementation of SLWM; national sustainable land management and Payment for Environmental Services monitoring; and management of biodiversity corridors. Additional support was received from the UNDP through the NDC Support Programme.

Table 11. List of major projects in Ghana under international and multilateral climate funds since 2012.

Name of Project	Fund	Amount of Funding Approved (USD millions)	Disbursed (USD millions)	Dates
Increased resilience to climate change in Northern Ghana through the management of water resources and diversification of livelihoods	Adaptation Fund (AF)	8.30	0.57	2015-2020
Ghana Agricultural Sector Investment	Adaptation for Smallholder Agriculture Programme (ASAP)	10.00	0.8	2014
Preparation Grant for Program Planning	Scaling-Up Renewable Energy Program	1.51		2015

	for Low Income Countries (SREP)			
Enhancing Natural Forest and Agroforest landscapes Project	Forest Investment Program (FIP)	30.00	5.0	2014
Engaging Local Communities in REDD+/ Enhancement of Carbon Stocks	Forest Investment Program (FIP)	10.00	2.95	2013-2018
Reducing Degradation and Deforestation due to Mining in Forest Landscapes	Forest Investment Program (FIP)	10.20		2015
Public-private partnership for the restoration of degraded forest reserve	Forest Investment Program (FIP)	10.00		2016
Dedicated Grant Mechanisms	Forest Investment Program (FIP)	6.00	6	2016
Preparation of Ghana's Initial Biennial Update Report to UNFCCC	Global Environment Facility (GEF5)	0.40	0.4	2013
Enabling Preparation of Ghana's Fourth National Communication and Second Biennial Update Report to UNFCCC	Global Environment Facility (GEF6)	0.85		2016
Ghana Climate Innovation Center	World Bank (contribution by Netherlands and DANIDA)	17.20		2016
Second additional financing for sustainable land and water management project	World Bank	12.80		2016
Sustainable rural water and sanitation additional funding	World Bank	45.70		2017
Sustainable land and water management	World Bank	8.60		2014

Adaptation Fund

The Adaptation fund provided a funding of USD 8,293,972 in 2015 for a programme entitled "*Increased Resilience to Climate Change in Northern Ghana through the Management of Water Resources and Diversification of Livelihoods*" for a period of 4 years. The programme aims to enhance the resilience and adaptive capacity of rural livelihoods to climate impacts and risks on water resources in the northern region of Ghana. This it to be achieved through the improvement of water access and increasing institutional capacity and coordination for integrated water management to support other uses of water resources especially for the diversification of livelihoods by rural communities. The programme focuses on three regions in the northern part of Ghana: the Upper East, Upper West and Northern Regions, based on their higher degree of exposure to climate variability and change characterized by increasing temperatures and decreasing and erratic rainfall.

Ghana is also one of the West African countries that have benefited from the AF funded regional project (USD 14,000,000) called "*Promoting Climate-Smart Agriculture in West Africa*" in 2018 for a period of 3.5 years for the food security sector. The project aim is to reduce the vulnerability of farmers and pastoralists to increase climatic risk, which undermines the level of food security, income generation, and the supporting ecosystem services of poor communities. It has supported strengthening of knowledge and technical capacity through regional and local interactions for the promotion of agriculture practices resilient to the adverse effects of climate change. It has also supported scaling up of best practices related to climate change adaptation in agriculture and pastoralism at local and regional level.

Other Global Financing Initiatives

Nordic Development Fund (climate change facility) sponsored a number of climate change studies that are relevant to achieving the NDC targets. These include the Climate-proofed water conservation strategies in Northern Ghana with the objective to promote transfer of knowledge and skill on the sustainable management of water resources through cost-effective climate-proofed water storage and conservation strategies.

Multilateral Development Banks (MDBs)

World Bank

The World Bank is usually the conduit through which these funds are channeled. Climate financing from the World Bank cuts across many sectors of the economy. Energy sector however, dominates the climate financing from the World Bank. Related to agriculture, there is the Sustainable Land and Water Management Project that brought to Ghana a total of US$13.25 million in grant and loans. The Government of Ghana also committed a total of US$4.5 million to the project. For technology transfer, the World Bank is financing the Ghana Climate Innovation Center with an amount of US$17.5 million. This is meant to target 500 businesses including agro industries in climate innovation. Other World Bank funded climate projects are listed in Table 12.

African Development Bank

The African Development Bank (AfDB) is an important financier of Ghana's development programmes generally. In the specific area of climate financing, one may cite the US$600 million loan the Bank facilitated for the Ghana Cocoa Board (COCOBOD) which has oversight of the cocoa industry in the country. The loan is meant to finance large scale pollination of cocoa farms, expanded tree pruning, construction of warehouses, rehabilitation of declining plantations and increased local processing.

IFAD

International Fund for Agricultural Development (IFAD) Ghana Agricultural Sector Investment Program promotes and mainstreams climate change resilience approaches in Ghana, particularly in the northern regions. It is financed through the Adaptation for Smallholder Agriculture Programme. Food and Agriculture Organisation (FAO) Supports the promotion of conservation agriculture and integrated pest management for sustained soil fertility and productivity.

Bilateral arrangements

The Nationally Determined Contributions Support Program (US$1,695,372; 2017-2020) is sponsored by the UNDP and Government of Germany and supports Ghana in achieving the NDCs via technical and institutional capacity building. The Government of Norway also

provided a grant of US$5.2 million to the Government of Ghana for community resilience through early warning systems.

DANIDA through its efforts at building stronger universities in Africa through a North South collaboration has supported the University of Ghana to carry out research on the theme; Adaptation and mitigation of climate change in Ghanaian agriculture. The initiative includes capacity building and networking and also support with equipment for research. DANIDA also supported a project (2016 – 2020) on Climate Smart Cocoa Systems for Ghana, a project with the aim to develop a comprehensive understanding of the impacts of climate change on the socio-biophysical basis of cocoa systems in Ghana and assess the role of agroforestry as a model for climate and carbon smart agriculture. Another funding had been provided to University of Energy and Natural Resources, Ghana for a project titled "Building Resilience on Lake Bosumtwi to Climate Change" to be executed between 2018 and 2022 to enhance the fishery resources in the lake Bosumtwi watershed. Building climate-resilience into basin water management was also funded by DANIDA from 2019 to 2024 at a total grant of 11,998,167 DKK to a consortium of institutions led by the Water Research Institute. The USAID also funded Sustainable Fisheries Management Project, over the period; 2013-2019. From 2012-2017, The German Federal Ministry of Economic Cooperation and Development (BMZ) funded Climate Change Adaptation of Agro-ecosystems in Ghana. Another climate change project in Ghana is the Adaptation at Scale in Semi-Arid Regions' (ASSAR), a five-year project (2013-2017) funded by IDRC and DIFID aimed at improving understanding of climate change in semi-arid areas across Africa and Asia. The West African Science Service Centre on Climate Change and Adapted Land Use' (WASCAL), is also a major Climate change project aimed at capacity building in the design of resilient land-use systems.

Other funding sources

Other funding sources that have provided grants for climate change projects in Ghana include the Rockefeller Foundation provided a grant to support the project entitled "Design and launch a Climate-smart Agricultural Finance Facility in Ghana". Bill & Melinda Gate Foundation also provided a grant to the International Institute of Tropical Agriculture to carry out a study "Predict the impacts of Climate change on the cocoa-growing regions in Ghana and Cote D'Ivoire". This project aimed at determining which environmental variables

drive the climate suitability of an area to grow cocoa, predict the change in climate for the cocoa-growing areas in Ghana.

Another funding (US$ 214,430.00) was received by the University of Ghana for Regional Integrated Assessment of climate change impact on livelihoods of smallholder farmers in Ghana (Navrongo) over the period 2012-2014 and 2015 – 2017. The funds were granted by United Kingdom UKaid of the Department for International Development (DFID), through the Agricultural Model Inter-comparison and Improvement Project (AgMIP: (www.agmip.org) for work in Sub-Saharan Africa and South Asia to substantially improved assessments of climate impacts on the agricultural sector. The analysis was structured around 4 core questions (Rosenzweig et al. 2016; Freduah et al. 2019; Adam et al. 2020).

Conclusion and recommendations

The Situational Analysis Study has underscored the importance of agriculture in Ghana. Climate change affect agricultural activities in diverse ways. In the key sub-sectors of crops, livestock, forestry and fisheries, the climate change impacts are experienced in various ways including in rainfall, temperature and humidity. In the main ecological zones of Ghana there are manifestations of the climate change impacts. How climate change impacts are managed is important in addressing the challenge of enhancing productivity in the agricultural sector. It is a multi-dimensional challenge which solutions must emanate from the identifiable components of the environment. In this regard, the following recommendations are proposed:

- ***Political:*** Agriculture is given a high priority in Ghana's political and socio-economic discourse with the President highlighting the agricultural programme of PFJ as the flagship of his government. The various national policy documents including the national development framework have underscored the importance of the agricultural sector. However, there is need to enhance policy coherence and strengthen policy implementation along the governance structures from the national through the regional to the municipal and district assemblies. Farmers and women must have stronger voices at the district level to articulate better their concerns. This may demand a radical change in the appointment of government representatives to the assemblies.

- ***Economic.*** Ghana's national budgetary allocation to the agricultural sector is still below the target of the Maputo Declaration at about 9.7% currently. However, the on-going programmes such as the PFJ and its constituent modules are likely to increase it. The funding from multi- and bi-lateral sources are also likely to increase agricultural expenditures. However, it is recommended that funding must be better targeted to address key constraints in the agricultural sector. Farmers' adoption of CSA is an important intervention area that economic planning must cater for. Market access and access to financial resources to finance their agricultural activities in crops, livestock, fishery and agroforestry, are crucial. Government must consider, adopt and implement this recommendation in collaboration with other stakeholders. The government should also redouble its efforts to attract climate financing into agriculture. There are multi- and bi-lateral sources of climate financing and given the country's commitment to the related international agreements of the UN system and AU, more climate financing could be attracted.
- ***Social***. Some of the key social-cultural constraints are the inadequate empowerment of women and removal of cultural biases against the female gender, the limited interest of the youth in agriculture. Government affirmative action to get women appointed to positions of decision-making, promotion of the girl-child education and engagement of queenmothers in designing programmes for women activism are necessary. There is also the need to strengthen Youth in Agriculture programmes going on in the country with emphasis on projecting successful youth as models for others. Besides, farmers' voice must be heard clearly and loudly in the corridors of power. The status of farmers in social and political circles is an important booster to the message being given to the youth that farming is important.
- ***Technological.*** Technology and innovation is crucial for lucrative agricultural practices. The current PFJ is promoting the use of technology and modern inputs including tractor services, improved seeds and fertilizers. However, the efforts to get farmers to benefit from technology adoption can be enhanced by strengthening the extension services system. Government and the development partners must strengthen extension services through employment or engagement of agricultural extensionists and the provision of the technologies for farmers. In this regard, the connection between the national research system and the agricultural productive system needs to be strengthened.

Research and Development outputs from the scientific institutions must be transferred to the end-users in the agricultural sector.

- ***Environmental.*** Even though Ghana has very good terrestrial and aquatic resources for agriculture, there is the threat of climate change impacts which are already being felt in unreliability of rainfall, floods and natural disasters. The promotion of CSA for agricultural practices including for crop and livestock farming, will contribute to enhancing productivity. Government should strengthen measures to counter forest and land degradation and pollution of water bodies. Sustainability has become a pivotal principle with the commitment to the SDGs by almost all countries of the world including Ghana. SDG 14 and 15 which focus on life under water and life on land respectively have put the spotlight on efforts to ensure sustainable environmental management. Ghana needs to intensify the efforts at conservation of biodiversity and controlling environmental pollution.
- ***Legal***. Enforcement of laws in Ghana is a weakness. There are laws which are fundamental to socio-economic and political progress for the nation – laws which protect the rights of individuals and communities and laws which protect ecosystems. However, there is weakness in the enforcement of these laws. It is recommended that, in the particular case of environmental laws including laws against pollution of water bodies, degradation of land and destruction of biological diversity, enforcement must be strengthened. There must be severe penalties for infractions of these laws. The government may consider setting up special courts for these cases.
- ***Institutional.*** Ghana has almost all the necessary institutions established for agricultural development of growth and for addressing challenges such as climate change. MoFA, MESTI the research institutions and universities can do a lot to improve the current status of agriculture in terms of policy formulation and review, policy implementation, monitoring and evaluation. It is recommended that the linkages between the relevant institutions be strengthened. In the case of institutions in the R&D system, linkages with the productive sectors of the economy is crucial for effective transfer and adoption of technology and innovation.

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Appendices

Appendix 1. Contributions to Nationally Determined Contributions pre-2020 reporting

No.	Sub theme	Name of Action	Supporting Policy	Status	Scope of Action	Source of Investments	Implementing Institutions
1	Climate Smart Agriculture or Conservation Agriculture	Planting for Food and Jobs (PFJ)	Food and Agricultural Development Policy (FASDEP II)	Ongoing	Introduce subsidy on Improved planting materials (seeds and vegetative materials) and fertilizers (organic and Inorganic). Enhance coverage of extension support services to farmers Enhance capacity of public extension service providers Scope is Nationwide	2017 - GHS 248,175,615.01 2018 – GHS 365,965,367 Source of funds: GOG & Donor	Lead: Ministry of Food and Agriculture (MoFA) Partners: Private Sector Agro Input Dealers, Regional and District Departments of Agriculture
2	Climate Smart Agriculture or Conservation Agriculture	Sustainable Land and Water Management Project	FASDEP II, National Environment Policy, Buffer Zone Policy	On-going	12 Districts in the Northern Savannah Zone (Wa East, Daffiama-Busie-Issa, Sissala, East, Sissala West, Bawku West, Talensi, Kasena Nankana West, Builsa South, West Mamprusi, Mamprugu	GEF: USD 12.77 Million (funds will be more because this is only AF2. There were funds from AF1 used during the period as well as GOG in-kind	Lead: MESTI Beneficiary Agencies: MoFA, EPA, Forestry Services Division, Wildlife Division, 12 District Assemblies

					Moagduri, West Gonja and Sawla-Tuna-Kalba).	contribution). GOG: USD 5.00 Million (this is for only AF2)	
3	Climate Smart Agriculture or Conservation Agriculture	Ghana Agriculture Sector Improvement Project (GASIP) Climate Change Component	FASDEP II NCCP	On-going	Location of climate change component is Northern Savannah and Transitional agroecological zones of Ghana. Action is mainly conservation agriculture Support Provision of climate information services	IFAD	Lead: MoFA Partners: District Departments of Agriculture, private sector
4	Climate Smart Agriculture or Conservation Agriculture	Savanna Agriculture Productivity Improvement Project (SAPIP)	FASDEP II	Just started	Northern Savannah Zone of Ghana		Lead: MoFA Partners: District departments of Agriculture, Private Sector, Commercial Farmers
5	Climate Smart Agriculture or Conservation Agriculture	Planting for Export and Rural Development (PERD)	FASDEP II NCCP TREE CROPS DEVELOPMENT	Launched in 2019	Location: Nation wide Action: targeted at economic trees		Lead: MoFA Partners: MLGRD

			POLICY				
6	Livestock and Fisheries	Rearing for Food and Jobs	FASDEP II NCCP LIVESTOCK DEVELOPMENT POLICY	Launched June 2019. Started on small scale	Strategic document developed	GOG, DPs, Private Sector	Lead: MoFA Partners: MLGRD, Private Sector
7	Climate Smart Agriculture or Conservation Agriculture	One Village One Dam (1V1D)	FASDEP II NCCP Irrigation Development Policy	On-going	Water harvesting to support dry season agriculture and livestock watering in Northern Savannah Zone of Ghana.	GOG	Lead: MSDI Partners: MoFA, GIDA
8	Livestock and Fisheries	Savannah Investment Project	FASDEP II	Planned	Location is Northern savannah regions of Ghana	African Development Bank	Lead: MoFA Partners: Private Sector, MLGRD
9	Post-Harvest Management	One District one Ware house (1D1W)	FASDEP II NCCP	On-going		GOG	Lead: MSDI Partners: MoFA, Buffer Stock Company

10	Post-Harvest management	SLWMP	FASDEP II Wildlife Policy NCCP	On-going	Action: upscale SLWM practices Location: 12 Districts in Northern Savannah Zone of Ghana	GEF, GOG	Lead: MESTI Partners: MoFA, EPA, FC, MLGRD
11	Climate Smart Agriculture or Conservation Agriculture	SLWMP	FASDEP II NCCP	On-going	Action: upscale SLWM practices Location: 12 Districts in Northern Savannah Zone of Ghana		Lead: MESTI Partners: MoFA, EPA, FC, MLGRD
12	Climate Smart Agriculture or Conservation Agriculture	SLWMP	FASDEP II NCCP				Lead: MESTI Partners: MoFA, EPA, FC, MLGRD

Appendix 2. List of persons for the interviews

Source of Data	Description of Data	Contact Person
MOFA – Crops Services Directorate	Varieties of crops developed and currently being promoted to farmers; dominant crop varieties	Kingsley Amoako
MOFA – PPMD	Policy documents; current projects e.g. government flagship programme 'Planting for Food and Jobs'	Angela Danson
MOFA – Volta Regional Office	Implementation of agricultural policies at the regional and district level	Delalali Kofi Nutsukpo
MOFA – SRID	Agricultural productions data and statistics; publications	Kofi Darko
MESTI – National Climate Change Committee	Policies and programmes on climate change under MESTI	Peter Dery
Environmental Protection Agency (EPA)	Climate change information; the NDCs and current initiatives	Dr. Antwi Bosiako Amoah
Council for Scientific and Industrial Research (CSIR)	Data on R&D e.g. research projects, agric. Technologies produced; research staff, skills and competences	Deputy Director-General (in charge of R&D)
Ghana Federation of Farmers and Fishermen Associations	Production incentives and challenges; climate change impacts; adaptive behaviors including technology adoption	John Kuwornu
Crops Research Institute	Improved varieties of crops e.g. maize, cassava and cowpea; climate-smart technologies	Prof. Hans Adu-Dapaah
Fisheries Commission	Fish production data from freshwater and marine sources; fishing communities in Ghana; aquaculture production data	Mr. Emmanuel Dovlo
Ghana Statistical Service	National accounts data – macro-economic data/ statistics	David Kombatt
National Development Planning Commission (NDPC)	National development framework; annual progress reports	Dr. Felix Addo-Yobo
Verala Verde EO	Agricultural value chain in Ghana; agro-forestry; climate chain	Vail Lauren Miller
Fisheries Commission	Oversight of fishing in marine and freshwater; aquaculture development	Samuel Manu
Ghana CCAFS Platform	NGO activities in climate change	Dr. N. Karbo
ESOKO (private sector)	Agricultural information – value chain activities	
Merhan Consult	Gender specialist in agriculture and value chain	Dr. Hannah Nyamekye
MOFA-Women in Agriculture and Development	Women's data and issues in agriculture across the value chains	Victoria Aniaku
MOFA- Animal Production Directorate	Data on livestock production and husbandry	Mavis Affutu

Appendix 3. Interview guide for the situational analysis study in Ghana/Kenya/Uganda/Zambia (based on the question on the ToRs/the Inception Report

1. Status and Trends in the Agriculture Sector in Ghana, with sub-sections on crops, livestock, fisheries and agroforestry

- The big vision for agriculture in Ghana is modernization. To what extent do the trends show that we are modernizing – any specific indicators with respect to the sub-sectors?
- How do you assess Ghana's efforts in achieving food security?
- Specifically, what are the successes and shortfalls of the government flagship agricultural programme/projects (e.g. Planting for Food and Jobs (PFJ) in Ghana)?

2. Impacts of Climate Change on Agriculture sub-sectors, with sub-sections on crops, livestock, fisheries, agroforestry and the production resources (land, soil and water etc.)

- What are the main impacts of climate change in agriculture – crops, livestock, fisheries and agro-forestry?
- How are we promoting Climate Smart Agriculture (CSA) and Sustainable Land Management (SLM) in Ghana?
- What are the current efforts to address climate-related impacts on Agriculture (crops, livestock, fisheries, agro-forestry/landscapes)?
- What are the success factors and what are the constraints?
- Considering the different roles women play in agriculture activities along the value chain, how has climate change impacted women?
- What intervention measures would you propose to reduce the impacts of climate change on vulnerable groups (e.g. women)?
- Who are the major actors in climate change activities? What are the strength and weaknesses of climate change governance? Is there any opportunity to make it more inclusive?
- What are the opportunities in the agricultural sector to reduce women's vulnerability to climate change?

3. In-Depth Analysis of the Macroeconomic and Sectoral Policy Enabling Environment.

- [From desk research, the Consultant draws on the relevant documents on the country's macro-economic and agricultural sectoral policies to discuss the enabling environment with the necessary statistics and data. Ask any questions for clarification.]
- To what extent is agriculture prioritized in Ghana's economic policy implementation?
- What are the main successes in the agricultural programme implementation?
- What are the shortcomings/ failures/ opportunities?

4. Evaluation of Adequacy of Response Measures, their Coherence with Relevant Policies, and Progress made Towards Implementing Existing Policies and Goals.

- How do you assess the level of coherence between the relevant agricultural and climate change related policies and strategies?
- What can be done to improve coherence and synergies?
- How do you assess policy implementation at the key levels of governance – national, regional and district?
- What are the strengths and weaknesses of existing sectoral policies?

5. Level and trends of Climate Finance Investments into the Agriculture Sector (public, development partners and non-state actors – private sector and civil society organizations).

- What are the main Climate Finance Investments (CFI) in the agriculture sector in Ghana?
- How would you prioritize these?
- What strategies can be put in place to attract more CFIs into the sector (national budget, other public sources, private sector, etc.)?
- What is the proportion of Climate Finance investments in relational to the agriculture sector budget?

6. Agricultural, Climate Data and Information Management Systems (IMS).

- What are the existing climate data and information management systems in the country? What mechanisms are required to make the systems socially-inclusive?
- How effective is the generation and dissemination of climate data for agricultural activities in the country?
- What are the reliable IMS (systems) for climate data for agriculture?
- What are the current climate data gaps for agriculture?
- To what extent is Ghana self-reliant in creating IMS for climate change in agriculture? (e.g. software? Human resources?)
- Which institutions apart from SRID manage agricultural data?
- What are the challenges, if any in managing agricultural data? (Technical, capacity, financial, etc)

7. Is there any mechanism to collate Climate change Funds/grants inflows that come to public institution such as Academia and CSIR), NGOs and CSOs?

- Is there a collation of CCFs/ grants in Ghana?
- Please provide source(s)

8. Is there a repository for research output and data from scientists/academia?

- Do you see the Academy of Arts and Science playing any role in organizing data repository?
- Any other institution(s) which can play the role of repository?

9. Opportunities for ensuring inclusive governance.

- How do you assess efforts in Ghana to empower women and youths to exploit opportunities in inclusive governance?
- How does women participation in inclusive governance contribute to addressing impacts of climate change in agriculture?
- How do youth contribute to addressing climate change impacts in agriculture?

- What are the gaps and opportunities for strengthening youth engagement in the management of climate change impacts in agriculture?

10. Existing MRV (mitigation) and M&E frameworks (adaptation). It would be useful to establish the extent to which the agricultural sector indicators have been integrated into the national M&E Framework under National Planning and the respective National Bureau of Statistics.

- What needs to be revised with respect to our MRV (mitigation) and M&E frameworks (adaptation)? Especially in relation to the NDCs?
- What are the main inclusions of agricultural sector indicators in the national M&E frameworks?
- How do these indicators align to the regional (CAADP) and global indicators (SDGs, etc)?
- Where should be the emphasis with respect to the SDG and AU 2063 indicators?
- How do you assess our overall progress towards the climate change targets?

11. How have we fared as a country in building resilience in Agriculture in vulnerable landscapes?

- What measures were implemented for building resilience?
- How successful have these measures been?
- Where there challenges in implementing these?
- What are the existing opportunities in implementing these?

12. How will you assess the performance in building resilience for gender and the vulnerable as a way of adapting to climate shocks?

- In the NDCs, what are we doing for the vulnerable?
- Any specific direction the current review of the NDCs is taking?

13. What contributions has the agriculture sector made towards achieving Ghana's NDCs?

- What are the benefits and constraints of the agriculture sector towards the achievement of Ghana's NDCs?

- Assess how NDC implementation in Ghana support the UN agenda 2030
- How NDC implementation in Ghana support the Africa Union's agenda 206314. Please suggest any reference materials that could be consulted for additional data/ information

14. What progress has been made towards low emission and climate resilient development of the agricultural sector

15. What are the opportunities in the agricultural sector to reduce women's vulnerability to climate change?