United Nations Industrial Development Organization

Climate Technology Centre & Network

Federal Ministry of Environment - Department of Climate Change

Federal Ministry of Science, Technology and Innovation – Department of Environmental Sciences and Technology

Technology Needs Assessment and associated action plan for climate change mitigation and adaptation in Nigeria's most vulnerable economic sectors

Technology Action Plan Report

Version 3.0

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List of Abbreviations

AFOLU	Agriculture, Forestry and Other Land Use
ANED	Association of Nigerian Electricity Distributors
ATA	Agricultural Transformation Agenda
BAU	Business-As-Usual
BUR	Biennial Update Report
CDM	Clean Development Mechanism
CTCN	Climate Technology Centre and Network
ECN	Energy Commission of Nigeria
FAO	Food and Agriculture Organization
FMARD	Federal Ministry of Agriculture and Rural Development
FMEnv	Federal Ministry of Environment
FMEnv - DCC	Federal Ministry of Environment's Department of Climate Change
FMITI	Federal Ministry of Industry, Trade, and Investment
FMP	Federal Ministry of Power
FMSTI	Federal Ministry of Science, Technology, and Innovation
FMWASD	Federal Ministry of Women Affairs and Social Development
FMWR	Federal Ministry of Water Resources
GCF	Green Climate Fund
GEF	Global Environment Facility
GEWE	Gender Equality and Women's Empowerment
IEA	International Energy Agency
IPPU	Industrial Processes and Product Use
MAN	Manufacturers Association of Nigeria
MMSD	Federal Ministry of Mines and Steel Development
NACCIMA	Nigerian Association of Chambers of Commerce, Industry, Mines and Agriculture
NASPA-CCN	National Adaptation Strategy and Plan of Action on Climate Change for Nigeria
NCIC	Nigeria Climate Innovation Centre
NDC	Nationally Determined Contribution
NEEAP	National Energy Efficiency Action Plan
NEMP	National Energy Master Plan
NEP	National Energy Policy of Nigeria
NESREA	National Environmental Standards and Regulations Enforcement Agency
NGO	Non-Governmental Organizations
NHSA	Nigeria Hydrological Services Agency
NIRP	Nigeria Industrial Revolution Plan
NIRSAL	Nigerian Incentive-Based Risk Sharing System for Agricultural Lending
NPCC	National Policy on Climate Change
NREEEP	National Renewable Energy and Energy Efficiency Policy

REDD+	Reducing Emissions from Deforestation and forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks
SMEs	Small and Medium Sized Enterprises
TAP	Technology Action Plan
TNA	Technology Needs Assessment
TNC	Nigeria's Third National Communication
UN	United Nations
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
WMO	World Meteorological Organization

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1. Introduction

Amid facing a number of development and climate challenges, Nigeria has requested the support of Climate Technology Centre and Network (CTCN) and United Nations Industrial Development Organization (UNIDO) for the development of a Technology Needs Assessment (TNA) and associated action plan for climate change mitigation and adaptation. This comprehensive TNA and action plan enables Nigeria to meet its climate change mitigation and adaption priorities and targets, as well as provide the guidance required by Nigeria in developing its climate finance pipeline. These documents will be used by Nigeria to implement its climate action plans, and to propose financing requests toward climate finance sources such as the Green Climate Fund (GCF). To ensure that men and women can benefit equally from actions set out in the TNA and that gender inequalities in activities and outcomes are reduced or eliminated, gender differences including different needs, priorities and interests, are taken into account throughout the entire TNA process and its outcomes.

Nigeria faces several climate change challenges that need to be addressed, especially in its vulnerable sectors. This is highlighted in Nigeria's Third National Communication (TNC) to the United Nations Framework Convention on Climate Change (UNFCCC) in March 2020 and other relevant documents. In particular, the TNC emphasizes the importance of technology transfers for Nigeria to address the impacts of climate change. Nigeria is a relatively small contributor to global greenhouse gas (GHG) emissions, with a total net national emissions amounting to 609,784 GgCO2 equivalent in 2016. According to the 2016 GHG inventory, Agriculture, Forestry and Other Land Use (AFOLU) sector was by far the largest source of emissions, with 60.1 percent, followed by the energy sector with 33.9 percent. Even though total net emissions remain low from a global perspective up to this point, addressing emissions from vulnerable sectors is critical for Nigeria as the TNC estimates that Nigeria should see its emissions increase by more than 58 percent until 2035 under a business-as-usual (BAU) scenario.

On the adaptation side, several vulnerabilities and climate risks have been identified, such as increased occurrence of droughts and floods, water scarcity, desertification, flood vulnerability and low agricultural yields, among others.

In July 2021, Nigeria submitted its updated Nationally Determined Contribution (NDC) and expressed its commitment to reducing its emissions 20 percent below the BAU scenario by 2030 unconditionally and 47% below the BAU by 2030 conditional on international support. To achieve these targets and priorities, it is crucial that Nigeria promotes technology transfer and has access to climate finance sources including the GCF. TNA aims to determine the prioritized technologies that are needed to address Nigeria's climate change challenges as well as identify activities and projects that can be the basis for funding requests to climate finance sources. The results of TNA will be beneficial for Nigeria in its pursuit of the country's commitments to the UNFCCC.

This report, therefore, will provide the Technology Action Plans (TAPs) for the prioritized technologies, which will include the necessary activities to introduce the technologies, financing options, and monitoring and evaluation methods. Similarly, it will provide an analysis of three prioritized sectors of Nigeria, namely, agriculture and land use, energy, and industry and commerce sectors. The report will also include an evaluation of each technology by providing a value chain analysis and gender assessment. This report overall will contribute to Nigeria's efforts in achieving its climate change targets and priorities, as well as contribute to establishing its climate finance pipeline.

2. Context

2.1. Overview of Nigeria

Nigeria is the largest economy in sub-Sahara Africa with a population of approximately 216 million.[1] Geographically, Nigeria is the 14th largest country in Africa with 910,770 sq.km, in which land area accounts for 910,769 sq.km and water area accounts for 13,000 sq.km.[2] Nigeria has one of the largest river systems in the world including the Niger Delta, which is the largest river delta in Africa and the third largest in the world, while most of Nigeria's land is covered by savannas and plains.[3] Furthermore, Nigeria is also characterized by three distinct climate zones, a semi-arid climate in the northern regions, a tropical savannah climate in most of the central region, and a tropical monsoon climate in the southern regions.[4]

Nigeria's economy has diversified in recent years, and the economy grew by an average of 7 percent from 2000 to 2014.[5] Even though Nigeria's real gross domestic product (GDP) growth rate fell to 2.7 percent in 2015, the country has enjoyed stable macroeconomic growth primarily led by the oil sector.[6] Yet, significant challenges remain such as food insecurity, high unemployment, and lack of access to energy, which are hampering the country's path to sustainable development.[7] As a result, 4 out of 10 Nigerians live below the poverty line with lack of access to basic services such as water and electricity.[8] The agriculture sector remains the largest sector in the economy as it contributes to 25.9 percent of the country's GDP while employing 70 percent of Nigeria's total employment.[9]

According to the World Economic Forum's 2022 World Gender Gap Report, Nigeria ranks 123 out of 146 countries on gender equality.[10] As of August 2022, women held 3.6 percent of seats in the lower house of parliament and 7.3 percent of seats in the upper house.[11] Only one woman has ever held the position of governor of any of Nigeria's 36 states.[12]

The majority ethnic groups in Nigeria - the Hausa-Fulani, Igbo, and Yoruba – make up around 60 percent of the country's population.[13] Minority groups face political, economic and cultural marginalization.[14]

The population of persons with disabilities in Nigeria was at 3.3 million - 2.32 percent of the population - at the 2006 Nigerian census.[15] Persons with disabilities face environmental, institutional, and social challenges,[16] limiting their opportunities to actively participate in society in general, and in the workforce in specific.[17]

Almost half of Nigeria's population is under the age of 15.[18] Older adults (65 years and above)

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[1] World Bank – Nigeria. 2022. Available at: https://data.worldbank.org/country/nigeria
[2] Ibid.
[3] National Geographic – Nigeria. 2022.
[4] World Bank Climate Knowledge Portal – Nigeria. 2021.
[5] World Bank – Nigeria Development Update. 2019.
[6] Federal Government of Nigeria. 2020. Third National Communication (TNC) of the Federal Republic of Nigeria.
[7] Federal Government of Nigeria. 2017. Intended Nationally Determined Contribution (INDC)
[8] World Bank. 2022. A Better Future for all Nigerians: Nigeria Poverty Assessment 2022.
[9] Statista. 2022. Agriculture in Nigeria.
[10] World Gender Gap Report 2022: https://www.weforum.org/reports/global-gender-gap-report-2022/in-full
[11] Inter-Parliamentary Union, Women in national parliaments: https://data.ipu.org/women-ranking?month=8&year=2022
[12] Dame Virgy Etiaba was the governor of Anambra state for 3 months, from November 2006 to February 2007.
[13] The World Factbook: Explore All Countries – Nigeria: https://www.cia.gov/the-world-factbook/countries/nigeria/
[14] An International Journal of Arts and Humanities. Ethnic Minorities and The Nigerian State. Page 90
[15] Nigeria-Population Census 2006: http://nigeria.opendataforafrica.org/xspplpb/nigeria-census
[16] Nigerian Country Report on Disability:http://www.disabilityrightsfund.org/wp-content/uploads/Country-Report_Nigeria_2018.pdf
[17] Models of Equal Employment Opportunity: https://doi.org/10.1300/J156v02n03_06
[18] UNICEF, Situation of women and children in Nigeria: https://www.unicef.org/nigeria/situation-women-and-children-nigeria

make up 3.1 percent of the total population.[19] Seventy-five percent of children live in poverty,[20] while 40.1 percent of Nigeria's total population lives below the poverty line.[21] 31 per cent of the adult population in Nigeria are illiterate.[22]

2.2. Climate change in Nigeria (mitigation and vulnerability profile)

Nigeria faces several climate change challenges that require immediate attention. Climate change has impacted the country's vulnerable sectors, especially agriculture and water resources, which are crucial for Nigeria's economy and sustainable development. According to the 2017 Climate Change Vulnerability Index, Nigeria is ranked as one of the ten most vulnerable countries in the world, with exposure to extreme climate events such as droughts, floods, sandstorms, and heat waves.[23] In particular, floods have been a recurring climate-related hazard in Nigeria, negatively affecting the Nigerian economy, agriculture, trade, and infrastructure.[24] Moreover, increased coastal flooding due to sea level rise has led to coastal erosion, severely impacting human settlements, coastal infrastructure, human health, as well as the overall economy.[25] Droughts and desertification has also become more frequent, resulting in crop failures and loss of livestock, which in turn is threatening the food security of Nigeria.[26] As a result, climate change impacts have been negatively affecting Nigeria's development, public heath, daily life of citizens, as well as the economy, and this trend is expected to continue if climate change issues are not being addressed.

In terms of mitigation, Nigeria's national emissions totaled 609,784 GgCO2 equivalent in 2016, which makes Nigeria a relatively small contributor to global GHG emissions. Based on the latest GHG inventory conducted in 2016, the AFOLU sector was the highest source of emissions with 366,733.9 GgCO2 equivalent, which represents approximately 60.1 percent of total national emissions. This was followed by the energy sector which was responsible for 33.9 percent of total emissions with 206,453 GgCO2 equivalent, the waste sector with 23,330.3 GgCO2 equivalent (3.8 percent), and the remaining 13,267.1 GgCO2 equivalent (2.2 percent) from Industrial Processes and Product Use (IPPU).[27] In this regard, the TNC estimates that Nigeria should see its emissions increase by more than 58 percent until 2035 under a business-as-usual (BAU) scenario. Nigeria needs to address these socio-economic and environmental challenges imposed by climate change, as climate change is expected to severely impact Nigeria's vulnerable populations including women, children, the elderly, and persons with disabilities, hindering the sustainable development of the country.

2.3. Climate change policy context in Nigeria (existing mitigation and adaptation actions)

Nigeria is committed to addressing climate change impacts and has been actively engaged in international climate change negotiations since becoming a Party to the UNFCCC in 1994 and ratifying the Kyoto Protocol in 2004. To date, Nigeria has submitted its first (2003), second (2014), and third national communications (2020) as well as its first Biennial Update Report (BUR) in 2018. Nigeria has recently updated its NDC and its second BUR and submitted these documents to the UNFCCC in 2021.

In addition to the above, Nigeria has also formulated several policies related to climate change, expressing its aim to foster a low-carbon, high-growth economic development path and build a

[19] Tanyi, Perpetua, Pelser, Andre, Mbah, Peter 2018/12/03 Care of the elderly in Nigeria: Implications for policy, VL - 4 10.1080/23311886.2018.1555201 Cogent Social Sciences
[20] UNICEF, Situation of women and children in Nigeria: https://www.unicef.org/nigeria/situation-women-and-children-nigeria
[21] World Bank data: https://data.worldbank.org/indicator/SI.POV.NAHC?locations=NG
[22] FAWCO 2021
[23] Maplecroft. 2017. Climate Change Vulnerability Index
[24] World Bank Climate Knowledge Portal – Nigeria. 2021.
[25] Ibid.
[26] Ibid.
[27] Federal Government of Nigeria. 2020. Third National Communication (TNC) of the Federal Republic of Nigeria.

climate-resilient society. For instance, the National Policy on Climate Change (NPCC) in 2013 identifies climate change as one of the major threats to economic development goals and food security, while indicating various adaptation and mitigation measures to integrate the threats of climate change into national sustainable economic development strategy in Nigeria. The 2020 National Action Plan on Gender and Climate Change has the goal of ensuring that national climate change processes in Nigeria mainstream gender considerations to guarantee inclusivity of all demographics in the formulation and implementation of climate change initiatives, programs and policies. Two of the action plan's priority sectors – agriculture, forestry and land use and energy and transport – align with the priority sectors of the TNA.

According to Nigeria's updated NDC, Nigeria aims to reduce its emissions 20 percent below the BAU scenario by 2030 unconditionally and 47% below the BAU by 2030 conditional on international support. In its first NDC (2017), specific measures to achieve the country's climate change objectives are identified, ending gas flaring by 2030, installing 13 gigawatt (GW) of off-grid solar photovoltaic (PV), using efficient natural gas electricity generating plants, achieving 2 percent in energy efficiency per year and leading to 30 percent by 2030, shifting to intermodal transport towards mass transportation, improving electricity grid, and implementing climate smart agriculture and reforestation. The first NDC also includes strategies for key sectors that are critical in meeting climate change adaptation objectives in Nigeria. These sectors include agriculture and land use, energy, and industry and commerce, which are also aligned with the three priority sectors in scope of the TNA. To implement these strategies and achieve the country's climate change objectives, however, it is crucial for Nigeria to gain access to climate finance.

2.4. Objectives of the Technology Action Plan

Nigeria has requested the support of Climate Technology Centre and Network (CTCN) and United Nations Industrial Development Organization (UNIDO) for the development of a Technology Needs Assessment (TNA) and associated action plan for climate change mitigation and adaptation. These will be used by Nigeria for the implementation of its climate action plans and for financing requests toward climate finance sources, such as the Green Climate Fund (GCF). The TNA will also need to respond to an intersectional analysis of gender differentials and the different needs, priorities and interests of women and men.

The TNA process is expected to support the setting up of coordination mechanisms to govern the TNA process and better coordinate climate action in the country, while at the same time achieving its Country Programming objectives. It will encompass the identification and prioritization of technologies that can support the achievement of the country's climate objectives. The TAPs for the prioritized technologies will provide the guidance required by Nigeria in developing its climate finance pipeline. It will bridge the gap among the technologies, enabling environment and investments.

3. Prioritized sectors and technologies

Prior to identifying prioritized sub-sectors and technologies, the TNA Committee was established as a coordination mechanism responsible for engaging with key stakeholders and to support the development of the TNA process. The committee includes key stakeholders from the prioritized sectors, representatives from government departments that have responsibility for policy formulation and/or regulation, private and public sector industry representatives, regulators, representatives from technology suppliers, finance, technology end users (e.g., households, small businesses, farmers) and academia. In this context, there was an emphasis on ensuring equal representation of women and men as well as participation of gender focal points and associations that promote gender equality and women's empowerment (GEWE) and other vulnerable groups, including persons with disabilities. Furthermore, throughout the TNA process,

the consulting team also made sure that there was an engagement and consultation with representations from the private sector.

3.1. Methodology

For Nigeria's TNA, the three priority sectors were selected in the inception workshop led by the Federal Ministry of Science, Technology and Innovation (FMSTI), in collaboration with Federal Ministry of Environment's Department of Climate Change (FMEnv – DCC) in September 2018. In this regard, the three prioritized sectors are agriculture and land use, energy, and industry and commerce. The three priority sectors are not only key in addressing Nigeria's development challenges but are also climate-sensitive and vulnerable to the impacts of climate change. Consequently, the sub-sectors were selected from these three priority sectors.

As part of pre-selecting the sub-sectors, all key national strategies and sectoral policies were reviewed and analyzed to identify development priorities. This process included a holistic review of climate change priorities of the country, which included NDC, Biennial Update Report (BUR), and other relevant documents. Overall, a total of 17 documents were reviewed in this process, and the sub-sectors were identified by performing a thorough assessment and desktop review of all the documents. For the agricultural and land use sector, four sub-sectors were identified, namely, crop production, livestock production, forestry, and fish production. As for the energy sector, electricity supply, energy demand and energy efficiency were identified as the sub-sectors for this sector. Finally, for the industry and commerce sector, the sub-sectors are agribusiness and agro-allied sectors, solid minerals and metals, oil and gas-related industries, and construction and manufacturing.

After identified, sub-sectors were pre-scored by the consulting team using a set of criteria to assist the actual selection and prioritization process by the key stakeholders. These criteria include, (1) relevance to development priorities; (2) potential for climate change mitigation; (3) potential for climate change adaptation; and (4) overall enabling environment, including regulatory, institutional, financial, and information. The initial scoring was further revised reflecting stakeholder feedback and input obtained through the stakeholder validation workshop and consultations. As a result, the prioritized sub-sectors were confirmed with consensus from the TNA Committee: crop production, livestock production, forestry, electricity supply, energy demand, energy efficiency, agribusiness and agro-allied sectors, solid minerals and metals, construction and manufacturing.

Based on the feedback received during the stakeholder validation workshop, a preliminary long-list of technologies was developed by the consulting team for the prioritized sectors and sub-sectors. This was followed by mitigation and adaptation TNA reports per sector, which identified how the technologies contribute to climate change mitigation or adaptation, the best practices of successful implementation of the technologies, as well as which among them could be applicable to the Nigerian context. In addition, this report was not only reviewed by the TNA committee, but also reviewed by the local experts who provided inputs to the reports based on their local expertise.

3.2. List of prioritized technologies

After the prioritized sectors and sub-sectors were confirmed with consensus from the TNA Committee, the consulting team developed the preliminary long-list of technologies. The technologies were then evaluated and scored based on the following criteria:

(a) Potential impact on climate change mitigation/greenhouse gas emissions reduction

(b) Potential impact on climate change adaptation

(c) Alignment with climate change policies and priorities

(d) Consideration of co-benefits (environmental, social, and economic)

(e) Technological constraints

(f) Readiness of Nigeria for the technology

The scoring results were reviewed by the local experts, as well as discussed during the regional workshops and finalized in the validation workshop on August 1st, 2022. The final prioritized technologies are summarized in the following table:

Table 1: List of Prioritized Technologies for the Technology Needs Assessment

Sector	Sub-sector	Technology
Agriculture and land use	Crop production	1. Climate Smart Agriculture (including drip irrigation) 2. Agricultural biotechnology (including crop diversification and new varieties) 3. Integrated Climate Change Monitoring and Early Warning System
	Livestock production	1. Selective breeding via controlled mating 2. Manure management 3. Livestock disease management
	Forestry	1. Agroforestry 2. Forest management techniques for mitigation (REDD+) 3. Ecosystem-based adaptation
Energy	Electricity supply	1. Solar PV/Concentrated Solar Power (Solar Thermal) 2. Waste-to-energy (biomass power generation) 3. Carbon Capture and Storage
	Energy demand	1. Improved cookstoves 2. Demand-side management 3. Smart grid
	Energy efficiency	1. Energy management systems 2. Energy efficient buildings 3. Energy efficiency standards and labels
Industry and commerce	Agribusiness and agro-allied sectors	1. Modular palm oil mills 2. Anaerobic digesters
	Solid minerals and metals	1. Use of alternative fuels 2. Advanced grinding technologies 3. Unhydrated cement recycling
	Construction and manufacturing	1. Shifting to renewable sources for electricity 2. Disaster-resilient buildings 3. Zero energy buildings

4. Technology Action Plans – Agriculture and Land Use

4.1. Sectoral overview

Nigeria is a relatively small contributor to worldwide greenhouse gas (GHG) emissions, with a total net national emissions amounting to 609,784 ktCO2 equivalent in 2016. Among this, however, the 2016 GHG inventory shows that the Agriculture, Forestry and Other Land Use (AFOLU) sector was by far the largest source of emissions, with 60.1 percent, followed by the energy sector.[28] Therefore, this sector is one of the prioritized sectors that needs to be leveraged in terms of climate change mitigation aspect.

The sector also experiences direct impacts of climate change and one of the most sensitive sectors to climate change. The climate change impacts for the sector include but not limited to depletion of water resources and unpredictable rainfall patterns, further impacting production system and crop productivity. Under the business-as-usual scenario, it is estimated that agricultural productivity could decline between 10 to 25 percent by 2080.[29] This loss in productivity would be detrimental to the already constrained food production to meet its domestic demand. Given its vast land, different regions face different climate impacts and need different technologies to mitigate those impacts. This point has been continuously raised by the stakeholders throughout the process of technology selection in the TNA. In this regard, it is essential that necessary measures will be taken to ensure that the sector can address both overall development and climate change challenges.

The agriculture sector, including land use and forestry, is a key driver for Nigeria's economy and the overall development of the country, since it is the main source of livelihood for most Nigerians. It is the largest sector and employer of labor, contributing approximately 27 percent to the GDP between October to December in 2020 and employing approximately 70 percent of the country's labor force.[30] Women make up a significant portion of the labor force, at 75 percent of the agricultural labor force in Nigeria. However, while there is a general lack of knowledge and skills among both women and men farmers when it comes to modern technologies, access to capital, market information and more, gender, poverty, geographical location, and disability status compound these issues.[31]

Nigeria has an abundance of land, approximately 82 million hectares, in which less than half of is currently under cultivation, presenting a transformative opportunity for Nigeria.[32] Despite this potential, the country is also a major importer of food, spending approximately USD 3 to 5 billion annually on food. This excludes technology imports to support agricultural mechanization and food processing. The sector faces two critical challenges related to sector development: the inability to meet domestic food requirements, which is a key factor in the country's food insecurity situation, and the inability to export at quality levels required for market success.[33] The two key sectoral challenges are mainly driven by outdated land tenure system that constraints access to land, a very low level of irrigation development, limited adoption of research findings and technologies, high cost of farm inputs, poor access to credit, inefficient fertilizer procurement and distribution, inadequate storage facilities and poor access to markets have all resulted in low productivity, at an average of 1.2 metric tons of cereals/ha, with high postharvest losses and

[28] Federal Republic of Nigeria. 2020. Third National Communication (TNC) of the Federal Republic of Nigeria under the United Nations Framework Convention on Climate Change (UNFCCC).

[29] Federal Republic of Nigeria. 2017. INDC.

[30] Statista. Contribution of agriculture to GDP in Nigeria from the 3rd quarter of 2019 to the 3rd quarter of 2021

[31] Federal Ministry of Environment, 2020. National Action Plan on Gender and Climate Change for Nigeria.

[32] IFC. 2020. A Country Private Sector Diagnostic: Creating Markets in Nigeria – Crowding in the Private Sector: Nigeria's Path to Faster Job Creation and Structural Transformation.

[33] Federal Ministry of Agriculture and Rural Development. The Agriculture Promotion Policy (2016 – 2020).

waste.[34] Therefore, the sector has a great potential to contribute more to the country's economy and development if those challenges and constraints are leveraged with appropriate technologies.

The agriculture and land use sector is comprised of three prioritized sub-sectors, namely, crop production, livestock production, and forestry,[35] that are summarized below.

Crop and livestock production sub-sectors – In Nigeria, increases in crop and livestock production have not kept pace with population growth, resulting in rising food imports and declining levels of national food self-sufficiency.[36] For the crop production sub-sector, this is a result of heavy reliance on rainfed agriculture, smallholder land ownership, poor planting materials and farm inputs/support such as fertilizer application, weak agricultural extension systems, and subsistence farming which generally lead to low productivity, among others.[37] For the livestock production, the low productivity is driven by low productive breeds, inadequate access to feeds and grazing lands, lack of processing facilities, low value addition and low technical inputs and extension service support in the management of the livestock and associated diseases.[38] As such, the focus of development in these sub-sectors is to achieve self-sufficiency in production for basic foods, agro-based and other industries.

While around 54 million of Nigeria's 78 million women live in rural areas and make their living off the land,[39] the fact that men are five times more likely to own land than women significantly limits production among female farmers.[40] Additionally, there is gender and age disparity regarding access to training on crop farming techniques, with women and youth disproportionately affected.[41] Cultural norms in Nigeria allow for both women and men to access livestock; however, larger animals such as cows are the responsibility of men, while women control smaller stock such as goats, chickens or rabbits as part of their household duties.[42] This smaller stock is easily disposed of to meet the family's daily food and income requirements. Not having control over the larger stock sidelines women from decision-making regarding animal products, as well as from accessing funds when the livestock is sold. Combined with the disproportionate levels of land ownership mentioned earlier, the lack of control over livestock further contributes to a woman's inability to build up physical assets.[43]

Crop and livestock production sub-sectors are also particularly important in addressing climate change. Relevant strategies have been identified in the NDC as well as in the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN). According to the TNC, the crop production sub-sector, accounted for 8.1 percent of total sectoral GHG emissions in 2016 while livestock sub-sector contributed to 7.9 percent of the total sectoral emissions.[44]

Forestry sub-sector – The forestry sub-sector is important in both meeting the development needs as well as addressing impacts of climate change. The sub-sector accounted for 2 percent of the GDP and 8 percent of the agricultural value added over the last two decades.[45] In relation to energy, the overuse of fuelwood driven by population growth in Nigeria is resulting in risk of

[34] FAO. Nigeria at a glance.
[35] Federal Republic of Nigeria. 2020. TNC.
[36] FAO. Nigeria at a glance.
[37] Ibid.
[38] Ibid.
[39] World Bank data: https://data.worldbank.org/indicator/SI.POV.NAHC?locations=NG
[40] Ibid.
[41] Ibid.
[42] Ibid.
[43] Ibid.
[44] Federal Republic of Nigeria. 2020. TNC.
[45] Federal Ministry of Environment. 2006. National Forest Policy.

deforestation. The concern on deforestation or forest degradation has been frequently raised by the stakeholders in the different regions during this TNA process. The gap in demand and supply of energy and related deforestation urgently needs to be addressed through introduction of improved forest management and forest industries as well as introduction of alternatives to fuelwood. Such measures will also mitigate adverse effects of droughts and desertification.[46] The forestry sub-sector is also the highest emitter of GHG emissions in the agriculture and land use sector, accounting for 84 percent of total emissions.[47]

While women play a vital role in forest management in Nigeria, there is evidence that the indigenous knowledge that contributes to forest management and the role of Nigerian women as drivers of change and social cohesion have been largely ignored by forest management stakeholders and REDD+ programs. Studies show that a shortage of forest products would particularly affect women's lives and livelihood, increasing their marginalization and poverty.[48]

4.2. Institutional framework

This section outlines the key stakeholders and institutions that will have important roles in implementing and scaling up the technologies that have been prioritized for the agriculture and land use sector. Key government institutions in this are presented in the table below:

Table 2: Key Government Institutions (Agriculture and land use)

Institutions	Description
Federal Ministry of Agriculture and Rural Development (FMARD)	The Federal Ministry of Agriculture and Rural Development upholds its mandate to "ensure food security in crop, livestock and fisheries, stimulate agricultural employment and services,[49]" among others. The ministry organizes and manages the sector and facilitates enabling environment to ensure the food security and agricultural business so that the sector contributes to the Nigeria's socio-economic development. It leads the entire agricultural sector in Nigeria; therefore, their involvement is essential to coordinate and ensure the participation of all the necessary actors and the dissemination of the prioritized technologies.
Federal Ministry of Environment – Department of Climate Change (FMEnv-DCC)	The Ministry of Environment, Department of Climate Change is the UNFCCC Focal Point for Nigeria and directs and oversees the governance of the TNA project as well as strategic implementation of TNA activities. It has an extensive knowledge and data in relation to agriculture and climate mitigation and adaptation, as well as associated gender concerns, priorities, and challenges. The ministry is responsible for the NDCs, and therefore leads the national strategies and policies on climate change as one of the core ministries.
National Environmental Standards and Regulations Enforcement Agency (NESREA)	NESREA is responsible for protecting and developing the environment, biodiversity conservation and sustainable development of Nigeria's natural resources. It enforces standards, regulation, laws, policies as well as guidelines regarding environmental protection and sustainable development. In light of the agriculture and land use sector, this ministry is expected to supervise the safe implementation and diffusion of the technologies.
Federal Ministry of Water Resources (FMWR)	The Federal Ministry of Water Resources is responsible for managing water supply, irrigation, freshwater, and aquaculture in Nigeria. In the context of the agriculture and land use sector, the involvement of this

[46] Ibid.

[47] Federal Republic of Nigeria. 2020. TNC.

[48] UN-REDD. The role of women as local indigenous knowledge holders in sustainable management of forests. Page 3

[49] Federal Ministry of Agriculture and Rural Development Website. Available at: https://fmard.gov.ng/who-we-are/

	ministry is especially important to promote resilient agriculture under climate change impacts such as water scarcity.
Federal Ministry of Women Affairs and Social Development (FMWASD)	The Federal Ministry of Women Affairs and Social Development upholds the mission to develop Nigerian women, children, persons with disabilities and socially excluded groups. It is responsible for advising the government on gender and children's issues. Given that women account for a relatively large part of labor force in the agriculture and land use sector, this ministry is expected to play an important role to ensure women's rights and their participation at all levels.

The following key stakeholders can also contribute to implementing and scaling up the prioritized technologies:

Table 3: Key Stakeholders in the agriculture and land use sector

Stakeholders	Description
Private sector	There is a significant number of private sector stakeholders involved in the agricultural sector and it is expected that more and more stakeholders would be involved, once the enabling environment is established. They will be key enablers and influencers in terms of financial, technical, and commercial development/diffusion of the technologies. Some of them were identified as follows. ▪ Nigerian Association of Chambers of Commerce, Industry, Mines and Agriculture ▪ Manufacturers Association of Nigeria ▪ Nigerian Incentive-Based Risk Sharing System for Agricultural Lending (NIRSAL) ▪ Nigeria Climate Innovation Centre (NCIC) ▪ Nigerian Association of Chambers of Commerce, Industry, Mines and Agriculture (NACCIMA)
Civil society	Non-governmental organizations and civil society organizations relevant to the agriculture sector will be key to the implementation of prioritized technologies. Their engagement and participation will be important for activities in the action plans such as policy formulation, awareness raising and sometimes project implementation, including financing. They are active in the fields of education, training, microcredit, and the resolution of neighborhood conflicts, that are also key to advance initiatives to defend women's rights and to advocate for an agricultural policy favorable to family farming and respectful of the environment.
Academia and research institutions	Academia and research institutions will play an important role in the identification and assessment of the technologies for agriculture. They are expected to advise stakeholders based on their scientific knowledge. They can also contribute to the post assessments on the efficiency of the technologies, as well as of their impact on farmers and environment. Some of them were identified as follows. ▪ National Water Resources Institute ▪ Center for Climate Change and Development, Alex Ekwueme, Federal University Ndufu-Alike Ikwo (AE-FUNAI)

4.3. Objectives and goals of the sector

The agriculture and land use sector is an important sector for the overall development of Nigeria. Despite the significant role the oil and gas sector plays in the overall economy, agriculture remains the base of the Nigerian economy, providing the main source of livelihood for most

Nigerians.[50] As indicated in the Agricultural Transformation Agenda and Vision 20:2020, achieving food security is a prerequisite to support the growing and projected population growth. Food insecurity disproportionately affects vulnerable populations, including households in poverty and female-headed households. Therefore, the expansion of this sector is one of the keys for country's development. Agriculture was also identified as one of the seven real sectors in the Agricultural Transformation Agenda 2011 – 2015, which was based on the Vision 20:2020, and emphasized the need to secure food and feed needs supported by development and dissemination of appropriate and efficient technologies.[51]

The National Action Plan for Gender and Climate Change prioritizes the following actions to address gender inequalities in agriculture and land use: building and strengthening institutional understanding of gender and climate change; improving agriculture-related infrastructure to adapt to the effects of climate change; enhancing local community participation; encouraging women to acquire formal advanced education in agriculture and forestry; ensuring gender-responsive budgeting; and safeguarding women's rights to land ownership.

At the same time, the agriculture sector also accounts for the largest GHG emissions, contributing to approximately 67 percent of overall GHG emissions.[52] Nigeria's NDC includes both unconditional and conditional GHG emissions reduction targets for climate change mitigation. These targets include 20 percent unconditional and 45 percent of conditional GHG emissions reduction compared to the business-as-usual level by 2030.[53] In this light, the reduction of GHG emissions in the agriculture and land use sector would be a key element to achieve the NDC targets of climate change mitigation. The NDC also includes strategies for key sectors, including the agriculture and land use sector, that are critical in meeting climate change adaptation objectives in Nigeria. The following measures were proposed for both climate change mitigation and adaptation for the agriculture and land use sector.

Mitigation measures:

- Climate smart agriculture
- Reforestation

Adaptation measures:

- Adopt improved agricultural systems for both crops and livestock
- Implement strategies for improved resource management (e.g., increase the use of irrigation systems, rainwater and sustainable ground water harvesting)
- For the forestry sub-sector:
  - Strengthen the implementation of the national Community-Based Forest Resources Management Program;
  - Support review and implementation of the National Forest Policy;
  - Develop and maintain forest inventory system;
  - Provide extension services; and
  - Improve management of forest reserves and enforce impact logging practice

In the agriculture, forestry and land use sector, several key strategies highlight the need to

[50] FAO. Nigeria at a glance.

[51] Government of Nigeria. The Transformation Agenda 2011 - 2015.

[52] Government of Nigeria. 2018. BUR 1.

[53] Government of Nigeria. 2017. INDC.

provide access to improved seeds, fertilizers, and appropriate technologies, such as irrigation systems and finance, to enhance food security in Nigeria. They also emphasize that improving agriculture is a central part of Vision 20:2020 and that the ambition laid out in Agricultural Transformation Agenda (ATA) cannot be met without climate smart agriculture.

The long-term development of the sector is guided by several medium-term plans, such as the Agricultural Promotion Policy and the Agricultural Transformation Agenda, each working to solve the core issues at the heart of limited food production and delivery of quality standards. For three out of the four sub-sectors, namely, crop production, livestock production, and fish production, development policies support achieving self-sufficiency in the production through access to inputs, services, and technologies.

For the forestry sub-sector, the National Forest Policy is in place to address the large gap between demand and supply of fuelwood, highlighting the large dependence on fuelwood to meet its energy demand, mainly for the rural population. Over-dependence on fuelwood is increasing the risk of depleting the forest and woodland reserves in Nigeria. It has been estimated that the country's 15 million hectares of forest and woodland reserves could be depleted within the next 50 years.[54] This is expected to drive further impacts on the environment, such as soil erosion, desertification, loss of biodiversity and flooding, among others.

In addition to considering these objectives mentioned above, a local-level, in-depth gender analysis is recommended during the design phase of any program aiming to roll-out the prioritized technologies. A gender analysis will examine the roles and responsibilities; needs, priorities and interests; access to power and resources; and power dynamics of women, men, girls, and boys within communities, allowing stakeholders to design contextualized gender-equitable programs. Gender expertise and guidance is necessary through the design, implementation, monitoring, and evaluation of prioritized technology policies and programs.

A summary of policy objectives for the four sub-sectors are summarized in the table below.

Table 4: Summary of objectives in the agriculture and land use sector

Sub-sector	Objective
Crop production	▪ To make Nigeria self-sufficient in the production of crops, including domestic and export crops
Livestock production	▪ To make Nigeria self-sufficient in the production of livestock products ▪ To improve the nutritional status of Nigerians through the domestic provision of high quality, protein-rich livestock products ▪ To provide locally all necessary raw material input for the livestock industry ▪ To allow for a meaningful and efficient use of livestock by-products ▪ To improve and stabilize rural income emanating from livestock production and processing ▪ To effectively protect the rural livestock farmer from the unpredictable risks ▪ To provide rural employment opportunities ▪ To effect proper land use and maintenance of ecosystem for expanded livestock production
Fish production	▪ To achieve self-sufficiency in fish production within five years ▪ To develop and modernize means of fish production, processing, storage and marketing by the adoption of improved technology and management practices ▪ To promote export trade in shrimps, crabs, oysters, periwinkles, and shark fins

[54] Federal Republic of Nigeria. 2014. National Energy Masterplan. Energy Commission of Nigeria. FMST.

	▪ To improve the quality of life in fishing villages through provision of infrastructure and basic utilities ▪ To provide and improve employment opportunities in rural areas ▪ To accelerate research on all aspects of fisheries ▪ To consolidate and improve existing training programs ▪ To promote fisheries curricula in the nation's institution ▪ To ensure proper utilization of all agro-industrial by-products ▪ To encourage private entrepreneurs through training and provision of credit for the development ▪ To rapidly develop aquaculture
Forestry	▪ Forest management: (1) to increase the total area under sustainable forest management to 25 percent of the nation's land area; and (2) to encourage forest industries to establish plantations to meet at least 60 percent of their raw materials' requirements ▪ Forest industries: to develop gender-responsive strategies for waste reduction and utilization at all stages of industrial activities ▪ Agro-forestry: (1) to help eradicate hunger through basic, pro-poor food production systems based on agroforestry methods of soil fertility and land regeneration; (2) to lift more rural poor from poverty; (3) to advance health and nutrition of the rural poor through agroforestry systems; (4) to conserve biodiversity through integrated conservation based on agroforestry technologies; (5) to protect watershed services through agroforestry; and (6) to assist the rural poor to better adapt to climatic change and to benefit from emerging carbon markets, through tree cultivation ▪ Wood fuels: (1) to ensure sustainable supply of wood fuels; (2) to conserve and protect the environment; (3) to provide income generating opportunities to communities; and (4) to promote viable alternatives to wood fuels ▪ Drought and desertification control: (1) to reduce the rate of desertification in the country; and (2) to mitigate the adverse effects of droughts and desertification

4.4. Overview of the technologies prioritized in crop production (including value chain analysis and gender assessment of technologies)

In the crop production sub-sector, the prioritized technologies are climate smart agriculture (including drip irrigation), agricultural biotechnology (crop diversification and new varieties), and integrated climate change monitoring system and early warning system that are detailed below.

Throughout this sub-sector - considering that the majority of the agriculture workforce in Nigeria are women, but also that they have limited land rights, lower size and quality of plots, insufficient capital, and competing demands on their time due to their domestic and care responsibilities - it is vital to ensure women's participation in crop production planning, policy, and budget processes. It is also important to build on their knowledge regarding sustainable gardening, water management, and farming practices; develop their capacity on the relevant technologies; improve their productivity and time and work burdens; remove financing barriers; and develop opportunities for women farmers to participate in, and move upward in the sustainable value chains. Additionally, building the capacity of women farmers may lead to increased production and therefore increased income, offering them greater resilience towards climate change.

4.4.1. Climate smart agriculture (including drip irrigation)

The Food and Agriculture Organization (FAO) defines climate-smart agriculture as "an approach that helps guide actions to transform agri-food systems towards green and climate resilient

practices."[55] It is an approach which involves a range of elements which must be embedded in local contexts. It relates to measures both on-farm and beyond the farm. As pointed out by several stakeholders in the technology validation workshop, the concept of climate smart agriculture covers several different technologies. Thus, it is important to define the concept and scope to effectively implement it. Some of climate smart agriculture practices relevant to the Nigerian context, including drip irrigation that is specifically prioritized, are detailed in the table below.

Table 5: Climate-Smart Agriculture Practices

Climate smart agriculture practices	Description
Crop production and soil management	Crop production needs to become more resilient to the impact of climate change. Climate smart crop production practices provide options which support sustainable food production, while at the same time, reducing negative impacts of climate change. ▪ Conservation agriculture: Conservation agriculture is a response to sustainable land management, environmental protection and climate change adaptation and mitigation. In many cases, conservation agriculture has been proven to reduce farming systems' GHG emissions and enhance their role as carbon sinks. It encompasses three main principles, defined by the FAO; minimum soil disturbance; soil protection by crop residues and/or cover crops; crop rotation and plant diversification.[56] Fundamentally it avoids tillage, thus, technologies such as no-till drills and direct seeders are necessary. ▪ Soil moisture conservation (mulching and conservation): Soil moisture conservation enhances the productive capacity by minimizing the amount of water lost from the soil. Mulching is a simple technique that buffers soil temperature and helps the soil-crop system reduce evaporation and the mineralization of organic matter. Mulching also counteracts the nutrient loss. Conservation tillage, which is also included in conservation agriculture practices, aims at reducing the tillage to increase the soil capacity to absorb and retain water. ▪ Precise management of nitrogen: Nitrogen is a nutriment crucial to the production of most crops. However, over-application of fertilizers may lead to the mineralization of nitrogen, therefore threatening food and water security. The precise management of nitrogen involves delivering nutrients to the plant in times of peak demand, in order to avoid using too much mineral fertilizers, which will reduce productivity of the soils. This might be supported by the use of nitrogen-fixing crops. Nitrogen management is also facilitated by conservation agriculture and precision agriculture technologies. ▪ Crop diversification: This technology will be detailed in the next section. ▪ Use of precision technologies for crop management (precision

[55] FAO, Climate-Smart Agriculture. Available at: https://www.fao.org/climate-smart-agriculture/en/
[56] FAO, Conservation Agriculture. Available at: https://www.fao.org/conservation-agriculture/en/?msclkid=783d3d53cf6011ec967dd4218e812234

	agriculture): Recording technologies and reacting technologies can support crop management, such as moisture and yield management. For example, soil mapping, soil moisture mapping, canopy mapping, yield mapping may be drawn from data gathered from sensors mounted on ground-based stations, rolling, airborne or satellite platforms, and spatial information. Technologies can also support the application at a variable rate of water (via irrigation), and other inputs, such as seeds, fertilizers and pesticides, therefore contributing to the management of nutriments and soil moisture conservation. Recording technologies can be used as a standalone system, while reacting technologies require data recording to be used. Both require Global Navigation Satellite Systems as a prerequisite.
Water management	Options for the adaptation to climate change in water management in the agriculture sector include water storage and irrigation schemes, among others. ▪ Drip irrigation: Drip irrigation refers to an agricultural system whereby water is delivered directly to plants through a number of emission points called "drippers".[57] This can lead to efficient use of water supply and reduction in water demand, which can help farmers adapt to climate risks such as droughts and extreme heat. ▪ Water harvesting: Water harvesting is the accumulation and storage of water / rainwater runoff for reuse before it reaches the aquifer or evaporates. Rainwater conservation and harvesting for agriculture use provides opportunities to reduce the high risk of yield losses associated with low rainfall and uneven distribution throughout the season. ▪ Smart Irrigation: Smart irrigation refers to an irrigation technology with IoT sensors. It allows farmers to automate their irrigation processes and enhance efficiency of water use. The sensors placed in the field, send real-time data to a central gateway that then automatically switches on a water pump whenever moisture or temperature values are outside the predetermined range. Wireless low-power networks are used to empower IoT sensors. The entire smart irrigation system can be managed by an end user through a custom cloud-based platform or mobile application. Conventional irrigation systems (e.g., sprinklers, center pivots, drip-irrigation, micro-irrigation) can be combined with IoT sensors and reinforced as a smart irrigation system.
Energy management	Within the context of climate smart agriculture, energy management aims at decreasing agriculture and food production's dependence on fossil fuels. Some of the technologies identified include: ▪ Solar pumps: The introduction of solar pumps would allow to replace fossil fuel-based generators with solar-based generators. ▪ Low carbon cold chain: Cold chains allow to better preserve agricultural productions for a longer

[57] CTCN, "Drip Irrigation" Available at: Drip irrigation | Climate Technology Centre & Network

	span. A cold chain is a temperature-controlled supply chain. It enables to maintain a desired low-temperature range over a series of activities, which can cover production, storage and distribution. Conventional technologies such as dry ice and transportation via refrigerated trucks are energy intensive. Low-carbon technologies include the combination of refrigerant plates and insulation boxes. The combination of refrigerant plates and insulation boxes allows to adapt the temperature depending on the needs of the product. Some systems can be integrated in trucks, thus becoming less energy intensive.

4.4.2. Agricultural biotechnology (crop diversification and new varieties)

Agricultural biotechnology refers to a biological approach that utilizes biotechnological methods and traditional plant breeding to produce crop varieties with enhanced carbon sequestration.[58] This technology contributes to both mitigation and adaptation aspects. Regarding the mitigation aspect, for instance, genetically modified crops produced by agricultural biotechnology conserved over 14,200 million kg of CO_2 in the year 2007, which is equivalent of over 6 million cars.[59] Therefore, it can potentially contribute to the reduction of GHG emissions from the agricultural sector, which accounts for the largest GHG emissions in Nigeria. On the other hand, it can contribute to diversifying crops and introducing new varieties, which can reduce the farmers' dependence on a single crop for income generation and enhance farmers' ability to adapt to climate change. Furthermore, it can introduce crops that are resistant to droughts, pests, and heat stress, which are all challenges faced by the agricultural sector in Nigeria. A gender-responsive roll-out of these technologies can improve the quality of life for women farmers, increasing their income and reducing the time spent on weed and pest control. Approaches should ensure that women and men participate at all levels of crop management including the decision-making around crop selection; inclusion in agricultural biotechnology research; representation in extension services and farmers' associations; access to resources for crop adoption and cultivation; and control over post-harvest crop and income management. Gender expertise and guidance is necessary through the design, implementation, monitoring, and evaluation of prioritized technology policies and programs.

Some of the varieties of biotech crops are listed below.

Table 6: Varieties of biotech crops

Variety	Description	Mitigation Function	Adaptation Function
Insect resistance crops	Refers to crops resistant to pests/insects which will be expected to occur more frequently. It requires fewer pesticide too, thus will result in reducing CO2 emissions caused by fossil-fuel based machines (e.g.: tractors) when applying pesticide, for instance.	Yes	Yes
Drought resistance crops	Refers to crops carrying genes for water-stress management. Some of the varieties that are available include rice, wheat, maize, sugarcane, tobacco, Arabidopsis, groundnut, tomato, potato, soybean, papaya and cotton.[60]	N/A	Yes
Heat tolerant	Refers to crops that are tolerant to the increased heat	N/A	Yes

[58] UNEP "Technologies for Climate Change Mitigation-Agricultural Sector"
[59] CTCN "Crop varieties with enhanced carbon sequestration." Available at: https://www.ctc-n.org/technologies/crop-varieties-enhanced-carbon-sequestration
[60] ISAAA, "Pocket K No. 43: Biotechnology and Climate Change" Available at: International Service for the Acquisition of Agri-biotech Applications (ISAAA)

crops	stress causing several damages such as increased plant mortality, fewer production, improper/inadequate growth (color and/or shape) and immaturity.		
Herbicide tolerant crops	Refers to crops enhanced herbicide tolerance. Farmers can reduce the level and frequency of ploughing for weed control. This merit facilitates no- or zero-tillage, and direct seeding practices which will reduce soil erosion, therefore reduces the loss of soil carbon and CO2 emissions.[61]	Yes	N/A
Crops that stay fresh longer	Refers to fruits and vegetables that stay fresh longer period of time and contribute to reducing postharvest waste, hence reducing GHG emissions caused by incineration.	Yes	N/A

Crop diversification and new varieties refer to enhancing the resilience of agricultural systems to climate change by increasing the variety of crops by introducing new and improved cultivated species.[62] For instance it includes practices such as growing different types of crops by season and rotating deep-rooted and shallow-rooted crops. The former practice allows stabilizing production throughout the year, and at the same time, the latter allows plants to draw water from different depths within the soil, therefore enabling moisture regeneration. This technology is also effective to reduce farmers' reliance on a single crop for income generation and enhance farmers' ability to adapt to climate change. Furthermore, a study conducted in Nigeria showed that crop diversification can help farmers resist to climate change impacts, such as droughts, flooding, and pests.[63] Adoption of early maturing crop varieties, for instance, has the potential of addressing water stress and soil deterioration.

4.4.3. Integrated climate change monitoring and early warning system

Integrated climate change monitoring and early warning systems refers to an integrated communication system that makes use of forecasting, modelling, and warning systems to allow stakeholders better understand and adapt to climate change impacts and natural hazards.[64] This technology warns the possible occurrence of a natural phenomenon that could cause disasters to enhance the farmer's ability to prepare and respond to climate related risks and events, such as flooding and droughts. This technology can also enable better agricultural planning, which can lead to improved productivity.

In general, climate change monitoring system (CCMS) provides probabilistic analysis or scenarios of future climate patterns based on several varieties of climatic data such as ocean circulations, sea surface temperature, precipitation and temperature. To supplement the capacity of monitoring, the World Meteorological Organization (WMO) provides national authorities in charge of climate monitoring with the network and data for monitoring. The Food and Agriculture Organization (FAO) also provides a useful modelling system named "MOSAICC" specifically for the agriculture sector. On this web-based interface, the simulation system is available for various stakeholders to assess potential impacts of climate change.[65] It provides projections of temperature and precipitation, climate data processing tools, crop models, analysis of agro-climatic indices, hydrological models, economic models, forest modes, and visual

[61] Heather Karsten, et. al., Food and The Future Environment – Herbicide Resistant Crops. Available at: Penn State's College of Earth and Mineral Sciences' OER Initiative.
[62] Climate Technology Centre and Network (CTCN), "Crop diversification and new varieties" Available at: Crop diversification and new varieties | Climate Technology Centre & Network
[63] Christine Heumesser and Holger A. Kray (2019).Productive Diversification in African Agriculture and its Effects on Resilience and Nutrition, World Bank.
[64] CTCN, "Integrated Climate Change Monitoring and Early Warning System" Available at: Integrated Climate Change Monitoring and Early Warning System | Climate Technology Centre & Network
[65] FAO (2015). MOSAICC A modelling system for the assessment of the agricultural impacts of climate change.

representations.[66]

Early warning system (EWS), in contrast, focuses more on issuing alerts and enhancing preparedness of farmers for climate related risks and events. The United Nations Office for Disaster Risk Reduction (UNDRR) defines EWS as "the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss."[67] It also suggests that EWS should comprise four fundamental elements; 1) knowledge of the risks; 2) monitoring, analysis and forecasting of the hazards; 3) communication or dissemination of alerts and warnings; 4) and local capabilities to respond to the warnings received.[68] In terms of its implementation, usually there are two different systems, namely decentralized and centralized systems. The former is mainly operated by a network of volunteers, while the latter is often implemented by national government agencies. The demand for decentralized systems is increasing due to lower operating costs and the need to predict and monitor climate variability and potential disasters at the community level. The table below describes the EWS technologies grouped by the four key components of EWS.

Table 7:Components and details of EWS

Components of EWS	Details of potential technologies and/or techniques
Risk knowledge	▪ Geographic Information Systems (GIS) tools: GIS helps to analyze data collected by sensors and geographically reference it into maps. It assists to grasp geographical distribution of risks or hazards. The interpretation of the results and data based on GIS in agricultural sector either requires advanced trainings, access to dedicated software, or to advisory services. ▪ Risk assessment tools: Based on several thresholds (e.g.: temperature rise, days of drought, precipitations etc.), risk assessment tools assist to identify possible damages caused by those variables to the agriculture sector. Better understanding on damages will serve for better preparedness.
Monitoring / Warning	▪ Upgrading observation capacity with technologies: Predicting weather and climate change is a core element of EWS. Therefore, upgrading or introducing observation capacities, such as satellite observations, remote sensing, and on-ground weather and hydrological stations, will enhance precision of monitoring within a timely manner. ▪ Data management and sharing system: Installing a data server and climate data processing software can help weather forecasting. Interconnected data sharing system enhance data collection capacity among different agencies or communities. Access by women and small-scale producers to simple but dependable radio technologies as well as Wi-Fi / cell phone alerts is essential for decentralized monitoring system. Farm-based mini-weather stations with accessible recording devices to gather and

[66] FAO (2021). *The modelling system for agricultural impacts of climate change (MOSAICC) tool and the enhanced transparency framework (EFT)*.
[67] United Nations International Strategy for Disaster Reduction (UNISDR) (2009). UNISDR Terminology on Disaster Risk Reduction (2009).
[68] Ibid

	contribute data for micro-climates will further support meteorological, climate and hydrological monitoring networks and enable women to be key members of these EWS networks. ▪ Regional Climate modelling: With computer program and data, climate modelling simulates weather patterns over time. By conducting simulations, climate models can predict and project weather patterns under different conditions.
Dissemination / Communication	Careful consideration of dissemination channels is important to ensure that women and marginalized groups in rural areas - who often do not have equal access to technology, communication, or services- do not miss out on critical information. ▪ Telecommunication system: Conventional telecommunication tools such as phones, facsimile, community-based loudspeaker can be an option. In the occasion of disaster when basic communication tools could face communication troubles, advanced technologies such as IP phones, satellite phones, VSAT (very small aperture terminal) are other options. ▪ Radio: Depending on frequency and service area, a couple of options are available such as, solar-powered radio, convenience radio, and MCA (multichannel access radio system). ▪ Alert system: Sign-up type system issues alerts to designated recipients who have signed-up beforehand. Location-based type system issue alerts to people within an affected area. Usually, alert is disseminated through SMS and emails. Phone trees or village representatives are also effective measurements to convey alert information. ▪ Information platform: Providing incidence related information at website and smartphone application are possible solutions. Restructuring website of national metrological/hydrological stations into more user-friendly setting will help better information dissemination. ▪ Social media: It can provide information to wide range of people. A careful consideration about misinformation is needed as any actor can transmit information on social media. Youth can play an important role in disseminating information through social media.
Response capability	▪ Gender-responsive public risk awareness: Expanding common knowledge about climate related risk and how existing gender inequalities exacerbate this risk, encourages proactive response to certain incidents. Campaign, participatory learning, informal education, and school education are the four major approach of risk awareness raising. All knowledge products and materials should be developed in local languages and be gender and disability-sensitive where applicable. (For example, the use of braille in written materials, sign language during events and meetings, closed and audio captioning in videos etc.). Messaging must also take into account

	illiterate populations, especially elderly women. Care must be taken that messaging does not reinforce gender stereotypes ▪ Last-mile communication protocols: To convey early warning information and trigger necessary actions, it is important to set up communication strategy that address appropriate targets with practical messages, tailored to their unique needs. ▪ Preparedness and response capacity building: Simulation exercises, trainings, drills, checklists are helpful to clarify actions and tasks to be in the case of receiving early warning information.

The following section identifies key stakeholders instrumental to the implementation of the three prioritized technologies in the crop production sub-sector.

Public sector:

Public sector is expected to provide an enabling environment for the diffusion of the technologies. This is achieved though, but not limited to, introducing gender-responsive strategies, policies, guidelines, regulations, and various kinds of supports. In doing so, the sector needs financial assistance from international and/or bilateral development partners that will support policy formulation and capacity building activities as well as leveraging private investment.

For instance, the public sector needs to lead the diffusion of climate smart agriculture despite the fact that it will be mainly implemented by farmers or communities themselves. The role of the public sector includes but not limited to *financial support* (e.g. creating a small grant and/or loan scheme available for farmers or private sector stakeholders who will adopt the technologies etc., with special loan packages designed for women and persons with disabilities), *technical support* (e.g. developing gender-responsive guidelines, good practices and model cases for specific techniques etc.), *scientific support* (e.g. provide reliable (and sex-disaggregated were relevant) data and research output etc.), *coordination support* (e.g. promoting the technologies with cooperation of relevant ministries, including ministries that safeguard the rights of women, persons with disabilities, and socially excluded groups etc.) and *policy support* (e.g. revising land tenure laws to promote access to lands, particularly for women and members of socially excluded groups etc.).

Regarding agricultural biotechnology and climate change monitoring and early warning system, they usually require advanced scientific knowledge and a great amount of investments, thus it makes more sense that the public sector leads the diffusion with close cooperation with the private sector stakeholders such as start-up companies who are promoting more advanced services or products related to those technologies.

Capital providers:

For climate change monitoring and early warning system, the involvement from the private sector is expected to be minimal, as financial returns cannot be expected under traditional business model. In the case of adopting public private partnership, the private sector might be interested in financing such approaches. However, public sector and international organizations are most likely to finance the actions. In contrast, for climate smart agriculture and agricultural biotechnology, capital providers would be interested in investing in advancing or developing the technologies, because they can expect to commercialize or monetize the technologies. Having said that, they would probably request the public sector for financial or administrative support to minimize investment risks. Furthermore, the public sector would still need financial assistance from international and/or bilateral development partners to create an enabling environment for capital providers. All financing schemes should be gender-responsive, ensuring that women, as

well as men, have access to finance despite structural barriers such as a lack of collateral.

Research institutions:

Research institutions are highly encouraged to lead the dissemination of the technologies based on their expertise and knowledge. Especially for agricultural biotechnology, scientific research would be essential to develop crop species addressing Nigeria's specific climate challenges. Research institutions can also contribute to promote new crops by providing reliable pieces of evidence/data concerning climate resilience of new crops or cost benefits, among others. Their involvement is also encouraged to provide technical capacity building programs so that farmers and communities can appropriately apply new technologies. Technical capacity building should take into account and address gender and location differentials around mobility, access to information, and literacy. Furthermore, for climate change monitoring and early warning system, research institutions can provide their analysis on data of climate variables which will be a core element in effectively implementing the technology.

Technology providers:

Technology providers are mainly contractors that have the required skills and expertise in providing facilities/equipment for the technologies, technical instructions, and data collection/analysis. Since all technologies involve varieties of measures and facilities, there is a great room that Small and Medium Sized Enterprises (SMEs) or start-ups of Nigeria will take some part of the provision of technologies. Non-Governmental Organizations (NGOs) and communities can be also technology providers. For instance, they can support the EWS's phase of last mile communication and preparedness, because they may have the extensive knowledge of local communities and its characteristics, which is useful for enhancing localized response capacity towards possible climate threats. Regarding climate smart agriculture as well, NGOs can provide technical assistance, when possible, through opportunities such as hands-on technical demonstrations and workshops. Working with women or youth-owned SMEs, and through women or youth-owned or run community-based organizations, will ensure a fair representation of women, youth, and other groups. Supporting internships or job shadowing programs increase the technical knowledge of women and youth.

Communities and farmers:

Local communities and farmers will be the main implementers of the technologies. For effective implementations, they should be well informed about the benefits and risks, if any, of the technologies, and sufficiently be supported technically and financially. This is the case especially for climate smart agriculture and agricultural biotechnology because these two technologies are mainly applied on farms. Regarding climate change monitoring and early warning system, in some cases, local communities themselves can collect and monitor the necessary climatic data and/or land conditions, and prepare themselves for a future catastrophe when adequate skills and equipment are available. At the phase of response action based on EWS, men and women may have distinct roles in their community considering traditional gender norms, therefore it is critical to design EWS to address to targets at-risk appropriately and trigger necessary actions. These norms could include women's higher illiteracy rates, lower mobility rates, and limited access to communications technology. Gender roles often lead to women not being able to make decisions for their households and/or taking the responsibility for the elderly, ill, and very young in case of a climate emergency.

4.5. Overview of the technologies prioritized in livestock production (including value chain analysis and gender assessment of technologies)

In the livestock production sub-sector, the prioritized technologies are selective breeding via controlled mating, manure management and livestock disease management that are detailed

below.

When considering the roll-out of livestock production technologies it is important to conduct a local-level gender analysis, as women's roles within livestock production systems differs from one area to the next and the distribution and ownership of livestock between women and men is strongly related to social, cultural and economic factors. However, as mentioned earlier, typically in Nigeria, larger animals are the responsibility of men, while women control the smaller stock. This leaves women out of vital decision-making, asset control, knowledge-sharing, and income-generation activities. It is therefore important to intentionally incorporate women farmers into policy and project design, implementation, capacity building, and financing activities to ensure that they are not left behind. Gender expertise and guidance is also necessary through the design, implementation, monitoring, and evaluation of prioritized technology policies and programs.

4.5.1. Selective breeding via controlled mating

Selective breeding via controlled mating is a technology for a systematic form of breeding in order to improve productivity and breed animals that are more resilient to climate change impacts.[69] This technology can enhance an animal's tolerance to climate change impacts, such as heat stress, droughts, pests and diseases, therefore will lead to improve or maintain livestock health, and quality and quantity of products. Furthermore, it can increase fertility rates and decrease mortality rates, which lowers the risk of farmers losing animals due to climate change impacts. Despite being considered mainly as an adaptation measure, this technology can contribute to cutting GHG emissions by promoting species that emit less methane from the rumen.

The goal of this technology can be categorized into two different types, namely increasing animal's resilience to climate change impacts and decreasing impacts to climate change caused by animal activity.

Given the impacts of climate variables, the first goal aims to increase the resilience of animals. For instance, in the livestock sector, temperature rise, which leads to excavated heat stress to animals, is one of the most serious climate change impacts that has been continuously worsening. High temperature affects animals and reduce their feed consumption, which will lead to poorer growth or less production. For example, some dairy cattle produce less milk if the average temperature beyond above 21 degrees Celsius. Furthermore, the fertility rate drops under high temperature.

For the latter goal, several pieces of study propose producing cows or sheep who belch less methane from rumen by selective mating, as the gene related to methane emission from rumen can vary and can be inheritable. However, it is also a challenge to identify species that are suitable for selective breeding because it embarks from collecting data on methane emission of different individuals. Furthermore, it would take a certain amount of time to proliferate the species emitting less methane.

With this background, CTCN suggests three different approaches for selective breeding.[70]

- **Outcrossing Mating**: This approach is the mating of "animals that are unrelated for at least 4 to 6 generations back is called an outcross.[71]" This approach can be effective when the genetic variation for a certain trait appears with a high probability.

[69] CTCN, "Selective breeding via controlled mating." Available at: Selective breeding via controlled mating | Climate Technology Centre & Network
[70] Ibid
[71] Ibid

- **Linebreeding**: This approach refers to a breeding closely related individuals (such as half-brother/half-sisters, cousins) to create a new species with an exceptional trait. This approach causes lower probability of harmful genetic defects than inbreeding.[72]
- **Inbreeding**: This approach is mating directly related animals (such as full siblings). This approach is a way to fix desired traits, while it has higher chances of genetic abnormality.[73]

When applying this technology, a careful consideration should be made on animal welfare and bioethics because it might harm animals in return of producing certain traits contributing to climate change. Furthermore, it may potentially cause an irreversible risk to remove some of genes from the overall genetical pool, which may lead to new weaknesses among animals such as diseases.

4.5.2. Manure management

According to the FAO, manure management is a practice to "ensure the recovery and recycling of nutrients and energy contained in manure and improvements in energy use efficiency along supply chains" for climate change mitigation.[74] Livestock manure and urine would significantly contribute to emissions of nitrous oxide (N2O) and methane (CH4), that has nearly 300 times and 25 times the global warming potential of carbon dioxide respectively, when they break down under anaerobic conditions where manure is stored in large piles or settlement ponds.[75] Therefore, managing manure would be crucial as a climate change mitigation measure in the livestock sector. In this regard, the TNC and BUR1 have pointed out that poor manure management was responsible for approximately 10% of total emissions from livestock in 2016 in Nigeria. It also suggests that manure management has the potential to reduce carbon dioxide emissions by 4.2% and methane emissions by 9.2%.[76]

Although manure management mainly addresses climate change mitigation and has limited adaptation impact, the outputs of manure management such as biogas and compost may have considerable adaptation impact, such as improved access to energy and food security.

Generally, there would be three different types of measures for manure management; 1) reducing livestock urinary nitrogen, 2) reducing GHG emissions from livestock manure, and 3) using manure to capture and use methane.[77] The following table details the example of manure management.

Table 8: Examples of manure management

Type	Measures
Reducing livestock urinary nitrogen	▪ Selective breeding: This measure aims to reduce urinary nitrogen by promoting animals with improving protein efficiency, which will lead to less nitrogen discharged as manure.

[72] Ibid
[73] Ibid
[74] Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. (2013). *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities*. Food and Agriculture Organization of the United Nations (FAO), Rome.
[75] Department of Primary Industries and Regional Development, Government of Western Australia. Managing manure to reduce greenhouse gas emissions
[76] Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. (2013). *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities*. Food and Agriculture Organization of the United Nations (FAO), Rome.
[77] Department of Primary Industries and Regional Development, Government of Western Australia. Managing manure to reduce greenhouse gas emissions

	▪ Balancing the protein and energy ratios though managing feeds[78]: This measure aims to reduce nitrous oxide from manure by balancing the protein and energy ratios. First, it is suggested to identify the protein levels and energy requirements (metabolizable energy) of fodders. If crude protein concentration in the diet is excessing the required level of animals, the exceeded amount of protein will be discharged as manure or urine becoming a source of nitrous oxide. To balance the protein and energy ratios, one option is providing additional source of energy, ideally high energy forages that are low in protein (e.g., oats, pellets and wheat), to enable animals to process the excess protein.
Reducing greenhouse gas emissions from livestock manure	▪ Manure stockpile aeration and composting: Stockpiling of manure is a popular measure to store manure under aeration and use as bedding/litter until it can be applied as fertilizer. It can store GHG in the soil and reduce its emittance. ▪ Adding urease inhibitors to manure stockpiles: Urease inhibitors are chemical additives that stop or reduce the rate that urea is converted to nitrous oxide.
Using manure to capture and use methane	This type usually aims to collect and use manure, hence reduce methane emission from manure. When applying this type, the amount of manure collected and operation of collection should be effectively designed, because it usually requires large amount of manure. This type could be a stable source of biomass/renewable energy and has a commercial potential by selling by-products (e.g., electricity and fertilizers). ▪ Methane fermentation: Refers to ferment flush manure under anaerobic environment to produce methane gas which will be burned and generate heat and electricity. ▪ Incineration: Refers to burn dried manure (mainly broiler manure) to generate heat and electricity. The by-product can be used as fertilizer. ▪ Carbonization: Refers to burn manure with less water to produce charcoal for improving soil health. ▪ Anaerobic digestion: Refers to a practice to digest organic wastes including manure in anaerobic conditions to accelerate de-composition of waste materials without emittance of methane gas. Depending on its modality, several different systems are available.[79]

4.5.3. Livestock disease management

Livestock disease management has two key components, namely prevention measures (biosecurity) measures and control measures taken once infection is observed. [80] This technology contains several different measurements, and they can be implemented at national,

[78] Sophie Folder, Tas Farming Futures (2015). "Getting the balance right – managing protein and energy ratios in feed for reduced livestock emissions"
[79] Douglas W. Hamilton, Oklahoma State University (2017). "Anaerobic Digestion of Animal Manures: Types of Digesters."
[80] CTCN, Livestock disease management | Climate Technology Centre & Network

regional, or farm level. Climate change impacts such as increasing frequency of heat stress, drought and flooding events can lead to increased spread of existing vector-borne diseases and macro-parasites, along with the emergence of new diseases. In this regard, livestock disease management can increase the animals' resistance to these threats. Despite being considered mainly as an adaptation measure, this technology can contribute to cutting GHG emissions by improving the animals' resilience to diseases, which can reduce animal loss and improve the efficiency of the farm.

Prevention (biosecurity) measures refers to a set of measures to protect animals from infection diseases, pests and weeds by managing the risks and spreading of infections. The examples of on-farm level measurements can be found in the following table.

Table 9: Example of prevention measures[81]

Measure	Description
Managing farm inputs	▪ Managing livestock: Refers to practices such as health checking of animals, isolating newly introduced animals before integrating them with others, separating vulnerable animals from animals at unknown health status. ▪ Managing stockfeed and water: Refers to practices such as inspecting stockfeed before unloading to detect pests, damage and contaminations, storing stockfeed properly to prevent damages, and ensuring the quantity and quality of water provided. ▪ Managing manure: Refers to practices such as capturing and storing manure and urine, especially high-risk species. ▪ Managing bedding: Refers to practices such as keeping beddings dry and vermin free, and disposing bedding when necessary.
Managing movement of people and goods	Refers to practices such as setting designated areas for visitors to clean boots and equipment before entering and leaving farms, and registering and recording visitors.
Managing farm practices	Refers to practices such as regular animal inspection, health checking of animals, understanding signs of sickness or deaths, planting vegetation or installing windbreaks to minimize effluent transfer, not-transporting or moving sick/unwell animals to prevent disease transfer. Advanced options using IoA (Internet of Animals) tools are also available to innovate livestock management. Examples include but not limited to: ▪ E-tags (EID: Electronic identification) enable to identify and monitor individual animals via tags attached to animals and software. ▪ Wearable devices that can automatically monitor several biological variants (such as temperature and times of rumen), and record data through devices attached to animals while reducing farmer's burden for animals' health monitoring. ▪ Motion sensors that are equipped to barns can effectively detect unusual animals' movement which can be a signal of animal's desires such as hoof disease.

[81] Animal Health Australia (2018). National Farm Biosecurity Manual Grazing Livestock Production

Managing wild animals, pests, and vermin	Refers to practices such as weed controlling, installing fences to prevent feral animals entering farms, increasing frequency of health check of animals, securely storing manure/urine disposal areas to keep away livestock and feral animals.
Training and preparedness	Refers to practices such as ensuring farmers to understand basic biosecurity knowledge and necessary first responses, introducing periodical check to identify sick and injured animals.

Along with the on-farm practices detailed in the table above, other preventive measures are also available such as DNA fingerprinting, genome sequencing and antiviral medications.

Control measures refer to a set of measures to suppress infections or diseases in short term and eradicate them in long term. In order to effectively implement them, four main aspects are needed to be considered, namely, 1) epidemiological factors (e.g., affected species, zoonotic potential, and transmissibility etc.), 2) ecology (e.g. location, habitat, season etc.), 3) technical and human resources, and 4) socio-economic factors (e.g. economy, culture, regulation etc.).[82] The measures should be carefully placed depending on each situation, since, in many cases, they affect livestock operations and farmers economically and socially. Some of the potential measures are detailed as follows:[83]

Table 10: Example of control measures

Measure	Description
Movement control or restriction	Refers to immediately place quarantine on suspect premises upon identification of suspect cases while tracing back the movements of suspect animals.
Stamping-out, slaughter or pre-emptive slaughter	Refers to a series of actions including slaughter of suspect animal on the infected premises or areas, followed by safe disposal of carcasses and disinfection of infected premises. While greatly affects famers economically, in many cases, this measure can be most cost-effective, and this is the only viable measure when untreatable epidemic by vaccination occurs.[84]
Zoning or compartmentalization	Refers to establish an extent of a zone or compartment based on geographical boundaries either to keep infected animals in a contaminated zone or to protect healthy animals in a protection zone.[85]
Vector and reservoir control	Refers to measures controlling vector (organism carrying disease agents) to prevent or eliminate vector populations, which usually includes the following four major measures[86]: 1. Habitat reduction is disrupting, eliminating or reducing areas where vectors (especially arthropods) grow such as stagnant water, flush manure and vegetation; 2. Minimizing contact is limiting exposure to arthropod vectors by restricting livestock to vector habitat and by housing livestock during peak vector activity times (especially dusk and dawn);

[82] World Organisation for Animal Health (2014). Guidelines for Animal Disease Control.
[83] Ibid
[84] William A. Geering, Mary-Louise Penrith, and David Nyakahuma, FAO (2001). Manual on Procedures for Disease Eradication by Stamping out.
[85] World Organization for Animal Health (2022). Terrestrial Animal Health Code, Chapter 4.4 Zoning and Compartmentalisation
[86] Center for Food Security and Public Health, Iowa State University of Science and Technology, College of Veterinary Medicine, and U.S. Department of Agriculture Animal and Plant Health Inspection Service (2014). FAD PReP/NAHEMS Guidelines: Wildlife Management and Vector Control For A Foreign Animal Disease Response In Domestic Livestock

	3. Chemical control is applying insecticides either to vector habitat areas or to animals, while this can be the least efficient measure to control vectors; and 4. Biological control is applying natural predators for vectors such as bacterial toxins (e.g., Bacillus thuringiensis), mosquitofish, or parasitic wasps.
Vaccination	Refers to apply vaccination or other medical measures. Vaccine can dramatically reduce disease, however, will require several technical capacities such as a specific storage system for vaccines and veterinary knowledge and skills to apply them.

The following section identifies key stakeholders instrumental to the implementation of the three prioritized technologies in the livestock production sub-sector.

Public sector:

Similar to the crop production sub-sector in the previous section, public sector is expected to provide an enabling environment for the diffusion of the technologies. This is achieved by, but not limited to, introducing gender-responsive strategies, policies, guidelines, regulations, and various kinds of supports. In doing so, the sector needs financial and technical assistance from international and/or bilateral development partners that will support policy formulation and capacity building activities as well as leveraging private investment.

For instance, public sector is expected to lead the diffusion of selective breeding via control mating and livestock disease management since these technologies may involve scientific research that cannot be afforded or managed by individual farmers. Furthermore, regulations may be effective and necessary to ensure the safety related to application of the technologies.

Capital providers:

There is a high potential of creating markets related to the selected technologies. Therefore, the involvement of private capital provider can be anticipated in the medium or long term (2030 – 2050), if enabling environment is established. For instance, manure management has commercial opportunities by commodifying by-products such as heat, electricity or fertilizers. Furthermore, livestock disease management can potentially create domestic markets, along with emergence of the idea of IoA (Internet of Animals) where information technologies are applied for better livestock management. However, in the short term (before 2025), international and/or bilateral development partners will be main capital providers to establish enabling environment for local investors. All financing schemes should be gender-responsive, ensuring that women, as well as men, have access to finance despite structural barriers such as a lack of collateral.

Research institutions:

Research institutions are highly encouraged to lead the dissemination of the technologies based on their expertise and knowledge. Particularly for livestock disease management, scientific data and knowledge are essential to minimize livestock diseases and implement control measures safely. Research institutions will greatly contribute to disease prevention too. Furthermore, they will contribute to adopt advanced techniques under selective breeding via controlled mating and manure management as well. It is also anticipated that research institutions and technology providers would work together to develop new techniques for those technologies.

Technology providers:

Technology providers are mainly contractors that have the required skills and expertise in providing equipment for the technologies and technical instructions. As all technologies involve varieties of technologies and techniques, there is a great room that SMEs or start-ups of Nigeria

will take some part of the provision of technologies. Subsidies from the government and/or international development partners as well as private investors may be efficient for SMEs and start-ups to develop new services or products and to conduct R&D for the prioritized technologies. Working with women or youth-owned or led SMEs will ensure a fair representation of women, youth, and other groups. Supporting internships or job shadowing programs increases the technical knowledge of women and youth.

Communities and farmers:

Local communities and livestock farmers will be implementers or users of the technologies. For the effective implementations, they should be well informed about the benefits and risks, if any, of the technologies, and sufficiently supported technically and financially. In livestock production sub-sector, scientific knowledge is critically important to protect animals and farmers themselves, that will lead to efficient dissemination of the technologies. In addition, indigenous knowledge or know-how inherited among Nigerian livestock farmers, especially among women, would be useful when incorporated in the process of technology dissemination. Furthermore, communities can be an enabler of the technologies. For instance, generation of bioenergy from manure requires great amount of manure constantly, therefore a single farmer may not be able to collect enough volume of manure. In that case, it is suggested to create a community-wide manure collection scheme to secure the volume.

4.6. Overview of the technologies prioritized in forestry (including value chain analysis and gender assessment of technologies)

In the forestry sub-sector, the prioritized technologies are agroforestry, forest management techniques for mitigation (REDD+), and ecosystem-based adaptation that are detailed below.

Forestry technology interventions should take into account women's and men's roles and responsibilities in forestry in Nigeria, including their access to and control over resources, education and knowledge, and involvement in decision-making. For example, in some areas, where men might be responsible for land management and the collection of wood for construction and tools, women would be responsible for seed conservation, livestock grazing, and fuelwood collection. Men and women also possess different knowledge on forests and tree species. Women’s lives and livelihoods may be disproportionately affected in case of shortages in forest products, increasing their marginalization and poverty.

4.6.1. Agroforestry

Agroforestry is the intentional integration of trees and shrubs into crop and livestock systems to create environmental, economic and social benefits. It contributes to both climate change mitigation and adaptation.

The forestry sub-sector is the highest emitter of GHG emissions in the agriculture and land use sector in Nigeria, accounting for 84 percent of total emissions.[87] In this regard, agroforestry practices can reduce GHG emissions by increasing carbon storage in biomass (both above-ground and below-ground). It can also provide a number of ecosystem services that can enhance resilience to climate change. For instance, it can improve water security by enhancing infiltration to soils and ground water, while trees can act as a buffer against floods, erosion, pests, and storms.

The common components for agroforestry are trees or other woody perennials, crops or forage, and animals. Depending on the combination of those components, three most common systems

[87] Federal Republic of Nigeria. 2020. TNC.

can be identified[88]:

- Agrosilvicultural systems: The combination of crops and trees
- Silvopastoral systems: The combination of trees and pasture and animals
- Agrosilvopastoral systems: The combination of trees, crops and pasture and animals

The selection of trees, crops and animals greatly depend on local contexts and communities' needs. However, it is suggested that the following four different perspectives for designing agroforestry.[89]

Table 11: Design Perspectives for Agroforestry

Design perspective	Description
Structural basis	This system pays a particular attention to space and time where agroforestry is practiced. For instance, adding woody species into different niches (different parts of farms and agricultural landscape) can increase diversity, sustainability and productivity.
Functional basis	This refers to the role or use of tree component, such as timber, fruit, fodder, and medicine. Typically, the inclusion of trees increases the number of products generated by agroforestry system, which then acts as a safety net for farmers. Other functions or benefits may also be important, such as the use of trees as windbreaks and prevention measures for soil erosion.
Socioeconomic basis	This refers to the purpose of the system in relation to human livelihoods, usually broken down into subsistence, commercial, and/or intermediate production systems. Agroforestry may be promoted to meet specific social goals such as poverty alleviation and food security.
Ecological basis	This refers to the suitability of the agroforestry system for a given environment. Thus, there are different types of agroforestry for tropical, temperate and arid environments that take into account the environmental, ecological and biological conditions of each area.

The common management techniques for agroforestry are summarized as in the table below.[90]

Table 12: Management Techniques for Agroforestry

Management techniques	Description
Crop diversification	Diversification is one of the most important aspects of agroforestry. It provides several different benefits inducing but not limited to, wider range of food products that leads to more stable productions, improved nutrition, risk hedging towards climate change (i.e., drought and floods, etc.), and reduction of pest attack.
Tree-crop interactions	Tree-crop interactions, that are a unique benefit of agroforestry, is a key consideration when designing an agroforestry system and a layout for planting. Basic principles include: ▪ increase the overall value of the system ▪ maximize complementarity

[88] FAO, Sustainable Forest Management (SFM) Toolbox – Agroforestry. Available at: https://www.fao.org/sustainable-forest-management/toolbox/modules/agroforestry/in-more-depth/en/
[89] Xu J, Mercado A, He J., Dawson I (eds.) (2013). *An Agroforestry guide for field practitioners.* The World Agroforestry Centre, East Asia, Kunming, China. 63 pp. Available at:http://apps.worldagroforestry.org/downloads/Publications/PDFS/B17460.pdf
[90] Ibid

	▪ decrease or eliminate competition between trees and crops ▪ minimize crop displacement, through appropriate tree management
Tree choice and planting arrangement	Choice and planting of trees, including species, place or layout, and total numbers of trees, are important to maximize the ecological benefits from trees while at the same time to reduce the potential competition with other components in an area such as crops.
Using perennial plants/crops	The use of perennial plants is less expensive in terms of inputs (e.g., time, seeds, fertilizer, and land.) compared to that of annual plants. A well-managed agroforestry system with perennial plants/corps will be able to become self-sustaining and minimize related labors of farmers.
Contour strips	Contour strips is an effective way to prevent soil erosion for sloping ground. In agroforestry practice, it is cost effective to develop contour strips with trees, grasses and/or other plants.
Soil and water conservation	Agroforestry can reduce soil erosion caused by wind and water, and prevent the runoff of sediment and potential pollutants into rivers, whilst keeping nutrients such as fertilizer in soil. Agroforestry systems slow water runoff and enhance infiltration, stabilize soil and reduce riverbank erosion.
Soil fertility management	Agroforestry systems can improve soil fertility. Leguminous trees planted as fallows or interspersed with crops can accumulate significant amounts of nitrogen in their leaves and roots, which is then made available to crops. Incorporating leaves into soil can increase crop yields several-fold.

4.6.2. Forest management techniques for mitigation (REDD+)

Forest management techniques for mitigation (REDD+) refers to the technology managing forests by either promoting afforestation or reducing deforestation to increase stand-level forest carbon stocks. [91] This technology can contribute to reducing GHG emissions from the atmosphere by slowing and halting forest loss (deforestation and forest degradation) while enhancing and conserving forest-carbon stocks. Activities under REDD+ also has the potential to improve water security by improving infiltration to soils and ground water, while trees can act as a buffer against floods, erosion, pests, and storms.

As mentioned earlier, the forest sub-sector is the highest emitter of GHGs in the agriculture and land use sector in Nigeria. In this regard, Nigeria became a partner country of the UN-REDD Program in 2010 and specifically indicates this technology in its TNC.

Generally, the forest management techniques for mitigation (REDD+) can be categorized into five different types[92], as detailed in the following table. Regarding the choice of REDD+ activities, however, a particular consideration should be made in light of the Nigerian contexts. Promoting wood products including wooden buildings can be considered as one of the techniques to enhance carbon stock as those products can store and maintain accumulated carbon for a relatively long term. However, several Nigerian stakeholders have raised a concern towards this technique given the country's serious deforestation. Therefore, it is important to select appropriate techniques that meet local conditions and stakeholders' needs.

[91] CTCN, "Forest management techniques for mitigation (REDD+)" Available at: Forest management techniques for mitigation (REDD+) | Climate Technology Centre & Network

[92] FAO, REDD+ Reducing Emissions from Deforestation and Forest Degradation – Overview. Available at: REDD+ Reducing Emissions from Deforestation and Forest Degradation

Table 13: Five categories and examples of REDD+ activity[93][94]

Category	Examples
Reducing emissions from deforestation	▪ Introduce forest monitoring systems with the application of various measures such as remote sensing and patrolling ▪ Create protection/conservation areas ▪ Create early warning systems and fire brigades forest fires
Reducing emissions from forest degradation	▪ Afforestation ▪ Reforestation ▪ Modify forest plantation management (e.g., species, genotype selections, species mixes, thinning and harvest, age structure etc.)
Conservation of forest-carbon stocks	▪ Reducing harvest intensity ▪ Lengthening harvest rotations ▪ Limiting emissions associated with management (e.g.: decreasing soil disturbance etc.) ▪ Forest monitoring through activities such as identifying species, measuring diameter and high of trees and deadwoods, tagging and marking trees. ▪ Create early warning systems and fire brigades forest fires
Enhancement of forest-carbon stocks	▪ Increasing off-site carbon stocks in wood products ▪ Optimize types of planting trees to enhance forest-carbon stocks (e.g., selectively breaded elite trees that grow faster)
Sustainable management of forests	▪ Create maps indicating land use and forest cover by several methods such as GPS, satellite imagery and participatory mapping ▪ Develop national forest inventories ▪ Establish judicial control of illegal loggings ▪ Promote sustainable selective logging ▪ Review and improve land use regulations ▪ Promote agroforestry ▪ Change agricultural activities ▪ Establish community-based monitoring systems including capacity building and awareness raising

When implementing REDD+ activities, several aspects, such as the seven safeguards for REDD+ activities[95] and the right of forest and indigenous communities, should be respected to prevent negative impacts to society, economy and environment as well as to prevent risks that harm or degrade the impacts generated by REDD+ activities.

4.6.3. Ecosystem-based adaptation

According to the Convention on Biological Diversity, Ecosystem-based adaptation (EbA) refers to “the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change.” Examples include livelihood diversification, sustainable forest management, integrated water resource management etc.[96] Though primarily an adaptation approach, EbA has the potential to reduce GHG emissions by

[93] Source: Ibid
[94] Source: Janowiak, M.; Swanston, C.; Ontl, T. 2017. Management of Forest Carbon Stocks. (2017). U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. Available at: U.S. Department of Agriculture, Forest Service, Climate Change Resource Center
[95] UNFCCC REDD+ Safeguards. Available at: REDD+ Web Platform.
[96] IUCN, “Ecosystem-based approaches to climate change adaptation” Available at: Ecosystem-based Approaches to Climate Change Adaptation | IUCN

halting habitat loss and ecosystem degradation.

EbA is a holistic strategy covering various practices with the three elements that are detailed in the following table. In contrast to heavy or grey infrastructures that may sometimes be costly to build or maintain and cause damages to the environment and ecosystem, EbA can be cost-effective and more sustaining since it takes the benefits and features of ecosystems.

Mainstreaming gender into EbA processes is one way to ensure their sustainability. This is done by identifying gender differences in adaptation needs and capacities; ensuring gender-equitable participation and influence; aiming for gender-equitable access to finance and other benefits; planning that is informed by gender analysis; engaging otherwise under-represented voices; implementing EbA actions that address gender-specific needs and capacities; gender equitable and inclusive governance of natural resources; and participatory monitoring & evaluation systems.[97]

Table 14: Elements, criteria and measures for ecosystem-based adaptation[9899100]

Element	Criterion	Examples of measure
EbA helps people adapt to climate change	Reduces social and environmental vulnerabilities	▪ Create buffer forests from perturbations (such as fire, invasive species, insects and diseases) ▪ Implement pasture management including anti-erosive measures ▪ Implement ecosystem restoration to increase infiltration of rainwater into topsoil ▪ Establish agroforestry systems to provide flexible livelihood options ▪ Introduce early warning systems ▪ Identify new markets for sustainable non-timber products such as nuts, crafts, honey and medicinal plants etc. ▪ Promote non-timber fuels to minimize the use of wood fuels ▪ Introduce alternative livelihoods aligned with ecosystem development (such as eco-tourism)
	Generates societal benefits in the context of climate change	▪ Deepen natural lakes to hold more water ▪ Restore mangroves with salt tolerant species ▪ Rehabilitate water points, watersheds and shores ▪ Manage upland wetlands to improve water flow and quality
EbA makes active use of biodiversity and ecosystem services	Restores, maintains or improves ecosystems	▪ Reforestation ▪ Afforestation ▪ Create protected/conservation areas ▪ Conserve or enhance genetic diversity of forests ▪ Modify forest plantation management (e.g., species, genotype selections, species mixes, thinning and harvest, age structure etc.)
EbA is part of an overall adaptation	Is supported by policies at multiple levels	▪ Integrate EbA into the wide range of policies for various sectors (e.g., development, land use, tourism, fisheries, forestry, agriculture, aquaculture, water

[97] Toward Gender Responsive EbA
[98] Source: UNEP Briefing Note 10 Ecosystem-based Adaptation and Forestry. Available at: UNEP
[99] Source: Global EbA Fund, What We Fund Available at: Global EbA Fund
[100] Source: Bruno Locatelli and Emilia Pramova, "Forests and Adaptation to Climate Change: What is at Stake?" Available at: World Research Institute

strategy		management, biodiversity, waste management, infrastructure etc.) ▪ Develop supply chain for value added products and premiums (e.g., providing certifications or establishing branding strategy)
	Supports equitable governance and enhance capacities	▪ Build partnerships among stakeholders for better forest management ▪ Enhance knowledge management including traditional/local knowledge, especially that of women. ▪ Conduct monitoring, evaluation, risk assessment, and research ▪ Integrate communities and vulnerable groups into land use planning (e.g., women, persons with disabilities, and indigenous groups) ▪ Introduce forest insurances

The following section identifies key stakeholders instrumental to the implementation of the three prioritized technologies in the forestry sub-sector.

Public sector:

The government is expected to provide the enabling environment through developing, reviewing, updating gender-responsive strategic and regulatory policies for the forest sector. The clear and coherent forest management strategy and policy will bring a stable basis for the technology implementation. The governmental agencies can be project implementers too. The government agencies are also expected to establish institutional coordination with different sectors such as agriculture and natural resources in order to promote the diffusion of the technologies,

Capital providers:

International or bilateral development partners, and international climate organizations would be the main capital providers for a certain period of time. Although involvement of private sector is expected to be minimal in short term (until 2025), it is not completely excluded, especially for agroforestry and ecosystem-based adaptation. For instance, a project in Kenya where a private company lends small loans to farmers in return of fulfilling conservational agroforestry practices required by the lender. All financing schemes should be gender-responsive, ensuring that women, as well as men, have access to finance despite structural barriers such as a lack of collateral.

Technology providers:

Technology providers are mainly contractors that have the required skills and expertise for the technologies prioritized. In some cases, NGOs and communities could also provide technologies such as nurturing seedlings for reforestation under forest management techniques for mitigation (REDD+). They have extensive knowledge and information about the local context. Working through women or youth-owned or run community-based organizations will ensure a fair representation of women, youth, and other groups. Supporting internships or job shadowing programs increases the technical knowledge of women and youth. When business models and markets are established, the technologies selected will provide various opportunities for the private sector too. For instance, some of the potential ideas are, a commodity business dealing with organic products produced by agroforestry using drones with increased planting speed capacity.

Communities and farmers:

It is expected that local/indigenous communities or farmers, especially women, will play a

significant role for the implementation as one of the essential stakeholders and as implementers of the technologies. This needs to be developed into a strategy and action plan in consultation with farmer group representatives, where women and men farmers are equally represented. They should be financially and technically supported by other stakeholders such as NGOs, development partners, public and private sectors. Working through women or youth-owned or run community-based organizations will ensure a fair representation of women, youth, and other groups.

4.7. Overview of barriers

The agriculture and land use sector of Nigeria faces the following barriers for the dissemination of prioritized technologies in the sector:

Table 15: Barriers in the agriculture and land use sector

Types of Barriers	Description
Political	None
Regulatory	▪ Outdated land tenure system impeding access to land*
Institutional	▪ Insufficient institutional arrangement ▪ Inefficient fertilizer procurement and distribution
Technical	▪ Insufficient technical capacity and facilities* ▪ Limited availability of climate data and land use ▪ Very low level of irrigation development
Financial	▪ High initial investment costs required ▪ Insufficient investment in the sector ▪ Lack of small finance for farmers* High cost of farm inputs
Geographical	None
Market	▪ Limited private sector involvement ▪ Poor access to markets*
Information	▪ Lack of information on all the technologies, available techniques and benefits* ▪ Weak agricultural extension systems
Behavioral	▪ Limited adoption of research findings and technologies ▪ Heavy reliance on rainfed agricultural practice ▪ High usage of wood fuels

*These issues are compounded for women farmers.

The sector faces two critical challenges related to sectoral development; the inability to meet domestic food requirements, which is a key factor in the country's food insecurity situation, and the inability to export at quality levels required for market success.[101] The two key sectoral challenges are mainly driven by outdated land tenure system that constraints access to land, a very low level of irrigation development, limited adoption of research findings and technologies, high cost of farm inputs, poor access to credit, inefficient fertilizer procurement and distribution, inadequate storage facilities and poor access to markets have all resulted in low productivity, at an average of 1.2 metric tons of cereals/ha, with high postharvest losses and waste.[102] Specifically for the forest sub-sector, deforestation and desertification are also serious challenges that are induced by high-usage of wood fuel, insufficient forest management and lack of sustainable energy resources.

In addition, Nigeria's economy entered a recession in 2020 due to falling global oil prices and

[101] Federal Ministry of Agriculture and Rural Development. The Agriculture Promotion Policy (2016 – 2020).

[102] FAO. Nigeria at a glance.

implementing measures to fight the spread of COVID-19.[103] The impacts of COVID-19 pandemic could further increase the poverty rate and reduce the country's economic and development outcomes.[104] Especially, the agriculture and land use sector where smallholder producers dominate is affected by COVID-19 and related prevention measures such as strict border controls. The impact of the limited international trade leads to several impacts including deteriorated food insecurity, increased prices of farm inputs (e.g.: fertilizers and fodder) and limited exports of wood products.

4.8.Action Plan 1: Raising awareness

4.8.1. Objectives

Raising the awareness of the relevant stakeholders such as government institutions, farmers and local communities, technology developers, end-users, potential investors, and financial institutions, will greatly contribute to the dissemination of all the technologies. This is because it will enable to develop basic understanding on the technologies among stakeholders, which lead to create an enabling environment for the technologies. In short-term (until 2025), this action plan will support the implementation and/or scaling-up of each technology. In medium (2025 – 2030) to long term (2030 – 2050), it will be effective to prepare the next steps to disseminate the technologies more widely. The importance of awareness raising has been repeatedly pointed out by the stakeholders during the technology selection workshops. To the extent possible, it is necessary to have equal representation of women and men in all awareness raising activities.

4.8.2. Activities (including cost indications)

Activity 1.1. – Awareness raising to farmers

The successful implementation of the technologies cannot be realized without the acceptance, support and participation of female and male farmers since they will be implementers and end-users of the technologies. It is therefore critical to nurture extended awareness and understanding, not only about the climate change impact on their agricultural practices, including forestry and livestock production, but also about advantages and disadvantages of using the technologies, impacts that the technologies would bring to them, and leading use-cases in different regions. Communities and farmer's associations/cooperatives would be also leveraged. This activity can be achieved through various channels such as demonstration farming, technical demonstrations, seminars, workshops, information and knowledge dissemination and other similar activities. Outreach activities under this activity must intentionally target women farmers through women-led community-based organizations, farmers' associations, women's cooperatives and more. All knowledge products and materials should be developed in local languages and be gender and disability-sensitive where applicable. (For example, the use of braille in written materials, sign language during events and meetings, closed and audio captioning in videos etc.). Messaging must also take into account illiterate populations. Care must be taken that messaging does not reinforce gender stereotypes

Activity 1.2. – Awareness raising to other relevant stakeholders

The successful implementation of the technologies also depends on availability of facilities related to the technologies and expansion of market for the technologies. In this regard, raising awareness of other stakeholders is also necessary. Technology developers would be interested in technical aspect of facilities for each technology, such as a drip irrigation facility under climate smart agriculture and how to commercialize it. The latter aspect would be of interest for financial

[103] African Development Bank. Nigeria Economic Outlook.

[104] IFC. 2020. A Country Private Sector Diagnostic: Creating Markets in Nigeria – Crowding in the Private Sector: Nigeria's Path to Faster Job Creation and Structural Transformation.

investors too. Designing a relevant market for the technologies is also important for technology developers and investors. This activity can be achieved through various opportunities seminars for various stakeholders among the sector, study visit to leading farmers or communities who have successfully introduced a technology, and other similar activities. All seminars, site visits or otherwise must, to the extent possible, aim for the equal representation of women and men.

Entity in Charge: The implementing entity for the awareness raising actions is proposed to be spearheaded by Federal Ministry of Agriculture and Rural Development and Federal Ministry of Environment with close coordination with other relevant ministries.

Costs: The costs associated with the implementation of this action is estimated at USD 30,000 - 40,000, which involves conducting workshops and trainings, engaging international experts, and deploying public awareness materials.

4.9. Action Plan 2: Capacity building

4.9.1. Objectives

Similar to the Action Plan 1, it is suggested to design this action plan to achieve the successful implementation of the technologies. Enhanced capacity will enable the technology implementation in short-, medium- and long term. In short term (until 2025), capacity building would enable decision makers and farmers to make informed decisions related to introducing the technologies. In medium (2025 – 2030) to long term (2030 – 2050), capacity building will be useful to apply more advanced techniques under the prioritized technologies.

4.9.2. Activities (including cost indications)

Activity 2.1. – Institutional and technical capacity building

This activity address to strengthen the capacity of relevant government institutions of the agricultural and land use sector. It is aimed to allow them to make informed decision to design the required gender-responsive policies such as regulations, standards, fiscal instruments and incentives, among others, to support the implementation and dissemination of the technologies. This activity will also aim to coordinate several government institutions to harmonize initiatives and strategies for better technology implementations. For instance, it can be anticipated that two different technologies under the different sub-sectors may offset each other, if institutional coordination is not realized. This is achieved though seminars, trainings, disseminating information and knowledge though information materials, and other similar activities. All seminars, trainings or otherwise must, to the extent possible, aim for the equal representation of women and men.

Activity 2.2. – Partnership building

This action aims to create various partnerships among different stakeholders to optimize each expertise and knowledge, as well as networks. For instance, the federal, state, and municipal government institutions can make partnerships for sharing or supplementing climate data that will be base information for all the technologies. Similarly, different levels of government institutions can cooperate to disseminate EWS by creating a standard protocol for issuing warning information. Partnerships among different parties can be of benefit to develop facilities and techniques for the prioritized technologies. For example, research institutions and private technology venders including start-ups and SMEs can collaborate for R&D activities such as developing climate resilient new crop varieties. The suggested activities include but are not limited to establishing memorandum of understanding and building research consortia, and creating online networking platforms for different stakeholders.

Entity in Charge: The implementing entity for the actions is proposed to be spearheaded by Federal Ministry of Agriculture and Rural Development and Federal Ministry of Environment with

close coordination with other relevant ministries.

Costs: The costs associated with the implementation of this action is estimated at USD 20,000 - 40,000, which involves conducting workshops and trainings, deploying information materials, and building online platforms.

4.10. Action Plan 3: Development of enabling environment for private sector engagement

4.10.1. Objectives

Developing enabling environment is critically important for efficient and effective dissemination of the technologies. In the agriculture and land use sector, the main implementers will be farmers and private sector stakeholders. Therefore, it is crucial to create and secure enabling environment to encourage them to take-up and scale-up the technologies and measures under each technology. The enabling environment is consisted of gender-responsive strategies, policies, regulations, standards, guidelines, adequate financing, and technical supports, among others.

4.10.2. Activities (including cost indications)

Activity 3.1. – Climate change impact assessment and potential mapping for each technology

This activity aims to identify and map potential locations to implement each technology based on assessment on climate change impacts in different regions. Although Nigeria has several pieces of data and research outputs of climate change impact on the country, it is suggested to downscale the assessment at regional level, given its unique and diverse climate conditions. Assessing climate change impact at will provide more concrete information on which issues and technologies are relevant in specific areas. That kind of information is useful not only for the government institutions but also for a number of communities, farmers, and private sector stakeholders in understanding how to best invest in the technology. Gender should be mainstreamed into all impact assessment and mapping exercises. The more localized the gender analysis is, the more relevant and useful it will be to communities and other stakeholders.

Activity 3.2. – Baseline study for identifying gaps and needs

This activity intends to conduct a baseline study to identify gaps and needs to be leveraged though activities for developing enabling environment. This activity is useful in mainly three ways because it can highlight areas and points needed to be improved or leveraged. Firstly, baseline study may be able to save financial expenditures for unnecessary activities. Usually, resources, either financial, human or technical, are not infinite, thus, it is important to invest the resources for most needed areas or technologies. Secondly, it can highlight gaps between the current situation and the future goals and inform stakeholders which gaps become priority. Lastly, the process of baseline study can be an effective opportunity for stakeholder involvement, which will lead to raise their awareness and address issues in actual agriculture and land use practices. The methods of baseline study include but not limited to reviewing relevant policy documents, interviews, stakeholder consultations, questionnaires, and surveys. Available Nigerian gender-in-climate change analyses should also be examined.

Activity 3.3. – Strategy and policy development and enforcement

This activity aims to develop and enforce relevant gender-responsive strategies and policies supporting the dissemination of the technologies at the short-, medium-, and long term. Although the government of Nigeria have been actively developing various climate change strategies and policies, it is still useful to develop strategies for diffusion of a specific technology or for the sector/sub-sectors. This is because equipping sector-wide strategies or strategies on each technology can be a signal for the private sector stakeholders that the government will commit

to disseminate a technology, therefore it can encourage new stakeholders enter the sector or market.

Compared to strategies, policies including regulations and standards need to be more specific and clearer, and ideally incentivize stakeholders to deploy the technologies. Examples include but not limited to issuing certifications for organic products by producers who practice some of the agroforestry techniques, tax breaks for city councils who implement a community-wide manure collection scheme and for smallholders who introduce the drip-irrigations technique, and developing legally binding protocols to control livestock disease outbreaks. It is also important to review and amend the existing policies such as the outdated land tenure system that may be hampering the sectoral development and improving food production.

Activity 3.4. – Guideline development

Following the development of gender-responsive strategies and policies, this activity will aim to create guidelines relevant for each technology. Guidelines can be effective to provide more detailed information and technical aspects needed for implementation of the technologies. Guidelines can supplement capacity building for farmers as well.

Activity 3.5. – Provision of adequate financing for private sector engagement

This activity intends to create adequate financing to farmers, especially smallholders, so that they will be able to invest in technologies and measures they need. Although some of the technologies and measures might be relatively affordable, smallholder producers will still require support for financing up-front costs. Based on this understanding, it is suggested to develop adequate financing measures for smallholders such as small loans. All financing schemes should be gender-responsive, ensuring that women, as well as men, have access to finance despite structural barriers such as a lack of collateral. In contrast, larger investments will require different financing schemes. For instance, forest management techniques for mitigation (REDD+) and ecosystem-based adaptation would require high volume of initial investment. Public Private Partnerships could be a way to involve the private sector in investing in these technologies. More specifically, up-front costs would be covered by grants and/or concessional financing from international resources who would then receive payments from the Nigerian government for the provision of services to producers. Furthermore, issuing bonds to the private investors would be also an option to cover up-front cost.

Entity in Charge: The implementing entity for the actions is proposed to be spearheaded by Federal Ministry of Agriculture and Rural Development and Federal Ministry of Environment with close coordination with other relevant ministries.

Costs: The costs associated with the implementation of this action plan is estimated at USD 60,000 - 80,000, which involves conducting baseline study, workshops, and trainings, deploying and disseminating guidelines, and engaging international experts.

4.11. Action Plan 4: Dissemination of technologies

4.11.1. Objectives

In this action plan, the activities are designed to focus on dissemination of each technology. While previous three action plans focus on transversal measures applicable for all the technologies, the following action plans detail more concreate activities for each technology.

4.11.2. Activities (including cost indications)

Activity 4.1. – Dissemination of climate smart agriculture (including drip irrigation)

This activity will embark from defining the concept of climate smart agriculture which include several different techniques and facilities. As design of the technology would be vary depending

on local context, it is important to tailor the concept to farmers' needs - taking into account gender differentials - and specific climate impacts. In this light the suggested steps include but not limited to stakeholders' consultations, interview, field observation, technical capacity building workshop, designing and implementing technical needs assessment and/or pilot project, and assessment of the pilot project. Based on several initial pilot projects, it will be suggested to identify good practices and guidelines to disseminate the technology to different communities and regions.

Given the very low irrigation development in Nigeria and the heavy reliance on rainfed agriculture, extension of climate-smart irrigation technology would be one of first techniques to be addressed. Climate smart irrigation, including related technologies such as water harvesting, solar water pumps and climate-smart water management, will require large up-front cost, thus will be deployed at community or farmer's association level. Providing incentives to farmers and/or communities to install efficient and climate-smart irrigation systems will be accomplished by development of policy tools such as guidelines and financial incentives mentioned earlier. It is also important to develop a market driven by the private sector, which include but not limited to R&D activities, developing locally available facilities, and creating credit scheme for farmers and/or communities. Climate smart agriculture has a high potential of improving crop productions in terms of quality and quantity, thus private sector has various market opportunities.

Activity 4.2. – Dissemination of agricultural biotechnology (crop diversification and new varieties)

In short term (until 2025), crop varieties that are already available would drive the dissemination of this technology. Therefore, farmers need to be encouraged to deploy those crops technically and financially. In addition to capacity building activities and provision of adequate financing mentioned earlier, monitoring and assessment on application of those crops will supplement effective diffusion of the technology. In medium (2025 – 2030) and long term (2030 – 2050), successful R&D lead by research institutions and private sector will support embedding the technology in the country.

Activity 4.3. – Dissemination of integrated climate change monitoring system and early warning system

While climate change monitoring system may be implemented at federal/national level due to high initial investment, analysis and application of data and information will be led by states or regional level. Therefore, institutional and technical capacity building mentioned earlier would significantly contribute to the diffusion. In contrast, early warning system can focus on diffusion at community or individual farmer level. Suggested activities include but not limited to identifying stakeholders with responsibilities and actions in the chain of early warning information, identifying most effective tools for issuing warning and creating gender-responsive preparedness plans.

Activity 4.4. – Dissemination of selective bleeding via controlled mating

The dissemination of this technology would take considerable amount of time, considering the technical complexity. In short term, technology transfer from international/bilateral partners would be anticipated with financial supports. In medium to long term, research activities led by Nigerian institutions would be a driver of the diffusion that will fit to the local context. At the same time, in short (until 2025) to medium term (2025 - 2030), livestock farmers need opportunities to enhance their technical capacity and knowledge, since the technology may replace traditional livestock species which require farmer's acceptance.

Activity 4.5. – Dissemination of manure management

The techniques under this technology can be implemented at two main levels, either at farmer or farm level, or at community or farmers' group level. It is imperative to ensure that women and

men farmers actively and equitably participate at both levels. For both types of implementations, external technical and financial supports are needed. At the farmer level, it is suggested to manage manure though livestock inputs such as managing forages and/or manure stockpile aeration. At the community level, it is suggested to develop a community-based manure collection scheme, given the required amount of manure and up-front costs for the techniques such as methane fermentation. This will be achieved though activities such as establishing a group of livestock farmers for manure collection and usage, establishing a designated collection point with appropriate storage facility such as an anaerobic digester, arranging collection route and schedule, developing standards to maintain quality of manure to be collected (for instance, manure with too much water may not be useful for generating solid fertilizer), developing market opportunities for by-products such as heat/electricity and fertilizer.

Activity 4.6. – Dissemination of livestock disease management

The technology covers various techniques; therefore, it can be implemented at mainly two different levels; individual farmers level and federal or states level. For the former, livestock farmers will require extension services including demonstration farming and workshops. Several prevention measures do not need heavy equipment or facilities, but may require changing current practices or introducing new techniques. In that sense, extension services can prepare farmers to adopt new techniques. Good understanding on the technology will lead to embed it in daily farm practice. In order to supplement the diffusion at individual level, small loans or credit would support farmers to introduce necessary facilities. All financing schemes should be gender-responsive, ensuring that women, as well as men, have access to finance despite structural barriers such as a lack of collateral. At the federal or states level, in contrast, it is suggested to develop standards or regulations for controlling livestock diseases. The policy needs to indicate clear and coherent measures when livestock disease outbreaks. Furthermore, public institutions are expected to lead research activity on vaccination, detecting new diseases with an external financial and technical support.

Activity 4.7. – Dissemination of agroforestry

The suggested way of implementation would be though community-based projects because the technology looks complex and risky for individual farmers. Given the diverse climate and forest conditions in Nigeria, an agroforestry project would embark from selecting target areas based on several criteria (such as soil and forest condition), while clarifying forest tenure system and other relevant policies. As the next step, participatory mapping would be also encouraged to visualize boundaries of the community's forest or farms and to ensure community's rights and ownership, which will lead to secure project environment. Developing a project component would follow. It is also crucial to establish a monitoring scheme to embed and sustain the technology. Furthermore, developing a stable market for products from agroforestry farms is critical for the technology dissemination. This can be achieved though, for instance, developing new products with high-market value and promoting the benefits of agroforestry.

Activity 4.8. – Dissemination of forest management techniques for mitigation (REDD+)

It is suggested to implement this technology as a project basis because it extends to various measures and techniques from reforestation to judicial enforcement towards illegal logging. Furthermore, developing a project with clear project components and evaluation indicator enables implementers to identify its climate mitigation impacts such as carbon sequestration. The project component would depend on needs of forest community, Nigeria's country objectives, and forest conditions. Therefore, it is essential to identify target areas for the project and clarify its objectives.

Activity 4.9. – Dissemination of ecosystem-based adaptation

This technology takes various forms when implemented. For instance, the implementation at coastal forest area (such as the Nigerian Delta) and mountain forest area would be different in terms of necessary measures and technical considerations. Therefore, it is suggested to implement this technology as a project basis to optimize the technology. Determining target areas would be a basis for project implementation. Depending on the target areas, target issues (e.g.: coastal erosion, decreased water catchment, soil degradation etc.) would vary, hence necessary measures can vary too.

Entity in Charge: The implementing entity for the actions is proposed to be spearheaded by Federal Ministry of Agriculture and Rural Development and Federal Ministry of Environment with close coordination with other relevant ministries.

Costs: The costs associated with the implementation of this action plan is estimated at USD 200,000,000 – 250,000,000, which involves conducting workshops and trainings, project development and implementation, developing information materials, conducting market research, deploying and disseminating guidelines, and engaging international experts.

4.12. Financing options

In the agriculture and land use sector, the main users of the technologies are expected to be private sector smallholders and community, and more rarely large-scale national institutions. It will therefore be crucial to provide the right financing conditions/schemes to trigger private sector investments from smallholders for the introduction of new technologies.

Under this approach, the government of Nigeria and international partners will mainly provide grant financing related to technical assistance, which include but not limited to awareness raising activities, policy development, technical assistance and capacity building. Based on the result of the technical assistance, the private sector will be encouraged to provide financing pertaining to the direct implementation of the activities. Furthermore, developing accessible small finance for farmers would catalyze the engagement of smallholders. Given the sector has a great potential of economic development, it is possible to create bankable and sustainable business models which will attract the private sector investment such as bonds and/or concessional finance.

Requests for external financing will focus on measures which are of high priority to the country and enable Nigeria to implement its NDC. Considering that the sector consists of smallholder producers, they will need to be at the center of the financing strategy for the introduction of all technologies. External financing will therefore be requested for preparing the enabling environment for their participation and implementation of the prioritized technologies.

External financing will also be essential to develop the enabling environment for private sector engagement in providing necessary technologies or facilities related to the prioritized technologies. Grants and concessional financing may also be used for blended finance, in order to support local financial institutions in provide financial products which are relevant to the needs of the private sector, especially for smallholder producers.

Longer term actions may also be supported by international partners, such as the introduction of agricultural biotechnology, selective breeding via controlled mating, and forest management techniques for mitigation (REDD+), among others. These require significant financial and technical resources. Therefore, it is expected that grants or concessional financing supports the introduction and implementation of these technologies, while additional financing supports capacity building to the private sector, in order to cover most of the risks perceived by the private sector.

Potential sources of financing include but not limited to the GCF, Global Environment Facility (GEF), Adaptation Fund, as well as regional and/or international organizations, international financing institutions and multilateral development banks such as the World Bank, and bilateral

donors.

4.13. Potential climate change impact

The successful diffusion of the prioritized technologies under the agriculture and land use sector will directly impact Nigeria's NDC while contributing to the country's overall development.

All technologies under the crop production sub-sector will enhance climate resilience of the sector though empowering farmers to adapt to climate change. Especially, climate smart agriculture will enable farmers to sustain their agricultural practice under the changing climate, while integrated climate change monitoring and early warning system will support them to response to climate impact as early as possible in order to optimize benefits or minimize damages. Furthermore, agricultural biotechnology (crop diversification and new varieties) will expand available crop varieties and may improve crop production and farmer's income.

The prioritized technology under livestock production sub-sector will be useful and essential to enhance the sector's resilience to climate change. Regarding selective breeding and livestock disease management, these are essential to sustain the livestock production under the new climate while minimizing its impacts and threats such as rising heat. In contrast, appropriate and effective manure management will contribute to reducing GHG emissions from the sector.

The successful diffusion of the prioritized technologies under the forestry sub-sector will result in climate change mitigation and adaptation in Nigeria. Agroforestry will realize harmonized development of agriculture and forest management where different benefits will interact and create greater impacts. Forest management techniques for mitigation (REDD+) can contribute to the NDC though enhancing carbon sequestration while promoting forest cover and its healthy growth. Furthermore, ecosystem-based adaptation will enable enhance resilience of Nigerian forests which will lead to enhancing climate resilience of the country and its people.

4.14. Monitoring and evaluation methods

Monitoring will provide routine tracking and reporting of key indicators and information that will allow to measure progress of the technology implementation. It will be essential not only for evaluation but also for adjusting implementation plans during project period to maximize impacts and ensuring accountability to the public and/or financial investors when applicable. People-level data will be sex and gender-disaggregated. Monitoring will be conducted using participatory methods at outcome, sectoral and portfolio level, against a set of criteria set in advance and revised as required. In the case of the technology action plan, outcome level indicators will contribute to sectoral level impacts, which will contribute to achieving the objectives of the technology action plan.

Table 16: Monitoring and Evaluation framework for the agriculture and land use sector

Technology Action Plan level objectives and indicators				Roles and Responsibilities			
The gender-responsive technology action plan will focus on strengthening the resilience of the sector while reducing GHG emissions by supporting the introduction of the technologies under each sub-sector.				Federal Ministry of Agriculture and Rural Development (FMARD) and Federal Ministry of Environment (FMEnv) will be responsible for the overall monitoring of the technology action plans in the agriculture and land use sector.			
Sectoral level objectives							
Crop production sub-sector	The action plan will contribute to improving food security and production though introducing climate resilient agricultural practices (climate smart agriculture) and diversifying crop varieties (agricultural biotechnology), while enhancing sectoral preparedness to climate impacts and related threats (integrated climate change monitoring and early warning system).						
Livestock production sub-sector	The action plan will contribute to enhance the sectoral resilience though proliferating climate resilient animal species (selective breeding via controlled mating) and nurturing capability to prevent and control disease (livestock disease management). It will also contribute to reduce GHG emissions though improving manure management.						
Forestry sub-sector	The action plan will contribute to reduce GHG emissions from the forestry sub-sector, the highest emitter in the agriculture and land use sector, though improving carbon sequestration by expansion of forest cover (agroforestry and forest management techniques for mitigation (REDD+)). The action plan will also contribute to enhance Nigeria's overall and sectoral resilience to climate change impacts (ecosystem-based adaptation).						
Expected Results (Outputs)	Indicators	Baselines	Targets	Data Source / Means of Verification	Timeline	Roles and Responsibilities	Budget
Action Plan 1: Raising awareness Outcome 1: Raised awareness with acceptance to the technologies, which will supplement for creating enabling environment for the technologies.							
Activity 1.1. – Awareness of farmers raised	Increased understanding and appreciation of the public on benefits of each technology	N/A	At least one workshop by technology conducted and reference materials produced At least 35% female participation in workshop	FMARD and FMEnv record	Q1 2023 – Q4 2023	FMARD and FMEnv	USD 30,000 – 40,000

Activity 1.2. – Awareness of relevant stakeholders raised	Increased understanding and appreciation of the public on benefits of each technology	N/A	At least one workshop by technology conducted and reference materials produced At least 35% female participation in workshop	FMARD and FMEnv record	Q1 2023 – Q4 2023	FMARD and FMEnv	
Action Plan 2: Capacity Building Outcome 2: Enhanced capacity for each stakeholder which will enable the implementation and scaling-up of the prioritized technologies.							
Activity 2.1. – Institutional and technical capacity built	Capacity building through training conducted and training manuals produced for technical/public-official personnel	N/A	At least one workshop by technology conducted and reference materials produced At least 35% female participation in workshop	FMARD and FMEnv record	Q1 2023 – Q4 2023	FMARD and FMEnv	USD 20,000 – 40,000

Activity 2.2. – Partnership built	Partnership building through networking opportunity and/or platform and encouraging knowledge exchange	N/A	At least one workshop or other similar opportunity (e.g.: business matching, conference, business-competition) conducted At least 35% female participation in workshop	Partnership developed	Q1 2023 – 2030	FMARD and FMEnv	
Action Plan 3: Development of enabling environment Outcome 3: Enabling environment for smallholder producers and private investment as well as for technology implementation is developed and financing available.							
Activity 3.1. – Climate change impact assessment and potential mapping for each technology conducted	Gender-responsive impact assessment and mapping	Climate impact assessment focusing on each technology conducted	At least one potential target area by technology identified based on assessment	Assessments and mappings conducted	Q3 2023 – Q2 2024	FMARD and FMEnv	USD 60,000 – 80,000
Activity 3.2. – Baseline study for identifying gaps and needs conducted	Gender-responsive baseline study	General gaps and needs identified	At least one study per sub-sector conducted	Gaps and needs identified	Q3 2023 – Q2 2024	FMARD and FMEnv	

Activity 3.3. – Strategy and policy developed and enforced	Number of policies (including gender responsive policies) and safety regulations developed	High level policies developed	Policies and binding regulations pertaining to ensure safe technology implementation developed	Policies developed, introduced and enforced	Q1 2024 – Q4 2024	FMARD and FMEnv	
Activity 3.4. – Guidelines developed	Number of guidelines developed	N/A	At least one guideline per technology developed	Guidelines developed	Q1 2024 – Q4 2024	FMARD and FMEnv	
Activity 3.5. – Adequate financing for private sector engagement provided	Number of new financing schemes	N/A	At least one scheme developed per sub-sector	Financial institution records	Q3 2023 – Q4 2025	FMARD and FMEnv	
Action Plan 4: Dissemination of technologies Outcome 4: Each technology is implemented with specific targets and objectives.							
Activity 4.1. – Climate smart agriculture (including drip irrigation) disseminated	Development of program	Several related practices/technologies implemented in some states	The concept of climate smart agriculture narrowed down with identified target technologies and issues	Concept identified	Q3 2024 – 2030	FMARD and FMEnv	USD 200,000,000 – 250,000,000

Activity 4.2. – Agricultural biotechnology (crop diversification and new varieties) disseminated	Development of program	Several related projects are under implementation yet none of the crops have been commercialized[105]	At least one dissemination strategy developed and at least one technical training program conducted At least 35% female participation in workshop	Dissemination strategy developed	Q3 2024 – 2030	FMARD and FMEnv	
Activity 4.3. – integrated climate change monitoring system and early warning system disseminated	Development of program	The technology is still at a planning stage have not yet received enough support to proceed to the next stage	The technology moves on to the implementation stage	Implementation program developed	Q3 2023 – 2030	FMARD and FMEnv	
Activity 4.4. – Selective bleeding via controlled mating disseminated	Development of program	Small number of cases implemented	At least one testing program developed	Testing program developed	Q3 2024 – 2030	FMARD and FMEnv	
Activity 4.5. – Manure management disseminated	Development of program	Small number of cases implemented	Technology mainstreamed at least one community/state/region	Dissemination program developed	Q3 2023 – 2030	FMARD and FMEnv	

[105] USDA "Agricultural biotechnology annual"

Activity 4.6. – Livestock disease management disseminated	Development of program	N/A	Policies and binding regulations pertaining to livestock disease management developed and enforced	Policies developed, introduced and enforced	Q1 2024 – 2030	FMARD and FMEnv	
Activity 4.7. – Agroforestry disseminated	Development of program	Several practices of agroforestry implemented	At least one additional target area identified, and program components designed and implemented	Program developed	Q1 2023 – 2025	FMARD and FMEnv	
Activity 4.8. – Forest management techniques for mitigation (REDD+) disseminated	Development of program	Several initiatives related to REDD+ implemented	At least one additional target area identified, and program components designed and implemented	Program developed	Q1 2023 – 2030	FMARD and FMEnv	
Activity 4.9. – Ecosystem-based adaptation disseminated	Development of program	N/A	At least one target area identified, and program components designed and implemented	Program developed	Q1 2023 – 2030	FMARD and FMEnv	

4.15. Proposed implementation timeline

The following figure shows the overall timeline for the implementation of the prioritized technology in the agriculture and land use sector.

Action Plan	Activity	2023				2024				2025				2026	""""	2030
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			
Raising awareness	Awareness raising to farmers															
	Awareness raising to other relevant stakeholders															
Capacity building	Institutional and technical capacity building															
	Partnership building															
Development of enabling environment for private sector engagement	Climate change impact assessment and potential mapping for each technology															
	Baseline study for identifying gaps and needs															
	Strategy and policy development and enforcement															
	Guideline development															
	Provision of adequate financing for private sector engagement															
Dissemination of technologies	Dissemination of climate smart agriculture (including drip irrigation)															
	Dissemination of agricultural biotechnology (crop diversification and new varieties)															
	Dissemination of integrated climate change monitoring system and early warning system															
	Dissemination of selective bleeding via controlled mating															
	Dissemination of manure management															
	Dissemination of livestock disease management															
	Dissemination of agroforestry															
	Dissemination of forest management techniques for mitigation (REDD+)															
	Dissemination of ecosystem-based adaptation															

5. Technology Action Plans – Energy

5.1. Sectoral Overview

The energy sector plays a critical role in supporting the long-term development vision for Nigeria, as it is estimated that approximately 35,000 megawatts (MW) of additional electricity generated on-grid and off-grid is needed for Nigeria's future economic growth. The projected growth rate will demand even greater electricity generation from a combination of sources by 2030. In addition to increasing electricity generation, improving access to electricity is essential to support the proposed modernization and industrialization for development. It is estimated that 70 percent of the population that live in rural areas currently do not have access to the electricity grid. This inadequate access to electricity has had a negative impact on the overall economic growth of Nigeria by placing significant constraints on the productive capacity of micro-entrepreneurs and rural supply chains. On the other hand, increase in economic activity and population growth have significantly increased fuelwood use to meet its energy demand. This is increasingly driving the risk of deforestation and increase in associated GHG emissions.

To achieve the required long-term development needs for Nigeria, the energy sector has objectives for each of its sub-sectors, namely, electricity supply, energy demand, and energy efficiency. Nigeria aims to increase access to electricity to 75 percent and 90 percent of the population (rural and urban) by 2020 and 2030, respectively, and at least 10 percent of renewable energy mix by 2025. Specific to renewable energy, Nigeria has developed the Renewable Energy Master Plan, which includes installed capacity targets, including 2,000 MW by 2025 for small-hydro, 500 MW of solar by 2025, 200 MW of biomass-based power plant by 2025, and 40 MW of wind energy by 2025. Furthermore, Nigeria aims to achieve universal coverage of 100 percent electrification by 2040.

The energy sector in Nigeria is comprised of three sub-sectors. These include electricity supply, energy demand, and energy efficiency. Each sub-sector is detailed in sub-sections below.

Electricity supply – The main sources of energy used in electricity supply in Nigeria are thermal and hydro, which approximately account for 80 percent and 20 percent, respectively. Other energy sources such as renewable energy sources contribute less than 1 percent of the energy mix. Currently, approximately 70 percent of rural population in Nigeria are not connected to the grid. In addition, 90 percent of those connected to the grid do not receive adequate power supply. This is mainly caused by the significant loss in electricity experienced during transmission and distribution. As such, Nigeria has long struggled with poor access to a reliable electricity supply, in which most households and businesses receive less than five hours of electricity per day. This inconsistent electricity supply has driven most businesses to acquire inefficient diesel-powered generators, contributing not only to significant GHG emissions but also leading to the use of more expensive electricity than electricity provided through the grid. The sub-sector currently accounts for 81.9 percent of total emissions of the energy industries category. As such, implementing appropriate technologies to mitigate climate change impacts while supporting the increase in electricity supply would be essential for the sector's overall development.

Energy demand – As mentioned above, the energy demand in Nigeria is expected to rise significantly in the coming years as demand from households, which has the largest share of the energy demand, will increase due to growing population. Currently in Nigeria, oil, natural gas, and biomass constitute the main sources of energy. Over 60 percent of the population depend on fuelwood for cooking and other domestic uses. Use of fuelwood, coupled with wide use of inefficient cooking methods, such as open fire, is deteriorating the current state of energy

demand in Nigeria. Fuel combustion activities contribute to approximately 65.6 percent of total emissions of the energy sector. Activities such as deforestation and burning of fuelwood for cooking are significant sources of climate change in Nigeria. As such, effective measures to shift to more sustainable practices will contribute significantly to Nigeria's climate change efforts.

Energy efficiency – Achieving energy efficiency has been identified as part of an effort to achieve cleaner and greener energy and reducing energy-related GHG emissions, especially related to electricity generation, transmission, and distribution losses. Energy efficiency is also identified as a key measure to contribute to Nigeria's climate change efforts in its NDC. Currently, Nigeria's residential, commercial, and industrial sectors experience inefficient application and use of electrical appliances, such as lighting, refrigeration, and air conditioning, among others. To date, the Government of Nigeria has prepared National Energy Efficiency Action Plan (NEEAP) and National Renewable Energy and Energy Efficiency Policy (NREEEP) to support the development in this sub-sector.

5.2. Institutional Framework

This section outlines the key stakeholders and institutions that will have important roles in implementing and scaling up the technologies that have been prioritized for the energy sector. Key government institutions in the energy sector are presented in the table below.

Table 17: Key Government Institutions (Energy)

Institutions	Description
Federal Ministry of Power (FMoP)	The Federal Ministry of Power (FMoP) initiates and formulates broad policies and programs on the development of power sector. The ministry is also responsible for tactical deployment of TNA activities and engagements. Their involvement is needed for institutionalization and implementation of results from climate change mitigation and adaptation action plan.
Federal Ministry of Environment, Department of Climate Change (FMEnv-DCC)	Department of Climate Change in the Federal Ministry of Environment is the UNFCCC's focal point agency for Nigeria. The department directs the governance of TNA projects and direct strategic implementation of TNA activities and engagement in Nigeria. The department is also responsible for promotion and incorporation of identified technologies in NDC implementation, climate change adaptation/mitigation and other related activities aligned with UNFCCC's provision. The department is important as a focal point agency for climate change mitigation/adaptation and TAP (Technology Action Plan), responsible for the NDCs and UNFCCC's reporting.
Energy Commission of Nigeria	The commission is responsible for carrying out, sponsoring, or promoting training and development of manpower in the energy sector relating to national energy policy and its implementation. Prioritized technologies require capacity buildings in various part of society and industry. The commission has the statutory mandate for the strategic planning and co-ordination of national policies in the field of energy in all its ramifications. By the Mandate, the commission is the apex government organ empowered to carry out overall energy sector planning and policy implementation, promote the diversification of the energy resources through the development and optimal utilization of all,

	including the introduction of new and alternative Energy resources like solar, wind, biomass and nuclear energy.
Manufacturers Association of Nigeria (MAN)	MAN is the organization for manufacturers in the private sector and is responsible for interfacing between Nigerian Chamber of Commerce, Industry, Mines and Agriculture (NACCIMA). MAN will engage with its member manufacturers on the recommendations on TNA action plans. Enabling manufacturers to comply/align with key climate change mitigation/adaptation action plans.
Federal Ministry of Science, Technology and Innovation (FMSTI)- Environmental Sciences and Technology, Renewable and Conventional Energy and Technology Acquisition and Adaptation Departments	The ministry is responsible for the planning and coordination of TNA activities and engagements including technical guidance. The ministry is also responsible for the strategic implementation of TNA activities and engagements. The ministry is expected to lead the pilot projects identified in the technology action plans.

The following key stakeholders can also contribute to implementing and scaling up the prioritized technologies:

Table 18: Key Stakeholders in the energy sector

Stakeholders	Description
Private Sector	Programs must involve the following stakeholders for its activities: ▪ Generating Companies (GenCOs): Currently, Nigerian electricity generation heavily relies on fossil fuel. The program to introduce solar PV needs to align with the Renewable Energy Master Plan. ▪ Distributing Companies (DisCo) For Demand Side Management and Smart Grid, the national grid operator shall actively engage in the discussion. Other than electricity-related industry, agricultural and food processing industry may have interests on waste to energy projects. Collection of biomass waste requires an involvement of waste management industry as well. For energy efficient buildings, the building industry is supposed to lead the discussion and introduce energy efficiency standards.
Civil Society	Nurturing general understanding on impacts of energy efficiency among civil society is particularly important for the energy sector. Providing education for school could be important for building an understating and awareness among society to transform communities into energy-sensitive communities.

5.3. Objectives and goals of the sector

In supporting the required long-term development needs for Nigeria, the energy sector has objectives for each of its sub-sectors, namely, electricity supply, energy demand, and energy efficiency. For electricity supply, Nigeria aims to increase access to electricity to 75 percent and 90 percent of the population (rural and urban) by 2020 and 2030, respectively, and at least 10 percent of renewable energy mix by 2025. Specific to renewable energy, Nigeria has developed the Renewable Energy Master Plan, which includes installed capacity targets, including 2,000 MW by 2025 for small-hydro, 500 MW of solar by 2025, 200 MW of biomass-based power plant by 2025, and 40 MW of wind energy by 2025. Furthermore, Nigeria aims to achieve universal

coverage of 100 percent electrification by 2040.[106]

For energy demand, to address the increasing use of fuelwood driven by growing population, the sector aims at reducing the percentage contribution of fuelwood consumption in the domestic, agricultural, and industrial sectors and to facilitate the use of alternative energy resources to fuelwood. For this sub-sector, the sector also aims to promote biomass as an alternative energy resource especially in the rural areas.

The energy sector also focuses on achieving energy efficiency as part of an effort to achieve cleaner and greener energy, with objectives to increase the share of electricity generated from renewable sources such as solar, wind and biogas, by 1 percent every year compared to 2012 level, reduce electricity generation, transmission and distribution losses from the current level of 15 – 40 percent to less than 10 percent by 2020, replacing all incandescent light bulbs in every home, industry, institution, and establishment with light emitting diodes (LED) and other energy saving lamps by 2025, achieving a broad range of equipment energy efficiency standards and labelling by 2025, and reducing energy-related GHG emissions by 15 percent compared to the 2013 level by 2025.[107]

In terms of gender consideration in the energy sector, at the household level, due to the gendered division of labour, the health of women and children is disproportionately affected by the use of fuelwood or charcoal for cooking.[108] In Nigeria, more than 98,000 deaths among women annually are attributed to ailments related to indoor and outdoor pollution.[109] This suggests that addressing the increasing use of fuelwood at the household level will achieve climate objectives in Nigeria while also improving the health conditions of women and children, further supporting the country's overall development.

In achieving the sectoral objectives, key policies, action plans and strategies have been prepared to guide the sectoral development. These documents include, but not limited to, National Energy Policy, NREEEP, Rural Electrification Strategy and Implementation Plan, National Energy Master Plan, and NEEAP. Furthermore, the Energy Transition Plan was launched in 2022 identifying strategies to achieve net zero emissions by 2060. These policies are identifying a pathway to achieve the sectoral objectives, further supporting Vision 20:2020. The Ministry of Power is also currently developing a National Action Plan on Gender Mainstreaming in Energy Access which will further support gender informed sectoral development.

Energy has been identified as a priority sector in Nigeria's National Action Plan on Gender and Climate Change, which prioritizes the following actions to address gender inequalities in energy: integrate gender and climate change into energy and transport sector legislations, programs and policies; create awareness on the relationship between climate change, gender and energy; support women to gain knowledge in energy technologies; reduce the emission of greenhouse gasses at schools and in households; and increase budget allocation on climate change and gender in energy and transport sector programs.

A local-level, in-depth gender analysis is recommended during the design phase of any program aiming to roll-out the prioritized technologies. A gender analysis will examine the roles and responsibilities; needs, priorities and interests; access to power and resources; and power

[106] Federal Ministry of Power, Works and Housing. 2016. RESIP.

[107] Federal Republic of Nigeria. 2016. NEEAP.

[108] Federal Ministry of Environment, 2020. National Action Plan on Gender and Climate Change for Nigeria.

[109] USAID. 2017. Power Africa Gender Analysis for Nigeria.

dynamics of women, men, girls, and boys within communities, allowing stakeholders to design contextualized gender-equitable programs. It is important to intentionally incorporate women into policy and project design, implementation, capacity building, and financing activities to ensure that they are not left behind. Gender expertise and guidance is necessary through the design, implementation, monitoring, and evaluation of prioritized technology policies and programs. Table 19 summarizes overall sectoral objectives identified in each sub-sector.

Table 19: Summary of objectives in the energy sector

Sub-sector	Objectives
Electricity supply	▪ To provide electricity to all state capital, local government headquarters as well as other major town by the year 2020 ▪ To ensure the provision of electricity to all remote and off-grid areas of Nigeria as well as increasing the energy mix of grid supplied electricity in line with regional policy and target ▪ To stimulate industrialization in the rural areas to minimize rural-urban migration ▪ To provide reliable and stable power supply to consumers, especially to industries ▪ To ensure the removal of bottlenecks limiting utilization of the full capacity of the existing electric power plants and development of off-grid electricity in Nigeria ▪ To broaden the energy options for generating electricity, including renewable energy resources ➢ **Hydropower:** (1) to increase the percentage contribution of hydroelectricity to the total energy mix and to ensure that a minimum contribution of 10 percent is maintained at all times from large and small hydropower combined; (2) to extend electricity to rural and remote areas through the use of mini and micro hydropower schemes; (3) to diversify the energy resource base and the mix between large, mini and micro hydro; (4) to ensure minimum damage to the ecosystem arising from hydropower development; (5) to attract private sector investments into the hydropower sub-sector; (6) to further contribute to remote and off-grid power development in Nigeria; (7) to develop socially acceptable and equitable hydropower; and (8) to ensure the safety and security of large and small hydro generating facilities ➢ **Solar:** (1) to increase the percentage contribution of solar energy to the total energy mix and to ensure a minimum electricity contribution of 3 percent by 2020 and 6 percent by 2030; (2) to extend electricity to rural and remote/off-grid areas, through the use of solar home systems and ultimately promote solar photovoltaic and solar thermal applications to ensure that solar energy can be used for production of electricity; (3) to increase the share of solar water heating technologies for social services, commercial and industrial processes ➢ **Wind**: (1) to develop wind energy as an alternative energy resources; (2) to develop local capability in wind energy technology; (3) to use wind energy for provision of power to rural areas and remote communities far removed from the national grid; (4) to apply wind energy technology in areas where it is technically and economically feasible; and (5) to develop and implement incentives for the development of wind farms and for the adoption of community-based wind system off the grid
Energy	▪ **Fuelwood:** (1) to greatly reduce the percentage contribution of fuelwood

demand	consumption in the domestic, agricultural, and industrial sectors; (2) to arrest the ecological problems of desert encroachment, soil erosion and deforestation; (3) to facilitate the use of alternative energy resources to fuelwood; and (4) to reduce health hazards arising from fuelwood combustion. ▪ **Biomass:** (1) to promote biomass as an alternative energy resource especially in the rural areas; (2) to promote efficient use of agricultural residues, animal and human waste as energy sources; and (3) to reduce health hazards arising from combustion of biomass fuel.
Energy efficiency	▪ To increase the share of green electricity by 1 percent every year on Year-to-Date (YTB) basis compared to 2012 level ▪ To ensure reduction of electricity generation, transmission, and distribution losses from the current level of 40 – 50 percent to less than 10 percent by 2020 ▪ To replace all incandescent light bulbs in every home, industry, institution, and establishment in Nigeria with LEDs and other energy saving lamps by 2025 ▪ By 2025, to establish a broad range of equipment energy efficiency standards and labelling ▪ By 2025, to reduce energy-related GHG emissions by 15 percent compared to the level of 2013 ▪ To consider energy efficiency and conservation in key sectors: residential sector, industry, transportation, services/commercial sector, agriculture, and energy efficient building designs

5.4. Overview of the technologies prioritized in electricity supply (including value chain analysis and gender assessment of technologies)

5.4.1. Solar PV/Concentrated solar power (solar thermal)

(a) Solar PV

Solar Photovoltaic refers to the technology of using solar cells to convert solar radiation directly into electricity. Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 MtCO2e in 2018. Of which, electricity generation (on-grid and off-grid) contributes 24% of the sector's GHG emissions. Nigeria's energy mix is dominated by fossil-fuel fired thermal power plants. Solar power generation can greatly contribute to reducing GHG emissions from the existing energy mix.

Utility-scale Solar PVs are not severely impacted by extreme weather events such as rise in sea level, droughts, or flooding, compared with fossil-fuel based power plants and other renewable energy technologies. In addition, distributed Solar PV application could make the power system more resilient to extreme climate events compared to the conventional centralized systems.

Solar PV has been explicitly identified in the NDC as a key climate change mitigation measure. Specific targets for Solar PV include a 6.5GW capacity for on-grid electricity, and 13GW off-grid renewable energy (i.e., mini-grids, solar home systems and streetlights, and self-generation) which are more likely to be achieved through Solar PV.

A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation. The expansion of the renewable energy industry contributes to generating more sustainable employment and livelihood. It also increases access to electricity, especially for off-grid applications, potentially reducing poverty.

Energy access is linked to physical safety and emotional wellbeing. Having electricity means

women and girls – who bear the burden of collecting alternative sources of energy – will not have to travel long distances to collect fuelwood, for example. The availability of well-lit public spaces can also help prevent gender-based violence and increase mobility.[110]

Studies show that access to electricity is an important tool in the economic empowerment of women. Women with electricity are more likely to work outside the home, they have greater access to information and their income is higher than those without electricity.[111]

Inadequate electricity supply is implicated in lower educational outcomes for girls and boys; higher incidences of child marriage; poor healthcare; and insufficient physical, psychological, economic and social services for older adults and persons with disabilities.[112] [113]Location plays an important role in access to electricity, as urban areas in Nigeria are better served by on-grid electricity than rural ones.[114]

Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.

Solar power technologies are overall around the stage of "early adoption", where the technologies are commercially available and becoming widely implemented, according to International Energy Agency (IEA) (2020). In fact, both utility- and small-scale solar power systems have been widely installed and operated across the globe. Furthermore, lifecycle cost of solar power generation has been decreasing rapidly, which is now more or less cost competitive against that of thermal power generation. Although solar PV application in Nigeria is very low, especially for utility-scale, Nigeria has identified solar technologies as the most promising among renewable energy sources. Nigeria's annual solar radiation ranges between 12.6 to 25.2 MJ/m2/day, with an average sunshine of 6.5 hours per day. The available solar energy is about 27 times the country's total fossil fuel resources and over 115,000 times the electrical power generated. Some commercially available solar PV technologies are highlighted in the table below:

Table 20: Solar PV technologies

Solar PV Cell Technologies	Description
Crystalline Silicon (c-Si) PV Modules	Modules consist of PV cells connected together and encapsulated between a transparent front (usually glass) and a backing material (usually plastic or glass). C-Si provide high-efficiency solar cells. Its commercial efficiency is typically in the range of 13 to 21 %. Modules are made from cells of either mono-crystalline or multi-crystalline silicon. • Mono-crystalline silicon (mono-c-Si) wafers are sliced from a large single crystal ingot in a relatively expensive process.

[110] Power Africa. Exploring the Relationship Between Energy Access and Gender-Based Violence. https://powerafrica.medium.com/exploring-the-relationship-between-energy-access-and-gender-based-violence-ee8d9e320437
[111] Ibid
[112] Ibid
[113] Tanyi, Perpetua, Pelser, Andre, Mbah, Peter 2018/12/03 Care of the elderly in Nigeria: Implications for policy, VL - 4 10.1080/23311886.2018.1555201 Cogent Social Sciences
[114] Made for Minds. Living in the Dark in Rural Nigeria. https://www.dw.com/en/living-in-the-dark-in-rural-nigeria/a-46755603

	• Multi-crystalline silicon (multi-c-Si) wafers are made from a variety of methods and is currently cheaper than mono-c-Si, but is generally not as efficient.
Thin Film PV Modules	Modules are made with thin-film deposition of a semiconductor on a substrate. Thin film cells are typically cheaper in comparison with c-Si due to both materials used and simpler manufacturing process. However, thin film cells are relatively less efficient than c-Si modules. Thin film technology options are as follows: • Amorphous silicon (a-Si) is a well-developed thin-film technology using silicon in its less-ordered, non-crystalline (amorphous) form. A-Si can be deposited on a wide range of both rigid and flexible low-cost substrates. Its low cost makes it suitable for applications where low cost is more important than high efficiency. Efficiency range is about 6 to 9 %. • Cadmium telluride (CdTe) is a compound of cadmium and tellurium, and consists of a semiconductor film stack deposited on transparent conducting oxide-coated glass. It produces high energy output across a wide range of climatic conditions with good low light response and temperature response coefficients. Efficiency range is about 8 to 16 %. • Copper Indium (Gallium) Di-Selenide (CIGS/CIS) is a compound of copper, indium, gallium and selenium. Commercial production is in the early stages of development. However, it has the potential to offer the highest conversion efficiency of all the thin film PV module technologies. Efficiency range is about 8 to 14 %.
Heterojunction with intrinsic thin-film layer (HIT)	Modules are composed of a mono-thin c-Si wafer surrounded by ultra-thin a-Si layers. HIT modules are more efficient than typical crystalline modules, but they are more expensive. Its commercial efficiency range is around 18 to 20 %.

(b) Concentrated solar power (solar thermal)

Concentrated Solar Power (CSP: Solar Thermal) systems generate electricity by concentrating solar energy using mirrors or lenses into a receiver. Electricity is generated when the concentrated energy from the sun allows heat transfer fluid to produce superheated steam, which is then used to turn turbines to generate electricity. CSP could make the power system more resilient to extreme climate events compared with conventional power systems, although not as resilient compared with Solar PV applications.

Solar thermal technology was not specifically identified as a mitigation measure in the NDC. However, the TNC includes CSP as one of the low carbon development options. Similarly, CSP is identified as part of solar technologies considered in the NREEEP. Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.

A shift toward renewable energy improves environmental quality by reducing air pollution emitted

from conventional electricity generation. The expansion of the renewable energy industry contributes to generating more sustainable employment and livelihood. It also increases access to electricity, potentially reducing poverty.

CSP technology is at the stage of “early adoption” according to IEA (2020). In fact, CSP had a total installed capacity of over 6.5 GW globally in 2019. Studies have been conducted on the potential of solar technologies in Nigeria, including CSP, indicating promising potential for grid-connected electricity. However, this has not yet been implemented in the country. There are mainly three types of CSP technology that can be considered for Nigeria:

Table 21: Types of CSP technologies

CSP technologies	Description
Linear concentrator systems	This system collects the sun’s energy by utilizing long rectangular, curved-shaped (U-shaped) mirrors. By moving the mirrors toward the sun, it allows the tubes to get heated, which allows the fluid inside the tubes to flow. Consequently, this hot fluid flows and then boils the water in the conventional steam-turbine generator to produce electricity. The major types of linear concentrator systems are: 1. Parabolic trough systems: receiver tubes are positioned along the focal line of each parabolic mirror 2. Linear Fresnel reflector systems: one receiver tube is positioned above several mirrors to allow the mirrors greater mobility in tracking the sun.
Dish/Engine systems	This system uses mirrors that are similar to the ones used in satellites; however, in order to minimize the costs, dish/engine systems is usually composed of many smaller flat mirrors formed into a dish shape. These dish-shaped mirrors allow the sunlight to be directed towards a thermal receiver which absorbs and collects the heat and transfers it to the engine generator. The most commercially available type of heat engine used today in dish/engine systems is the Stirling engine, which uses the heated fluid to produce mechanical power by moving pistons. The mechanical power in turn is used to run a generator to produce electricity.
Power tower systems	A power tower system is composed of heliostats, which is a large field of flat, sun-tracking mirrors that focus and concentrate sunlight to a receiver on top of a tower. A heat-transfer fluid heated in the receiver is used to generate steam, which is then used in a conventional turbine generator to produce electricity. Some power towers use water/steam as the heat-transfer fluid, while other advanced designs are experimenting with molten nitrate salt due of its superior heat-transfer and energy-storage capabilities.

5.4.2. Waste-to-energy (biomass power generation)

Waste-to-energy technologies refer to the combustion of solid waste as an alternative source to produce heat or electricity. In the context of electricity supply, this includes the use of agricultural biomass waste or municipal solid waste as fuel for the generation of electricity. Biomass energy

could make the power system more resilient to extreme climate events, especially for decentralized (off-grid/mini-grid) applications wherein the area affected by power outage is limited. Efficient utilization of biomass is part of the climate priorities of Nigeria. However, this focuses on its efficient use rather than as fuel for power generation. The NREEEP identifies strategies to promote biomass power generation in the country. Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy. A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation. In addition, utilization of biomass, especially solid waste, avoids improper disposal that pollutes the environment. The expansion of the renewable energy industry contributes to generating more sustainable employment and livelihood in Nigeria. It also increases access to electricity, especially for off-grid applications, potentially reducing poverty.

Biomass power generation technologies are generally mature and considered to be competitive wherever low-cost agricultural or forestry waste is available. Additionally, new technologies that show significant potential of further cost reductions are emerging. Yet, technologies to make pollutant emissions reduced to acceptable levels are required in the case of using municipal solid waste, which could result in higher total costs. Nigeria has abundant biomass resources in the form of wood waste, agricultural residues, and municipal solid waste. However, biomass power generation has not been implemented yet in the country.

Biomass power generation technologies can be characterized by their burner/boiler technology, which can be further categorized into two categories: fixed bed combustion and fluidized bed combustion. Technology options available for both fixed bed combustion and fluidized bed combustion are detailed in the following table:

Table 22: Biomass power generation technologies[115]

Biomass power generation technologies	Description
Fixed bed combustion	A fixed bed combustion system generally has grate furnaces which are appropriate for burning biomass with high moisture content. Primary air passes through a fixed bed in which combustion, gasification, and drying take place. This option is more cost-effective for small scale applications (less than 30MW). Technology options available for fixed bed combustion systems are fixed grate, moving grate and vibrating grate boilers; however, the most common technology being implemented today is the water-cooled vibrating grate boilers. ● Water-cooled vibrating grate boilers generate power from wood residues and therefore is a technology suitable for Nigeria as the country has significant wood waste. These boilers burn low-heating-value of approximately 13.8MJ/kg wood residues using natural circulation, providing capacity of 10MW for typical power plant.
Fluidized bed combustion	Fluidized bed combustion (FBC) system burns biomass in a self-mixture of gas and solid bed material that allows air to enter from below for

[115] IRENA 2015. Biomass for Heat and Power – Technology Brief

	combustion. The heat transfer in a fluidised bed combustion provides good conditions to complete combustion with low excess air demand. As opposed to a fixed bed combustion system. this option is more used in large-scale applications (exceeding 30MW). The main technologies available for fluidized bed combustion are bubbling FBC and circulating FBC. ● Bubbling fluidized bed combustion (BFBC): These boilers generally utilize solid biomass with advanced steam parameters and highly efficient. BFBC boilers can handle fuels that are considered difficult to combust or pulverize. In addition, since it utilizes sufficiently low-temperature combustion, the release of pollutants like nitrogen oxides can also be reduced. ● Circulating fluidized bed combustion (CFBC): CFBC boilers is characterized by its compatibility and flexibility, as the technology can utilize various form of fuels from wood wate to plastics, with capacity that ranges from 10MW to 100MW.

5.4.3. Carbon capture and storage

Carbon Capture and Storage (CCS) is the process of capturing CO2 from emission sources such as power plants, transporting, and storing it in underground geological formations. CCS prevents CO2 release into the atmosphere. It contributes to GHG emissions reduction even in hard-to-abate sectors such as cement industry. CCS is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO2 emission reduction. CCS can also contribute to improving environmental quality by reducing air pollution from the treatment process. CCS technology adaptation does not bring significant social co-benefit. CCS technology could improve product feature drastically to environment friendly one and could change economy of the product.

There are 26 large-scale CCS facilities are operating commercially in the world. Yet, it is hard to say that CCS technologies are mature and widely deployed. Several applications of CCS, including chemical absorption of CO2 from ammonia production and natural gas processing, are already widely deployed today. Many of other applications are still at the early adoption stage, such as chemical absorption from coal-fired power generation and hydrogen production from natural gas, compression of CO2 from bioethanol production and coal-to-chemicals plants, and CO2 storage in saline aquifers. Several other applications, including DAC (direct air capture) and CO2 capture from cement and iron and steel making, are still at the pilot stage. CCS have not been implemented yet in Nigeria. CCS technologies can be categorized into three categories: post-combustion carbon capture, pre-combustion carbon capture, and oxy-fuel combustion systems.[116]

- Post-combustion carbon capture: post-combustion carbon capture is generally being implemented in conventional natural gas and pulverized coal-fired (PC) power generation. In this process, chemical solvents such as amine are used to capture carbon dioxide from low-pressure flue gas, and the carbon dioxide-rich solvent is then heated with stream to reverse the carbon dioxide absorption reaction. Afterwards, the carbon dioxide is collected

[116] National Energy Technology Laboratory. 2022. Carbon dioxide capture approaches

and compressed for transportation and storage.

- Pre-combustion carbon capture: this process is expected to be used in gasification plant and is potentially a more cost-effective option than post-combustion carbon capture process. Since carbon dioxide is captured at high pressure conditions with higher concentrations, it can be effective with smaller equipment than in post-combustion carbon capture, which can reduce overall capital costs. Various applications are still at the research and development phase, with the use of solvent called selexol may be available in the short term (before 2030), and membranes and sorbents may be available in the mid to long term (2030 – 2050).
- Oxy-fuel combustion carbon capture: Similar to pre-combustion carbon capture, oxy-fuel combustion carbon capture is still at a research and development phase. This system captures carbon dioxide by condensing the water in the exhaust stream and can also significantly reduce nitrous oxide emissions compared to other processes. However, this process may have higher capital costs compared to pre-combustion carbon capture as it is critical to use high purity oxygen stream.

The following section identifies key stakeholders instrumental to the implementation of the three prioritized technologies in the electricity supply sub-sector.

Public sector:

Public sector is expected to provide an enabling environment for the diffusion of the technologies. This is achieved by introducing gender-responsive policies and regulations for the energy sector such as regulations and standards. This is particularly important for waste-to-energy and CCS technologies as Nigeria does not have the relevant policies related to these technologies to date. In doing so, the public sector needs financial assistance from international and/or bilateral development partners that will support policy formulation and capacity building activities.

Capital providers:

Considering that the standard business model of the energy sector where revenue from the service users is anticipated, there is significant opportunities of private sector involvement if a sustainable business model is established. Capital providers, therefore, can expect financial return from energy suppliers. Financial investments will stimulate energy suppliers and technology providers, hence greatly contribute to the diffusion of the technology. In the long term, involvement of capital providers enhances the growth of the sector. Potential capital providers vary such as international and/or bilateral development partners including international climate funds, the Nigerian government, local financial institutions, and private investors. All financing schemes should be gender-responsive, ensuring that women, as well as men, have access to finance despite structural barriers such as a lack of collateral.

Research institutions:

Since some of the technologies prioritized in the electricity supply sub-sector are not yet available in Nigeria (waste-to-energy technologies and carbon capture and storage), research institutions can take the lead in conducting assessments for these technologies to ensure that these technologies can contribute to reducing GHG emissions in Nigeria. It is expected that research institutions coordinate closely with the technology providers.

Technology providers:

In the case of the three technologies selected, technology providers will mainly provide the necessary technologies as well as solutions to the energy suppliers and distributors. There is a

great room for Nigerian SMEs to take a certain amount of market share once they are nurtured, while multi-national corporations may be the main players for a period of time. Working with women or youth-owned or led SMEs will ensure a fair representation of women and youth. Supporting internships or job shadowing programs increases the technical knowledge of women and youth.

5.5. Overview of the technologies prioritized in energy demand (including value chain analysis and gender assessment of technologies)

5.5.1. Improved cookstoves

Improved cook stove technologies pertain to cooking stoves with improvement in efficiency (available in different forms and sizes). In Nigeria, about 50% of the population depends on traditional biomass for their energy needs, with only 45% of the population having access to electricity (2016). Since those without electricity use fuelwood as their primary fuel source, improving the energy efficiency of cook stoves by introducing alternative fuels such as sustainable biomass or liquefied petroleum gas is expected to result in significant emissions reduction in rural areas. Promoting the use of improved cook stoves leads to less use of fuelwood. This prevents deforestation, which in turn makes the land resilient against flooding. The technology also has social impacts with respect to health, empowering women, and saves lives by avoiding respiratory diseases particularly in rural population.

Efficient cooking saves time, leading to more time for other activities contributing to economic growth. Improved cook stove technologies are mature and widely deployed around the globe, especially in developing countries.

Improved cook stoves have been implemented in Nigeria, including those under the clean development mechanism (CDM). In addition, the Federal Government of Nigeria intends to implement a program to meet the country's clean cooking targets.

Efficient and sustainable use of biomass resources is a priority for Nigeria considering that demand for biomass leads to deforestation. The NDC and TNC identifies efficient cookstoves to reduce biomass fuel demand, along with alternative heating sources such as Liquified Petroleum Gas (LPG). Specific targets include, 48% of population (26.8 million households) using LPG and 13% (7.3 million) using improved cookstoves by 2030.

5.5.2. Demand-side management

Demand-side management consists of the planning, implementing, and monitoring activities of electric utilities to encourage consumers to modify their level and pattern of electricity usage. It allows distribution utilities to satisfy power needs of more customers with little to no increase in power supply generation. While demand-side management could contribute to GHG emissions reduction, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.

Although the technology is not explicitly identified, the NDC identifies economy-wide energy efficiency as a key mitigation measure, with a target of 2% per year in energy efficiency. The NREEEP specifically encourages energy efficient measures. This technology can contribute to meeting these targets. In addition to the tangible energy efficiency targets, applying demand side management appliances contribute to improving environmental quality by reducing emitted air pollutants from power generation at site.

Demand-side management technology is mature and has been successfully implemented in developing countries. In particular, and relevant to Nigerian context is Brazil, which has the same generation mix of hydro and thermal power. While information on demand-side management in Nigeria is limited, it is assumed that Nigeria has the potential to implement given the government's strategy to promote energy efficiency. Demand-side management consists of demand response, energy efficiency, and strategic load growth components. Each component is described in the table below:

Table 23: Demand-side management components[117]

Demand-side management components	Description
Energy efficiency	The following demand-side management strategies are primarily used to achieve energy efficiency: ● Implementing energy efficient buildings and applications to reduce overall energy consumption by encouraging behavioural change ● Regular maintenance of electrical equipment in order to recover heat waste, updating the system by using modern equipment ● Enhance energy efficiency in transmission and distribution networks by incorporating distributed generation, advanced control systems for voltage regulation, and modern technologies such as smart metering, low-loss transformers, and fibre optics
Demand response	Demand response strategies are incentives involving short-term load manipulation programs to change the electricity usage of end-users. Demand response programs are divided into two main categories: reality-based and market-based programs. 1. **Reality-based program**: this encourages end-users to decrease their loads and/or to participate voluntarily or involuntarily in controlled appliance use. ● Interruptible load program: providing discounted electricity rates as compensation for shutting down the electricity load for a certain period. Generally applied to large industrial and commercial end-users. If an end-user does not participate in the program, the end-user is given a penalty as this is an involuntary program. ● Direct load control program: by informing the end-users beforehand, the utility is allowed to directly reduce the power supply during peak demand period. The end-users generally receive compensation for the interruption. ● Emergency program: giving incentives to consumers to reduce their usage during peak demand period. This is a voluntary program and thus there is no penalty if the consumer decided to not participate. 2. **Market-based program**: this provides real-time market electricity prices so that consumers adjust their electricity consumption ● Demand bidding program: a program that allows end-users to bid for specific load curtailments

[117] Jabir et al. (2018) Impacts of demand-side management on electrical power systems: a review

	• Real-time pricing program: rates such as time-of-use rates, critical peak rate, and real-time rate are informed to change consumer behaviour
Strategic load growth	The utility increases electricity load by utilizing heat pumps, dual fuel heating, thermal storage, and promotional rates. However, this is not as effective as other strategies since strategic load growth is occasionally conducted as a result of increase in electricity demand, and does not directly lead to change in consumption behaviour.

5.5.3. Smart grid

Technology for the electrical system that can sensibly execute the operations to all interconnected elements from generator to consumers. While smart grid system could contribute to GHG emissions reduction, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.

Although the technology is not explicitly identified, the NDC identifies economy-wide energy efficiency as a key mitigation measure, with a target of 2% per year in energy efficiency. The NDC also includes improving the electricity grid as one of its key measures. The NREEEP encourages energy efficient measures. This technology can contribute to meeting these targets.

Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.

Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.

Although smart grid is a relatively new concept, its deployment is increasingly progressing, with China, India and Brazil leading smart grid development among developing countries. Smart grid technology has not been deployed in Nigeria. However, some smart-grid applications that may be deployed in Nigeria are the following:

Table 24: Smart-grid technologies[118]

Technologies	Description
Smart grid components in monitoring and control	
Distribution Automation System	Monitors the status of distribution networks in real time and controls electrical switching devices remotely. Major functions include (i) automatic fault detection and remote recovery of distribution lines; (ii) real-time data acquisition; (iii) remote control and monitoring of switches; and (iv) load balancing of distribution networks using modern technologies.
Wide Area Monitoring System	Support system stabilization to avoid system outages, coordinated voltage regulation, and oscillation damping. Phasor measurement units and synchrophasors are used to improve power system reliability and assessment of performance. Time-stamping through phasor measurement units allow measurements from different locations and utilities to be synchronized and combined, providing a precise and comprehensive view of the entire interconnection.

[118] Asian Development Bank. ADB Sustainable Development Working Paper Series No. 42: Outlook for Increased Adoption of Smart Grid Technologies in ADB Energy Sector Operations. 2016.

	Synchrophasor measurements can be used to indicate grid stress and can be used to trigger faster corrective actions in emergency situations.
Flexible Alternate Current Transmission System	Based on power electronics technology developed to control power flow flexibly and quickly to ensure optimal flow, quality, and reliability of power supply.
Smart grid components in renewable energy	
Weather Forecasting Systems	Renewable energy sources such as solar and wind are intermittent in nature. Predicting their availability is important in optimal usage of resources. Commercial off-the-shelf solutions in advanced power and weather modeling are available, which help in effective integration of renewable energy sources. These solutions deploy cameras, sensors, imaging techniques, and computer-based data and analytics systems to forecast availability of renewable sources and calculate the amount of renewable energy that can be generated.
Energy Storage System	Battery solutions is an energy storage system used to (i) regulate the power supply frequency by balancing power supply and demand, (ii) store renewable energy, and (iii) manage capacity by shave or shift peak.
Simulation Systems	Simulation systems in national or regional control centers help in forecasting, controlling, and monitoring renewable energy generation including fluctuation of system parameters such as voltage and frequency.
Distributed Generator Monitoring and Control	Minimize problems in evacuation of renewable energy, in particular solar photovoltaic and wind energy due to transmission congestion, lack of transmission access, and excess supply during low load periods by sending signals in real time to renewable generators via supervisory control and data acquisition (SCADA).

The following section identifies key stakeholders instrumental to the implementation of the three prioritized technologies in the energy demand sub-sector.

Public sector:

Similar to technologies prioritized under the electricity supply sub-sector, the public sector will play an essential role in the dissemination of technologies prioritized in the energy demand sub-sector. Specific activities may include, but not limited to, the formulation and review of relevant gender-responsive policies and standards, coordination with utilities to promote the technologies, and encourage behavioral change through awareness raising campaigns. It is critical that the public sector develops incentives that promote reducing energy demand in parallel to the dissemination of the technologies. In particular, collaboration towards developing an enabling policy for clean cooking industry should be considered aligned with ongoing efforts of the EU-GIZ Nigeria Energy Support Program - under the Nigeria Institutional Clean Cookstoves Acceleration Scheme (NICCAS). These scheme includes expanding LPG for institutional cooking, as well as distributing up to 5,600 LPF stoves.

Capital providers:

For improved cookstoves, international or bilateral development partners, and the Nigerian government would be main capital providers for certain period. Although the involvement of the private sector is expected to be minimal in the short term (until 2025), it is not completely

excluded. As for demand-side management and smart grid, considering that the standard business model of the energy sector where revenue from the service users is anticipated, there is significant opportunities of private sector involvement if a sustainable business model is established. All financing schemes should be gender-responsive, ensuring that women, as well as men, have access to finance despite structural barriers such as a lack of collateral.

Technology providers:

Technology providers will be mainly development partners, multinational-corporations or SMEs who have adequate technologies that is operable under the Nigerian climate and energy status. Working with women or youth-owned SMEs will ensure a fair representation of women and youth. Supporting internships or job shadowing programs increases the technical knowledge of women and youth.

Consumers:

Each consumer will contribute to the energy value chain though their payment of energy bill. The energy price should be properly and transparently regulated by the government until the energy market is well matured. Once it is ready, it is possible that the energy sector can be deregulated, and the price can be determined by the market mechanism. To stimulate the diffusion of the technologies, private banks and/or development partners may play a key role by providing small financial incentives and/or packages for households and/or communities. Female-headed households should be prioritized for special loan packages.

5.6. Overview of the technologies prioritized in energy efficiency (including value chain analysis and gender assessment of technologies)

While women play a key role in energy monitoring and management at the household level,[119] and while women and youth can play important roles as energy efficiency advocates and change agents, women - especially those who are illiterate - continue to be marginalized in energy efficiency messaging.[120] Women or men with disabilities (who are deaf or blind for example) will also be marginalized.

5.6.1. Energy management systems

This involves the introduction of energy management tools aimed at improving energy use in mining, manufacturing including food and beverage, and chemical industries through introduction of innovative technologies such as high energy efficiency and variable motors, on-site electricity generation, energy system optimization and energy management standards. While energy management systems could contribute to GHG emission reduction, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.

Although the technology is not explicitly identified, the NDC identifies economy-wide energy efficiency as a key mitigation measure, with a target of 2% per year in energy efficiency. The NREEEP encourages energy efficient measures. This technology can contribute to meeting these targets. Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.

Improvements in energy efficiency have positive macroeconomic impacts, boosting economic

[119] World Bank Group. Gender Equality and Energy. Page 8
[120] Power Africa. Power Africa Gender Analysis. Pages 9-12

activity. Energy management system is a mature technology and widely deployed at factories, buildings, households around the globe. While information on energy management systems in Nigeria is limited, it is assumed that Nigeria has the potential to implement given the government's strategy to promote energy efficiency. In addition, there are several energy management companies in Nigeria providing such service in the country. Energy management systems that can be implemented in Nigeria are described in the following table:

Table 25: Energy management systems

Technologies	Description
Advanced Metering Infrastructure	Utility companies are able to implement a variety of load reduction and energy saving programs, reduce cost of providing electricity, and provide significant operational and efficiency improvements. Advanced metering infrastructure comprises smart energy meters that can measure two-way power flow, energy usage with time of use, and other system data; communication networks that transmit meter data to the utility; utility information management systems that process the transmitted data; and features to transmit pricing and energy information from the utility company to the consumer.
Building Energy Management Systems and Factory Management Systems	Building energy management systems are computer-based systems used in managing the electrical appliances and equipment used in commercial buildings. Factory management systems are next-generation energy management systems that manage and control energy in a factory both on the supply and consumption side by maximizing the benefits of distributed cogeneration using renewable and natural gas resources. It also utilizes Information and Communication Technology (ICT) and sensing technologies for visualizing waste generated by facilities, information sharing, and implementing improved productivity through operation-rationalization and labor saving.

5.6.2. Energy efficient buildings

Buildings that incorporate measures to alter energy-consuming behavior and as a result, reduce overall energy consumption. Energy efficient buildings could contribute to GHG emissions reduction. However, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity. Energy efficient building designs incorporate more resilient materials for structure, as well as incorporate the use of on-site electricity generation (i.e., Solar PV). This results in increased climate resilience.

Although the technology is not explicitly identified, the NDC identifies economy-wide energy efficiency as a key mitigation measure, with a target of 2% per year in energy efficiency. The NREEEP encourages energy efficient measures. This technology can contribute to meeting these targets. Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation. Improving building's energy consumption have positive macroeconomic impacts, reinforcing supply chain and material supply value chain boosting economic activity.

Technologies associated with energy efficient building, including solar power, energy storage system, and energy management system, are mature technologies and widely deployed around the globe. While information on energy efficient buildings in Nigeria is limited, it is assumed that

Nigeria has the potential to implement given the government's strategy to promote energy efficiency.

5.6.3. Energy efficiency standards and labelling

Energy efficient standards and labels are sets of procedures and regulations that, respectively, prescribe the minimum energy performance of manufactured products and the informative labels on these indicating products' energy performance. Energy efficiency standards and labels could contribute to GHG emission reduction. However, similar to other technologies identified in this sub-sector, its impact could be limited in the Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.

Although the technology is not explicitly identified, the NDC identifies economy-wide energy efficiency as a key mitigation measure, with a target of 2% per year in energy efficiency. The NREEEP encourages energy efficient measures. This technology can contribute to meeting these targets. Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation. Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.

Energy efficiency standards and labelling do not require any sophisticated technologies, while it is required to establish an evaluation and monitoring system, which includes human and financial resources. While information on energy efficiency standards and labelling in Nigeria is limited, it is assumed that Nigeria has the potential to implement given the government's strategy to promote energy efficiency.

The following section identifies key stakeholders instrumental to the implementation of the three prioritized technologies in the energy efficiency sub-sector.

Public sector:

The public sector is expected to provide the enabling environment through developing, reviewing, updating gender-responsive strategic and regulatory policies related to energy efficiency. For energy efficiency standards and labelling, the public sector will be the main implementers. In addition, the public sector needs financial assistance from international and/or bilateral development partners that will support policy formulation and capacity building activities.

Capital providers:

Given the significant implementation costs for the technologies, international, regional or bilateral development partners will be main capital providers. Although the involvement of the private investors would be minimal in a short term (until 2025), they are not completely excluded, especially when the business model of the technologies becomes financially stable. All financing schemes should be gender-responsive, ensuring that women, as well as men, have access to finance despite structural barriers such as a lack of collateral.

Technology providers:

Similar to prioritized technologies for the energy demand sub-sector, technology providers will be mainly development partners, multinational-corporations or SMEs who have adequate technologies that is operable under the Nigerian climate and energy status. Working with women or youth-owned or led SMEs will ensure a fair representation of women and youth. Supporting internships or job shadowing programs increases the technical knowledge of women and youth.

5.7. Overview of barriers

Nigerian energy sector undermines the following barriers for the dissemination of prioritized technologies in the sector.

Table 26: Barriers in the energy sector

Types of Barriers	Description
Political	▪ The relation between the energy and power sectors is complex, with different political interests among stakeholders
Regulatory	▪ Methodologies to achieve policy targets has improved especially within renewable energy based mini-grid programmes. However, it remains vague to actually support the increase of energy access to address energy demand, energy efficiency and application of other renewable energy sources such as waste to energy.
Institutional	▪ Broad range of stakeholders involved in the energy sector, with each stakeholder having slightly different objectives and appears to have overlapping mandates.
Technical	▪ Insufficient technical capacity ▪ Access to electricity is a challenge, especially in rural areas
Financial	▪ Several prioritized technologies are capital-intensive and require significant investments, and government budget is not enough to address this Insufficient financial resources in the energy sector
Geographical	Difficult to cater universal services with vast area coverage
Market	▪ Abundance of fossil fuels in the market hinders the progress towards a low carbon economy due to some of the identified barriers in policy, regulatory and institutional arrangement
Information	▪ Limited information available for the prioritized technologies
Behavioral	▪ Despite energy efficiency being an important issue, promotion of energy efficiency behavior is still limited ▪ High consumption behavioral patterns and customs remain prevalent, especially among households in rural areas

The Nigerian energy sector faces several challenges. Nigeria is an economically developing nation with some population still lacking access to electricity. Given the country's vast land area, it is necessary to work on different themes such as energy supply and efficiency improvement, reflecting the actual situation of each region. In addition, oil and gas are naturally endowed in Nigeria, which can be an obstacle when promoting low carbonization or energy efficiency improvements from an economic perspective.

In Nigeria, it is critical to improve energy efficiency to meet the country’s climate change targets. At the same time, given the country’s growing electricity demand, increasing electricity supply is equally important, which creates a challenge when promoting energy efficiency.

Moreover, the technologies listed as priority technologies include technologies that have never been introduced in Nigeria. Securing financial resources to realize this will be an issue. Since it is difficult for Nigeria's domestic energy industry and related beneficiaries to secure project costs, it is necessary to utilize public funding systems such as development financial institutions and international financial institutions.

The impact of COVID-19 on the energy sector is mixed. On the one hand, the outbreak of COVID-19 has led to a decline in oil and gas demand, as well as decrease in oil and gas

production, providing an opportunity for Nigeria to shift to clean energy sources. On the other hand, COVID-19 has exacerbated the county's economic recession, resulting in shortages of clean energy technologies, minimized the budget for human capital development in the energy sector, and diminished the overall labor force in the sector.

5.8. Action Plan 1: Raising Awareness

5.8.1. Objectives

Implementation of the prioritized technologies for the energy sector will help in achieving the sectoral goal and Nigeria's NDC goals. Implementation of the technologies aligns with National Energy Policy of Nigeria (NEP) and National Energy Master Plan (NEMP) and helps the country to realize renewable energy generation mix. The National Energy Efficiency Action Plan (NEEAP) also stipulates introduction of prioritized energy efficiency related technologies. To achieve these objectives, building and raising awareness among stakeholders in the energy sector is indispensable. This action plan ultimately aims to alter the high consumption behavior patterns that can be observed among the end-users of Nigeria, which is considered as one of barriers in implementing the prioritized technologies. On top of industry's understanding, the general public as a user of energy shall have an understanding and awareness on energy efficiency to reduce overall energy consumption. The action plan needs to address both industry and users to achieve policy goals. To the extent possible, it is necessary to have equal representation of women and men in all awareness raising activities.

5.8.2. Activities (including cost indications)

Activity 1.1 – Awareness raising for energy sector

Nigeria's energy sector has a significant impact on global warming as the country yields oil & gas as primary sources for energy. Even though the industry seems to have an understanding on the importance of mitigating climate change impacts, to successfully implement supply side technologies, it is important to raise awareness on the state-of-the-art technologies identified in earlier sections. Building awareness among energy sector stakeholders with workshops, seminars and or technology briefings will be important. All workshops and seminars must, to the extent possible, aim for the equal representation of women and men. This activity aims to address not only behavioral barriers, but also the lack of information within the sector on the prioritized technologies.

Action 1.2 – Awareness raising for industry

Energy issues are not entirely resolved by the energy supply side; therefore, the users of energy and electricity should also have an understanding on the importance of energy saving. Building an awareness among industries to promote energy efficiency and energy saving would support the country's energy efficiency targets and energy consumption. This activity ensures that awareness raising activities are conducted along the energy value chain.

Action 1.3 – Awareness raising for general public

Building and raising an awareness on energy saving among the general public is important. As indicated earlier, households especially in rural areas continue to have high consumption behavior patterns and customs, which is leading to a significant number of emissions. Some prioritized technologies involve the general public as a direct user of technologies, such as improved cookstoves and/or adoption of energy management system tools. Energy efficiency labeling and standard require public understanding of its merits to induce consumer actions. All

knowledge products and materials should be developed in local languages and be gender and disability-sensitive where applicable. (For example, the use of braille in written materials, sign language during events and meetings, closed and audio captioning in videos etc.). Messaging must also take into account illiterate populations. Care must be taken that messaging does not reinforce gender stereotypes.

Activities will be carried out with parallel manner to build general public awareness and attention to energy saving simultaneously.

Entity in Charge: Key organization is the Federal Ministry of Power and other relevant organization will involve discussions for individual topics.

Costs: Cost associated with Action 1 largely depends on engaging energy experts which can be drawn from both local and international consultants. The total cost is estimated at USD 30,000 – 40,000.

5.9. Action Plan 2: Capacity building

5.9.1. Objectives

After the previous activity raised awareness on the prioritized technologies, this activity aims at enhancing technical and institutional capacity for each stakeholder. Developing institutional capacity will enable the implementation of policies, standards, and regulations that would lead to creating the necessary environment for deploying the prioritized technologies. On the other hand, enhancing technical capacity is more focused to building technical know-how on the prioritized technologies, so that institutions can formulate effective pilot projects. The activities will be divided into supply side, demand side, and energy efficiency capacity building.

5.9.2. Activities (including cost indications)

Activity 2.1 - Supply side capacity building

Supply side capacity building are related to solar PV, CSP and waste to energy technologies. Technical and institutional capacity building shall be executed for related sectors.

Electricity supply related industry shall have a better understanding on the technologies and how to develop effective projects, while the private sector shall realize the opportunities to invest in renewable technologies to alternate from conventional fossil fuel-based power generation. The sectoral capacity building and project development shall address to related sectors such as waste management sectors for waste to energy projects.

CCS is a relatively unique technology. Parties related to the CCS technology shall focus on commercial viability and locational availability to realize project in Nigeria. Since there is no preceding project in Nigeria, the country must seek technology partners and funding partners to implement the project even though, we understand an ongoing Industrial CCUS programme is being implemented by the World Bank Group in collaboration with the Office of the Vice President. All seminars, trainings or otherwise must, to the extent possible, aim for the equal representation of women and men.

Activity 2.2 - Demand-side capacity building

For demand-side technology, understanding of the technology by the general public, including technical aspects, is indispensable to achieve overall energy efficiency improvements and curve out power demand.

For large scale demand side projects, key government organizations and private sector shall have enhanced knowledge on the technical know-how, as well as on the possible technology application and achievable goals through the technology implementations. Designing the implementation of smart grid and energy efficient building requires detailed project management capacity, which are further elaborated in the next section.

Activity 2.3 - Energy efficiency capacity building

Among the listed prioritized technologies, energy efficiency standards/labeling and energy efficient buildings require a slightly different form of capacity building as opposed to the previous capacity building activities.

For energy efficient buildings, the supply chain must be prepared to build a structure sufficient to fulfill the required standard. Nigeria's buildings overall has not yet been fully furnished with energy efficient building materials and therefore applying certified building materials may results in higher building costs. The tenants should understand and accept price escalation, but certain transitional scheme may be needed to bridge the tenant's affordable costs and envisaged energy efficiency building.

The standard for energy efficiency is the backbone for these activities and the standard shall be understood by the end-users. The standard development shall be aligned with National Energy Efficiency Action Plan (NEEAP).

Entity in Charge: the implementation entity for the action is centralized with the Federal Ministry of Power with close communication with Federal Ministry of Science, Technology and Innovation. Energy efficiency in industry shall be promoted through Energy Commission of Nigeria and Manufacturers Association of Nigeria.

Costs: awareness raising activity involves costs associated with seminar, promotional activities and deploying information materials to the public. The costs associated with implementation of this actions in estimated at USD 20,000 – 40,000.

5.10. Action Plan 3: Development of enabling environment for private sector engagement

5.10.1. Objectives

Developing the enabling environment and coordinating with the private sector will be critical for deploying the prioritized technologies in the energy sector. Once capacities of key government institutions and stakeholders have been enhanced through capacity building activities described in the previous section, they will be well-informed to develop the appropriate policies and projects to promote the technologies. Strategies to develop projects for the individual technologies are detailed in the following sections, with explanation given on a sub-sector basis. For large-scale projects, longer period is required for project preparation.

5.10.2. Activities (including cost indications)

Activity 3.1 - Climate change impact assessment and potential mapping for each technology

This activity aims to identify and map potential locations to implement each technology based on assessment of gendered climate change impacts in different regions. Nigeria's each region has its own characteristic regarding energy supply and demand situation. Hence the assessment shall be performed to conduct climate change impacts in regional scale to determine locations

and involving parties both public and private sectors to carry out the projects.

Electricity supply

Prioritized technologies in electricity supply are different in project suitability. The solar PV and CSP projects shall be located where climatic conditions are the most suitable. Project location where currently rely on fossil fuel sources can be convertible to renewable energy while need to consider the usage pattern. PV electricity supply requires battery to fulfill peak electricity demand. Waste to energy projects shall be located and developed where one can have access to potential fuel/waste feedstocks. The fuel can be either industrial waste from food and agriculture industry or municipal solid waste. Either case, the availability and characteristics of waste feedstock shall be carefully examined to design stable electricity generation from proposed waste to energy projects. CCS projects need to be deployed at locations with high CO2 sequestration potential.

Energy demand

Developing energy demand projects differ between projects for improved cook stoves and other technologies prioritized under energy demand. For improved cook stoves, it is important to develop projects in regions where households continue to use fuelwood as energy source. On the contrary, demand-side management and smart grid projects need to be developed in locations where there is need to reduce energy demand.

Energy efficiency

Projects regarding energy management system can be implemented in institutions, facilities, or buildings, where implementing energy management system can result in reduced energy consumption. For energy efficiency standards and labelling, however, projects need to be developed at a larger scale to lead people's purchasing behavior towards energy efficiency products. Moreover, certain products can be identified to deploy energy efficiency standards and labelling to examine the impact of implementing this technology.

Activity 3.2 - Baseline study for identifying gaps and needs

This activity intends to also include conducting a gender-responsive baseline study to identify gaps and needs to be leveraged though activities for developing enabling environment. This activity is useful in mainly three ways because it can highlight areas and points needed to be improved or leveraged. Firstly, gender-responsive baseline study may be able to save financial expenditures for unnecessary activities. Usually, resources, either financial, human or technical, are not infinite, and thus it is important to invest the resources for most needed areas or technologies. Secondly, it can highlight gaps between the current situation and the future goals and inform stakeholders which gaps become priority. In this case, the extent of awareness / capacity building is required, and the enabling environment needed to foster prioritized technology dissemination, as well as gender sensitivity activities. Lastly, the process of baseline study can be an effective opportunity for stakeholder involvement, which will lead to raise their awareness and address issues in the energy sector. The methods of baseline study include but not limited to reviewing relevant policy documents, interviews, stakeholder consultations, questioners, and surveys.

Activity 3.3 - Policy development and enforcement

To establish an enabling environment for the deployment of prioritized technologies, several key policies and regulations need to be either developed or updated. For the prioritized technologies

under electricity supply, existing policies need to be updated based on the new Energy Transition Plan and introduce de-risking measures and incentive mechanisms to enhance investment, especially for renewable energy projects. In particular, to deploy waste-to-energy technologies, it is important the policies in both the energy sector and waste sector are aligned to promote coordination among stakeholders from each sector. As for CCS, even though it is yet to be introduced but development efforts through the World Bank Group is currently being undertaken[121], regulations such as for safe geological storage need to be formulated and later enforced to establish a domestic market for carbon capture. In addition, for the energy demand sub-sector, a framework to promote the prioritized technologies and incentive mechanisms need to be developed for scaling up the technologies. Finally, for the energy efficiency sub-sector, regulations and standards on energy efficiency need to be put in place. For instance, for energy efficiency buildings, establishing a standard on energy efficient buildings will be necessary.

Activity 3.4 - Guidance Development

This activity is particularly aimed at technologies that have not been implemented in Nigeria. For instance, in Nigeria, there is no guideline for establishing energy efficient buildings and presenting cost-effective designs that may help in disseminating this technology. Guidelines may be also important for technologies such as improved cook stoves that are intended to be utilized by the general public. Guidelines showing the standardized procedure will prevent the technology being misused and enhance its effectiveness.

Activity 3.5 - Provision of adequate financing

In parallel to activity 3.1 (climate change impact assessment) and activity 3.2 (baseline study), entities in the energy sector need to search for adequate financing sources for both pilot project implementation and technology dissemination. In particular, electricity generation projects, demand-side management and smart grid projects are relatively capital intensive. Furthermore, investment returns are not always guaranteed in energy efficiency projects. To identify financing sources, it is critical that entities coordinate closely with the Nigeria government. An option can be to build on the Investment and Financial Flow document adopted by the UNFCC, which identifies the investment and financial flows necessary to implement climate mitigation and adaptation actions that will achieve Nationally Determined Contributions (NDC) targets. Aside from the IFF, cost implication from the Energy Transition Plan could also be reviewed and harmonized with the IFF to tease out key financial costs. Most of the prioritized technologies under the energy sector will require international financial support in the form of grants or concessional loan, as well as private sector initiatives will the main tools utilized to cover the up-front costs of the prioritized technologies. In certain cases, public private partnerships may also be considered to attract private sector investment and minimize the risk for implementing the technologies.

Entity in Charge: Federal Ministry of Power collaboration with Federal Ministry of Science, Technology, and Innovation. Energy Commission of Nigeria will also play a key role in this activity.

Costs: Implementation costs need to be calculated during project design in Action 3.2. The total cost of implementing this action is estimated at USD 60,000 – 80,000

[121] IFC 2022. IFC and World Bank to help Nigeria pave the way for Domestic Carbon Storage. Available at: https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=26819

5.11. Action Plan 4: Dissemination of technologies

5.11.1. Objectives

The objective of this activity is to disseminate the prioritized technologies in Nigeria in order for Nigeria to achieve its climate and development objectives. This activity will disseminate prioritized technologies by developing pilot projects. Technologies need to be evaluated whether the technology is applicable to the local context and assess if the dissemination of prioritized technologies has a positive impact towards achieving Nigeria's climate change targets. This section therefore will provide details on basic components that need to be considered in disseminating technologies by sub-sector.

5.11.2. Activities (including cost indications)

Activity 4.1 - Dissemination of electricity supply technologies

Based on the results of climate change impact assessment and consultations with relevant stakeholders, pilot projects will be prepared to disseminate prioritized technologies under the electricity supply sub-sector. Given that the private sector in Nigeria is expected to be instrumental in delivering the prioritized technologies in the mid to long term (2030 – 2050), the private sector will be heavily involved in the development of pilot projects. Potential pilot projects for solar PV and CSP may include the dissemination of solar rooftop PVs, utility scale solar power generation plants, and multi-megawatt CSP plants. The technologies eventually will be adopted by power generation companies or independent power producers in the country. For waste-to-energy technologies, pilot projects need to be developed in coordination with the waste sector. As for CCS, pilot projects can be considered for either power plants or non-power sources. For power plants, CCS can be implemented in gas-fired power plants, whereas for non-power sources, CCS can be installed in the steel industry or gas processing. The pilot projects will inform whether the technology is economically viable and contribute to Nigeria's climate change efforts. Moreover, how to further scale up the technologies will be determined by the results of the pilot projects.

Activity 4.2 - Dissemination of energy demand & energy efficiency technologies

Similar to technologies prioritized under electricity supply sub-sector, pilot projects will be prepared for the prioritized technologies for energy demand and energy efficiency, which will be based on the assessments conducted in activities 3.1 and 3.2. In particular, the results identifying opportunities for energy transition will be an important indicator for developing pilot projects. For instance, pilot commercialization of improved cook stoves needs to be implemented in locations where there is high reliance on using fuelwood and other conventional methods. On the other hand, pilot projects for demand-side management and smart grid technologies will be developed in collaboration with utilities as well as the private sector including distribution companies. For energy efficiency technologies, energy management systems can be deployed in several companies in Nigeria to assess its effectiveness. For energy efficient buildings, its construction and operation may be piloted in several locations, while a pilot project for energy efficiency standards and labels may need to focus on one area or product before disseminating the technology at a wider scale. Overall, the scaling up of these technologies in both energy demand and energy efficiency sub-sectors is dependent on the acceptance of the general public and the private sector. Therefore, it is critical to continue to conduct awareness raising and promotional activities to ensure the general public's understanding and acceptance of the prioritized technologies.

Entity in Charge: Federal Ministry of Power is the pivotal ministry and other relevant organization also involves in dissemination of each technology. Energy Commission of Nigeria is particularly important for promotion of technologies.

Costs: Costs associated with Action 4 includes project development and implementation. The costs associated with the implementation of this action is estimated at USD 500,000 - 1,000,000

5.12. Financing options

This section provides a general overview of the financial options that can be considered in implementing the technology action plan. For the energy sector, the main users of the technologies are expected to be private sector stakeholders, including generation and distribution companies, and companies from other industries. It will therefore be crucial to provide the right financing conditions/schemes to trigger private sector investments for the introduction of new technologies.

The first set of activities, which includes the capacity building and awareness raising of relevant stakeholders on the prioritized technologies, will be financed by international organizations or bilateral donors in the form of grants. Enhancing the capacity of relevant stakeholders is the necessary step in establishing an enabling environment for the prioritized technologies. Conducting the necessary assessments and developing pilot projects can also be financed by grants or concessional loans from international organization and bilateral donors. Potential sources of financing include the GCF, GEF as well as international organizations, such as the World Bank, African Development Bank and bilateral donors. In regard to the dissemination of technologies, it is preferred that the financing will be led by the private sector, including local financial institutions to establish a sustainable business model for the prioritized technologies. The use of concessional financing from international partners, as well as other sources of funds such as climate financing can also be considered for supporting private sector engagement in the dissemination and development of technologies that require high investment costs, such as utility scale solar power generation plants. Key elements in disseminating the technologies in each sub-sector are detailed below:

Electricity supply

Since solar and waste to energy technologies are becoming economically viable options as energy sources worldwide, private sector financing or co-financing with the public sector can be options for disseminating the technologies. In this regard, it is important that risks are well-mitigated, and the enabling environment secured for attractive power purchase agreements. In particular, for waste to energy technologies, involvement of the agricultural and waste sectors may be necessary in ensuring stable fuel supply and further enhancing the project's viability. On the contrary, CCS technologies is still limited in terms of commercial availability and therefore public sector finance to supplement private sector investment will be critical.

Energy demand

For improved cook stoves, the deployment should be led by the federal or state government, especially in the form of grants. Since introducing improved cook stoves can also address health-related issues, financial support from international donors can also be expected. For demand-side management and smart grid, concessional financing may be leveraged as the upfront investment costs can be significant depending on the scale of implementation.

Energy efficiency

For energy management system, financing will depend on where the technology will be implemented, which in turn will determine the size of the energy management system. Grants and concessional financing may be used initially to implement the technology. For energy efficient buildings and energy efficiency standards and labeling, the deployment is likely to be led by the federal and state government with grant support in the short term (until 2025).

5.13. Potential climate change impact

The successful dissemination of the prioritized technologies can lead to two main benefits. First, it can lead to GHG emissions reductions, and second, it can prevent environmental degradation.

The deployment of prioritized technologies in electricity supply sub-sector can contribute to emissions reduction. In particular, solar PV and CSP systems can reduce the country's reliance on fossil fuels and diversify Nigeria's energy mix. Introducing waste to energy technologies can lead to both reduction of GHG emissions and reduction of air pollution that is associated with waste. Similarly, CCS technologies has the potential of reducing emissions from not only the energy sector, but also the industry sector.

In the energy demand sub-sector, improved cook stoves can also contribute to emissions reduction by limiting the reliance of fuelwood, especially in rural areas. This can in turn prevent forest degradation, which can bring multiple positive benefits including carbon sequestration. Demand-side management and smart grid, as well as energy efficiency technologies can reduce overall energy consumption, which is one of largest sources of emissions in Nigeria.

5.14. Monitoring and evaluation methods

Monitoring will provide routine tracking and reporting of key indicators and information that will allow to measure progress of the technology implementation. It will be essential not only for evaluation but also for adjusting implementation plans during project period to maximize impacts and ensuring accountability to the public and/or financial investors when applicable. People-level data will be sex and gender-disaggregated.

Monitoring will be conducted using participatory methods at outcome, sectoral and portfolio level, against a set of criteria set in advance and revised as required. In the case of the technology action plan, outcome level indicators will contribute to sectoral level impacts, which will contribute to achieving the objectives of the technology action plan.

Table 27: Monitoring and Evaluation framework for energy sector

Technology Action Plan level objectives and indicators	Roles and Responsibilities
The technology action plan will focus on strengthening the resilience of the sector while reducing GHG emissions by supporting the introduction of the technologies under each sub-sector.	Federal Ministry of Power – Lead Ministry but will ensuring coordination with the Federal Ministry of Science Technology and Innovation from the technology development context of the TAP Energy Commission of Nigeria – Ensure operational alignment to strategic formulation of energy supply / demand Federal Ministry of Science, Technology and Innovation – Facilitate development, adoption and diffusion of the prioritized energy climate technology, as well as ensure the innovation ecosystem is sustainable for wide dissemination. Federal Ministry of Environment – Will be responsible for monitoring of the technology implementation as it relates to impact on mitigation and adaptation for UNFCC reporting purpose. The Federal Ministry of Science Technology and Innovation could also support in this role as a means of ensuring the TAP is being implemented accordingly. Federal Ministry of Works and Housing – Will be responsible for ensuring strategic planning towards energy efficiency implementation for housing projects – public and private sector.
Sectoral level objectives	
Energy Sector	Implementing the prioritized technologies for the energy sector will help Nigeria achieve its objectives of the sector, meeting its NDC goals, and achieve a low-carbon and sustainable growth. The implementation of the technologies aligned with National Energy Policy of Nigeria (NEP) and National Energy Master Plan (NEMP) helps the country to realize renewable energy generation mix. The National Energy Efficiency Action Plan (NEEAP) also stipulates introduction of prioritized energy efficiency related technologies. To achieve these objectives, a roadmap for the development of prioritized technologies for the energy sector needs to be developed with actions, measures and timelines defined. The timeline for its implementation should be in line with the policies described above. The project costs are referred with international experiences, however, the amount shall be changed due to the project nature, even during the project implementation, as well as leverage on existing related projects and relevant documents with indicative cost implication to avoid duplication of efforts.

Expected Results (Outputs)	Indicators	Baselines	Targets	Data Source / Means of Verification	Timeline	Roles and Responsibilities	Budget
Action 1 Coordinate policy alignment with prioritized technologies Outcome 1: Raised awareness and acceptance of the technologies, creating the necessary enabling environment							
Activity 1.1 Awareness raising of industry	Increased understanding and awareness on energy supply-side's roles & responsibilities	N/A	At least one workshop hosted by energy industries and produce reference materials as an outcome of event At least 35% female participation in workshop	Number of workshops held & Reference Materials	2023/Q1-Q4	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria	USD 30,000 – 40,000
Activity 1.2 Awareness raising of other relevant stakeholders	Increased understanding and awareness on energy demand's roles and responsibilities	N/A	At least one workshop hosted by energy industries and produce reference materials as an outcome of event At least 35% female participation in workshop	Number of workshops held & Reference Materials	2023/Q1-Q4	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria, Manufacturers Association of Nigeria	

Activity 1.3 Awareness raising for general public	Increased understanding and awareness on energy efficiency in general public with acknowledging energy efficiency labels	N/A	At least one workshop hosted by energy industries and produce reference materials as an outcome of event At least 35% female participation in workshop	Number of workshops held & Reference Materials	2023/Q1-Q4	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria, Manufacturers Association of Nigeria	
Action 2 Capacity building and awareness raising of prioritized technologies Outcome 2: Built capacity of relevant stakeholders to enable the implementation and scaling-up of prioritized technologies							
Activity 2.1. Supply Side capacity building	Knowledge bases are built among energy supply businesses and stakeholders.	Common understanding is insufficient in energy supply side.	Hold at least one sector wide workshop to share knowledge and policy goals. At least 35% female participation in workshop	Number of workshops held	2023	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria	USD 20,000 – 40,000

Activity 2.2 Demand-side capacity & awareness building	Knowledge bases are built among building industry	Common understanding on demand side management and grid management is absent	Hold at least one workshop for grid management aiming for smart-grid and demand side management technology At least 35% female participation in workshop	Number of workshops held	2023	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria, Manufacturers Association of Nigeria	
Activity 2.3 Energy efficiency capacity building	Promote concept of energy efficiency in general public and promote energy efficiency standard	General public has insufficient understanding on energy efficiency	Hold at least one sector wide workshop to promote energy efficiency standards. At least 35% female participation in workshop	Number of workshops held & Standard enactment	2023	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria, Manufacturers Association of Nigeria	
Action 3 Pilot project formulation and installation of prioritized technologies Outcome 3: Pilot project prepared, and assessments conducted for the implementation of prioritized technologies							

Activity 3.1 Climate change impact assessment and potential mapping for each technology	Gender-responsive impact assessment and mapping	Climate impact assessment focusing on each technology conducted	At least one potential target area by technology identified based on assessment	Assessments and mappings conducted	2023 Q4 ~ 2024 Q3	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria, Manufacturers Association of Nigeria	USD 60,000 – 80,000
Activity 3.2 Baseline study for identifying gaps and needs	Gender-responsive baseline study	General gaps and needs identified	At least one study per sub-sector conducted	Gaps and needs identified	2023 Q4 ~ 2024 Q3	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria, Manufacturers Association of Nigeria	
Activity 3.3 Strategy and policy development and enforcement	Number of policies and standards developed, including gender responsive policies.	High level policies developed	Policies and binding standards pertaining to ensure technology implementation developed	Policies developed, introduced and enforced.	2023 Q4 ~ 2024 Q3	Federal Ministry of Power, Federal Ministry of Environment	

Activity 3.4 Guidance Development	Number of guidance documents developed	N/A	At least one guidance document per technology developed	Guidance developed	2024	Activity 3.4 Guidance Development	
Activity 3.5 Provision of adequate financing options	Number of financing schemes and gender-responsive loan packages	N/A	At least one scheme developed per sub-sector	Financial institution	2023 Q3 ~ 2025 Q1	Federal Ministry of Power, Federal Ministry of Environment	
Action 4 Project Appraisal and technology dissemination Outcome 4: Each prioritized technology disseminated with specific targets and timeline							
Activity 4.1 Dissemination of electricity supply technologies	Development of project	Several projects are identified/implemented in states/regions	At least one dissemination /project formulation are implemented in technologies	New project document developed	2024 4Q and onwards	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria	USD 500,000 – 1,000,000

Activity 4.2 Dissemination of energy demand & energy efficiency technologies	Developmen t of project	Several projects are identified/impl emented in states/regions	At least one dissemination /project formulation are implemented in technologies	New project document developed	2024 4Q and onwards	Federal Ministry of Power, Federal Ministry of Environment, Energy Commission of Nigeria	

5.15 Proposed implementation timeline

The following figure shows the overall timeline for the implementation of the prioritized technology in the energy sector with respect to the identified sub-sectors

Action Plan	Activity	2023				2024				2025				2026	"""	2030
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			
Raising awareness	Activity 1.1 Awareness raising of industry															
	Activity 1.2 Awareness raising of other relevant stakeholders															
	Activity 1.3 Awareness raising for general public															
Capacity building	Activity 2.1 Supply Side capacity building															
	Activity 2.2 Demand-side capacity & awareness building															
	Activity 2.3 Energy efficiency capacity building															
Development of enabling environment for private sector engagement	Activity 3.1 Climate change impact assessment and potential mapping for each technology															
	Activity 3.2 Baseline study for identifying gaps and needs															
	Activity 3.3 Strategy and policy development and enforcement															
	Activity 3.4 Guidance Development															
	Activity 3.5 Provision of adequate financing options															
Dissemination of technologies	Activity 4.1 Dissemination of electricity supply technologies															
	Activity 4.2 Dissemination of energy demand & energy efficincy technologies															

6. Technology Action Plans – Industry and Commerce

6.1. Sectoral Overview

The industry and commerce sector is the driving force to Nigeria's industrialization and is expected to play a significant role in supporting the country's growing population. In 2020, the industry sector contributed to approximately 22 percent of Nigeria's GDP, primarily led by the oil and gas-related industries.[122] In this regard, Nigeria has some of the largest oil and gas reserves in the world, accounting for over 90 percent of foreign exchange earnings and significant portion of government's revenue. The manufacturing sector is also an essential sector to Nigeria's economic growth, which is dominated by cement production that is the highest among West African countries.[123] Yet, the industry sector accounted for only 3 percent of export revenues but over 50 percent of imports, spending over USD 30 billion annually on import of various manufactured goods, leading to a balance of payments deficit for the past decade.[124]Therefore, it is evident that developing domestic industries in the industry and commerce sector as well as diversifying Nigeria's overall economy are crucial for Nigeria's long-term sustainable development.

Moreover, given the dependence on carbon-intensive industries and fossil fuels, decarbonizing the industry and commerce sector and accelerating the transition to a low carbon economy is critical in achieving Nigeria's climate change objectives. In this context, even though the Industrial Processes and Product Use (IPPU) sector alone only contributed to less than 2 percent of Nigeria's total emissions in 2017, emissions from the IPPU sector increased by approximately 5 times from year 2000 to year 2017 (2000 – 2,511 GgCO2eq, 2017 – 11,618 GgCO2eq).[125] Projections estimate that GHG emissions from the IPPU sector will increase due to the development of the industry and commerce sector along with population growth.[126] Among the sub-sectors, cement and iron and steel sub-sectors accounted for the most GHG emissions, contributing 53.4 percent and 46.4 percent of the aggregated emissions, respectively. As a result, reducing GHG emissions from the cement and iron and steel sub-sectors will be needed, along with reducing overall energy consumption in the sector.

Despite having high potential to reduce GHG emissions and promote energy efficiency, however, the industry and commerce sector of Nigeria faces several challenges. One of the challenges in the sector is the lack of information on the latest technologies and innovation that may contribute to reducing emissions from the sector as well as enhance energy efficiency. In addition, the limited coordination among stakeholders and institutions hinders the process of implementing necessary policies and activities, including institutional and technical capacity building. Similarly, the absence of coherent standards and quality control measures has made products from the sector less competitive while keeping high level of value chain emissions. Furthermore, according to the Nigeria Industrial Revolution Plan, the lack of necessary infrastructure including insufficient supply of electric power is a major constraint for both in terms of productivity in the industry and commerce sector and the transition to a low carbon economy. Difficulty in addressing these challenges stems from the lack of financial resources, fiscal investments, and participation from the private sector.

There is a lack of women's representation across industry, commerce and business in Nigeria.

[122] Statista. 2020. Nigeria-distribution of GDP across economic sectors from 2010 to 2020
[123] Transforming Energy Access. 2021. Bioenergy in cement manufacturing in Nigeria.
[124] Federal Government of Nigeria. 2014. Nigeria Industrial Revolution Plan.
[125] Nigeria. 2021. National GHG Inventory Report NIR1 2000 - 2017
[126] Effiong et al. 2019. Sectoral contributions to carbon dioxide equivalent emissions in the Nigerian economy

Studies have shown that a lack of women's representation in any sector – particularly in leadership roles – leads to an inadvertent male bias in decision and policymaking.[127] A local-level, in-depth gender analysis is recommended during the design phase of any program aiming to roll-out the technologies prioritized in this TNA. A gender analysis will examine the roles and responsibilities; needs, priorities and interests; access to power and resources; and power dynamics of women, men, girls, and boys within communities, allowing stakeholders to design contextualized gender-equitable programs. It is important to intentionally incorporate women into policy and project design, implementation, capacity building, technology transfer, and financing activities to ensure that they are not left behind. Gender expertise and guidance is necessary through the design, implementation, monitoring, and evaluation of prioritized technology policies and programs.

In this context, the sub-sectors prioritized for the industry and commerce sector are agribusiness and agro-allied sectors, solid minerals and metals, and construction and manufacturing. The following section provides a brief overview of each sub-sector.

Agribusiness and agro-allied sectors – Agribusiness and agro-allied sectors include food processing, which cover beverages and packaged foods, sugar, palm oil processing, cocoa processing, leather and leather products, rubber products, and textiles and garments. In this regard, Nigeria aims to become a leading agribusiness and agro-allied industrial nation by applying technology in intensifying production across a number of agro products. Yet even though some of these industries may align with Nigeria's development and industrialization plan, not all identified sectors in scope directly align with climate objectives in Nigeria. In particular, industries such as sugar, palm oil processing and cocoa processing may consider sustainable agriculture measures to increase productivity and production of by-products. Nevertheless, it needs to be noted that these may lead to additional GHG emissions if not properly managed.

Women's participation in any type of business in Nigeria faces a number of constraints. Disparity in land ownership, and the lack of collateral and credit history limits women's access to financial services. Less than one-third of loans are given to women and some financial institutions will only grant a woman a loan with the consent of her husband.[128] Education and training play a role; in 2018 the literacy rate for rural women was 35 percent, compared with 60 percent for rural men.[129] Women also spend up to four (4) hours a day less than men on wage-earning activities due to their domestic responsibilities.[130] According to the World Bank, "women could increase the yields on their farms by an estimated 20–30 percent if they had the same access to productive resources as men."[131]

Some agribusiness sub-sector policies, such as Presidential Initiative on Cassava, are gender-blind. Palm oil practices including land grabs, being barred from accessing forest resources, and low earnings may disproportionately affect indigenous peoples, mostly women deepening their dependence on men and broadening the gender gap.[132]

Solid minerals and metals – The solid minerals and metals sub-sector include cement, auto

[127] Power Africa. Power Africa Gender Analysis. Pages 9-12

[128] African Development Bank. Economic Empowerment of African Women through Equitable Participation in Agricultural Value Chains. Page 24

[129] Statista: https://www.statista.com/statistics/1124741/literacy-rate-in-nigeria-by-area-and-gender/

[130] African Development Bank. Economic Empowerment of African Women through Equitable Participation in Agricultural Value Chains. Page 25

[131] World Bank. Leveling the field, closing gender gap in Agriculture in Africa. Page 6

[132] Baiyewu-Teru, Abiodun. 2017. Social impacts and gender imbalances related to oil palm in Nigerian forest landscapes.

assembly, basic metals, aluminum, and chemicals. According to the Industrial Revolution Plan, the solid minerals and metal sub-sector significantly contributes to large scale midstream and downstream industrial activities in Nigeria, which is also an integral part of Nigeria's economy, Similar to agribusiness and ago-allied sectors, not all sectors in scope directly support climate objectives in Nigeria, such as auto assembly, aluminum, and chemicals. However, sectors such as cement and basic metals, including blooms, billets, sheet metal, plates, bars, rods, wire, and structural frames, support the construction industry in which development of affordable housing is needed to support the growing population.

According to Nigeria's 2004 Labor Act, women cannot be employed for night work in a public or private industrial undertaking and cannot work underground in any mine. No such stipulations are made for men.[133] This may be one reason for the low representation of women in the solid minerals sector which stood at 6.8 percent for 2019.[134]

Construction and manufacturing – This sub-sector generally focus on construction, with emphasis on supply of housing stock and construction of buildings, and light manufacturing, such as manufacturing of consumer and home goods. The construction sector supports the development and sale of affordable housing units which will require the use of solid minerals and metals, such as cement and iron and steel. For the light manufacturing sector, these include production of electronics and home appliances, which supports climate objectives related to energy efficiency. By efficiently assembling and producing appliances such as air conditioners and refrigerators, this will also support in achieving energy efficiency.

The World Bank has identified construction and manufacturing among the sectors that have the highest employment potential for youths in Nigeria.[135] It is difficult to find current data on the rates of women's participation in either sector; however, gender stereotypes as well as cultural and social norms appear to keep women's participation at a minimum.[136]

6.2. Institutional Framework

This section outlines the key stakeholders and institutions that will have important roles in implementing and scaling up the technologies that have been prioritized for the industry and commerce sector. Key government institutions in the industry and commerce sector are presented in the table below. These government institutions can develop relevant policies and strengthen the enabling environment for the diffusion of prioritized technologies while implementing the action plans:

Table 28: Key Government Institutions (Industry and Commerce)

Institution	Description
Federal Ministry of Industry, Trade, and Investment (FMITI)	The Federal Ministry of Industry, Trade, and Investment (FMITI) is responsible for diversifying Nigeria's economy by promoting trade and investment, with an emphasis on increased production and

[133] World Resources Institute. Gender and Extractive Governance: Lessons from Existing Legal and Policy Frameworks. Page 30

[134] Premium Times. Women make only 6.8% of Nigeria's extractive sector workforce. 3 August 2021. https://www.premiumtimesng.com/news/headlines/477265-women-make-only-6-8-of-nigerias-extractive-sector-workforce.html

[135] World Bank/IBRD/IFC (November 2018) Nigeria Systematic Country Diagnostic (SCD) Transitioning to a Middle-Class Society https://openknowledge.worldbank.org/handle/10986/23099

[136] Kasam, Shirka & Amin, Nor. (2020). Gender Discrimination in Building Construction Industry in Nigeria: Threat to Achieving Goal-5 of Vision 2030. World Journal of Engineering and Technology. 08. 33-41. 10.4236/wjet.2020.81004.

	export of non-oil and gas products. Therefore, the ministry aims to adopt policies and initiatives that attract investment, enhance industrialization, increase trade, and develop businesses.
Federal Ministry of Science, Technology, and Innovation (FMSTI)	The Federal Ministry of Science, Technology, and Innovation (FMSTI) facilitates the development and deployment of technology transfer, as well as promotes innovation and science to accelerate Nigeria's socio-economic development. The ministry formulates and monitors policies that are related to science, technology, and innovation, while coordinates science and research and development activities in various sectors, including industry and agriculture.
Federal Ministry of Power (FMP)	The Federal Ministry of Power (FMP) is in charge of generation, transmission, and distribution of electricity to all facets of the country. It aims to be a key enabler of economic growth and sustainable development by facilitating the delivery of affordable and reliable power supply. This is primarily done by developing relevant policies and strategies, as well as coordinating with stakeholders in the power sector.
Federal Ministry of Mines and Steel Development (MMSD)	The Federal Ministry of Mines and Steel Development is responsible for encouraging the development of Nigeria's soil mineral resources, namely, gold, iron ore, bitumen, lead-zinc, limestone, and coal. The institution is also in charge of developing the steel and mining industries in Nigeria.

The following key stakeholders can also contribute to implementing and scaling up the prioritized technologies:

Table 29: Key Stakeholders in the Industry and Commerce sector

Stakeholders	Description
Private sector	▪ Manufacturers Association of Nigeria (MAN) (Industry sub-sector): The Manufacturers Association of Nigeria (MAN) is the focal point of coordination and communication between the government institutions and industry/businesses. During its establishment, it was set up as a platform for the private sector, especially in the manufacturing industry, to advocate and formulate policy suggestions to the government, so that policies align with the interests of the private sector are developed. MAN is also responsible for promoting Nigeria-made products, monitoring government policies, as well as providing information to the private sector. ▪ Chambers of Commerce, Industry, Mines and Agriculture (NACCIMA): The Chambers of Commerce, Industry, Mines and Agriculture (NACCIMA) is the umbrella organization for all the various chambers within Nigeria, including city, state, bilateral, and multilateral chambers. NACCIMA is responsible for ensuring an enabling environment for the private sector while promoting growth and competitiveness for all businesses. To achieve these objectives, NACCIMA disseminates relevant information that would lead to innovation and development, encourage protection of interests and coordination among stakeholders in the private sector. ▪ The private sector, including MAN and NACCIMA, can play a

	significant role mainly in disseminating the technologies, supporting capacity building efforts, and creating the enabling environment.
Public institutions	▪ Nigeria Climate Innovation Centre (NCIC): The Nigeria Climate Innovation Centre (NCIC) supports Nigerian businesses and SMEs in developing profitable solutions to climate change mitigation and adaptation. The institution was established in 2018 by the World Bank with the support of the Federal Government of Nigeria to provide capacity building support, promote venture development, and enhance access to finance and the market to green businesses in the prioritized sectors. In this context, the prioritized sectors are renewable energy, waste management, smart agriculture, and water solutions. ▪ Public institutions like NCIC can primarily assist capacity building activities and promote information sharing on the prioritized technologies.
Academia/Research institutions	▪ Academic and research institutions can contribute to the assessment of the prioritized technologies in the industry and commerce sector. This would allow stakeholders to identify the appropriate technologies that are needed in the sector.
Civil Society Organizations	▪ Civil society organizations can assist in policy formulation and awareness raising of the prioritized technologies. These organizations can also support the promotion of the technologies, pressuring businesses in the industry and commerce sector to deploy the prioritized technologies.

6.3. Objectives and goals of the sector

According to Vision 20:2020, the industry and commerce sector will play an essential role in the country's long-term development, especially through the promotion of greater global competitiveness in the production of processed and manufactured goods by linking industrial activity with primary sector activity, domestic and foreign trade, and service activity.[137] Similarly, Vision 20:2020 sets out the ambition to establish a diversified and competitive economy in Nigeria with a globally competitive manufacturing sector that is tightly integrated and contributes to no less than 25 percent of the country's GDP. The Vision 20:2020 was supported by a 5-year medium-term development plan, the Nigeria Industrial Revolution Plan (NIRP), covering the period up to 2020. The plan identifies four sub-sectors that are considered as "anchor sectors" to drive Nigeria's industrialization. These sub-sectors include, agribusiness and agro-allied sectors, solid minerals and metals, oil and gas related manufacturing, and construction, lighting manufacturing and services.[138] The policy also identifies seven enablers or support structures that will transform the four sub-sectors, which are, infrastructure, skills, innovation, investment climate, standards, local patronage, and financing.[139] The anchor sectors identified in the NIRP are also the sub-sectors selected for developing the TAP.

The significance of the industry and commerce sector is also highlighted in Nigeria's climate change priorities. In its NDC, adopting green technologies in the industry sector as well as

[137] World Institute for Development Economics Research. 2014. WIDER Working Paper 2014/019: Industrial development and growth in Nigeria – lessons and challenges.

[138] Federal Government of Nigeria. 2014. Nigeria Industrial Revolution Plan.

[139] Ibid.

benchmarking international best practices in energy usage are indicated as mitigation measures. On the other hand, for adaptation, measures for the industry and commerce sector include increasing knowledge and awareness of climate change risks and opportunities, implementing risk assessments and risk reduction measures, incorporating climate change into ongoing business planning, promoting, and marketing emerging opportunities from climate change, among others. Implementing the prioritized technologies and associated action plans, therefore, contributes to the targets identified in the policies and plans related to the industry and commerce sector. Table 30 summarizes objectives for the sub-sectors identified under the industry sector.

Table 30: Summary of objectives in the industry and commerce sector

Sub-sector	Objective
Agribusiness and agro-allied sector	▪ **Food processing:** (1) facilitate the development of private sector led aggregators and bulk buyers of agro produce to bridge the gap between smallholder farmers and large industrial processers; (2) create regular platforms for large industrialists and buyers of key agro-products to engage large, medium, and smallholder farmers on standards needed at manufacturing plants; (3) organize stakeholders to jointly govern usage and needs for users of major transport corridors. ▪ **Sugar:** establish some 28 sugar factories of varying capacities and bring about 250,000 hectares of land into sugar cane cultivation over the next 10 years ▪ **Palm oil processing**: meet 100 percent of domestic demand and replace current imports and contribute surplus production that can be exported by 2020 ▪ **Cocoa processing:** (1) increase cocoa bean output by increasing cultivations, improving yields, and standardizing harvest procedures; (2) facilitate the development of cocoa warehousing investment; (3) identify and facilitate public-private interventions in key rural road infrastructure; and (4) review export incentives scheme ▪ **Leather products:** (1) promote large single-owned cattle ranches or establishment of grazing reserves for multiple small-scale herders; (2) improve technical standards of hides, skins and tanneries; (3) commercialize local tannery technology; and (4) develop capacity for export standards and knowledge ▪ **Rubber products:** (1) increase raw rubber output; (2) harmonize tariff regime; and (3) review export incentives ▪ **Textiles and apparels:** (1) develop energy supply scheme to ensure regular supply of electricity to textile firms in Norther Nigeria; (2) implement cotton supply interventions; (3) implement cotton standards; and (4) use cotton fund to retool existing plans
Solid minerals and metals	▪ **Cement:** (1) sustain the achievement of the past 10 years; (2) seek alternative uses of cement to boost local demand; and (3) make Nigeria a significant net exporter of cement to the sub-region by 2020 ▪ **Auto assembly**: (1) promote auto sector development by developing auto supplier parks; (2) increase procurement of locally assembled automobiles; (3) develop capacities of auto skills and anti-smuggling measures; and (4) attract at least five international firms into the country (e.g. Daimler, General Motors, Nissan, Toyota, Honda)

	▪ **Aluminium**: develop the aluminium subsector by streamlining tariff regime, reviewing standards, and providing incentives to export scrap aluminium ▪ **Basic metals/steel:** (1) promote investment downstream; (2) prove-up mineral resources; (3) provide incentives on exporting scrap metal; and (4) cluster new steel players in each of Nigeria's geo-political zones
Construction and manufacturing	▪ **Construction (housing supply):** develop and sell low-income and middle-income housing estates (with minimum of 300 units per project) to boost housing stock in Nigeria. ▪ **Light manufacturing:** further develop durable home goods by implementing product standardization, developing technical standards on specific products, develop value-chain partnerships, and securing intellectual property ad branding. ▪ **Services:** develop services in retail and formal trade sectors, haulage services, call centres, shared service centres, and engineering services.

6.4. Overview of the technologies prioritized in agribusiness and agro-allied sectors (including value chain analysis and gender assessment of technologies)

The technologies prioritized under the agribusiness and agro-allied sectors are modular palm oil mills and anaerobic digesters. This section will provide an overview of the prioritized technologies, including value chains and gender assessment of the technologies.

6.4.1. Modular palm oil mills

Palm oil mills produce crude palm oil, crude palm kernel oil, as well as other biomass from fresh fruit bunches. In this regard, Nigeria is one of the leading producers of palm oil globally, producing 64 million tons in 2018, which is only behind Indonesia, Malaysia, Thailand, and Colombia.[140] Since biogas consisting of methane is produced as a by-product palm-oil mill effluent (POME) in the production of crude palm oil, inefficient palm oil mills contribute significantly to global climate change. Especially if the biogas is not captured properly, palm oil mills release methane directly to the atmosphere, which has 25 times GHG potential higher than carbon dioxide. In Nigeria, there are several large- and small-scale palm oil mills operating in the country; however, these mills not only release significant amount of GHG emissions, but are also associated with negative environmental impacts, such as air, water, and soil pollution, as well as biodiversity loss.[141]

Several advanced milling technologies and methods have been recently developed which aim at reducing environmental degradation while improving production. In general, providing fiscal incentives to reduce the overall cost of the technology is required to disseminate the technology. In this regard, several advanced milling technologies and methods that are applicable to the Nigerian context are highlighted in the table below:

Table 31: Advanced milling technologies and methods

Advanced milling technologies and methods	Description
Modular palm oil mill	Modular palm oil mill is a small-scale palm oil that is designed for remote areas. It is an automated mill like industrial (large-scale) mill but with lower capacity

[140] FAOSTAT. 2021.
[141] Anyaoha and Zhang. 2022. Technology-based comparative lifecycle assessment for palm oil industry: the case of Nigeria

	(typically from 1-10 tons/hr.) and high efficiency. The produced oil palm wastes are used to generate steam and electricity for the operation of the mill, making it self-sustaining. Another design can include the generation of biogas from the produced palm oil mill effluent. The biogas is used to generate electricity for the mill, making the palm oil mill sustainable and cost-efficient.
Biogas utilization using anaerobic digester	Biogas, which is a mixture of methane, carbon dioxide, hydrogen sulfide, and a small portion of other gases, can be produced anaerobically. Modern anaerobic digesters allow to produce biogas with high yields that can be utilized to other applications. Applications include, but not limited to, power generation using biogas, for co-firing boilers, and for flaring. Furthermore, materials that were unable to be converted to biogas (10 to 30 percent) are rich in nitrogen and so it can used as fertilizers. To be effective, however, it needs to deploy a biogas digester to capture the methane that would otherwise be released to the atmosphere.
Scum and sludge treatment	Raw POME is generally treated with open lagoon systems which contribute to GHG emissions. During this process, sludge and scum frequently accumulate, requiring regular desludging activities with heavy machinery. Improvements in scum and sludge treatment, therefore, reduce maintenance costs and provide economic benefits while minimize the use of heavy machinery and electricity, contributing to reducing GHG emissions. Studies estimate that improvements in scum and sludge treatment can reduce 6,500 tons CO2eq per year [142] Utilizing microorganisms and dewatering containers are some of the technologies that can be deployed to improve scum and sludge treatment.
Biochar production	Biochar is a form of charcoal produced from the biomass residues from palm oil processing which can enhance carbon sequestration and improve nutrient and water retention in the soil. This in turn can contribute to not only climate change mitigation, but also to root development and biodiversity. Producing biochar has the potential to reduce 62,100 tons CO2eq per year from the overall palm oil production cycle. [143]
Green hydrogen	By using anaerobic fermentation process, hydrogen via microflora can be produced from POME. This process produces biogas that consists of approximately 36 percent hydrogen and 64 percent carbon dioxide, but methane-free. In addition to this, by deploying an electrolyzer or a steam reformer powered by biogas, hydrogen from POME can be used to generate electricity and provide an energy storage solution. For scaling up this technology, however,

[142] Winrock International.2021. Technology options for the treatment and valorization of palm oil mill effluent in Indonesia.
[143] Ibid.

	further cost reductions are needed and thus this technology may be more available in the long term.

6.4.2. Anaerobic digesters

Anaerobic digestion is the process in which microorganisms break down organic matter in the absence of oxygen. Anaerobic digestion is often implemented in industrial settings to manage wastes streams. Through anaerobic digestion, three main outputs are produced, namely, biogas which can used for energy production, nutrient-rich digestate, and liquid liquor that can used as fertilizers. Anaerobic digestion systems can capture and utilize methane, and thus can contribute to reduction of GHG emissions. According to the Third National Communication, inadequate disposal of industrial has led to not only led to the release of GHG emissions, but also contribute to environmental degradation, primarily water and air pollution. Therefore, deploying this technology aligns with Nigeria's climate change and environmental strategies. Yet, maintenance costs can be high, and the technology requires enough land to operate. Even though this technology is commercially available, these disadvantages need to be addressed for the technology to be implemented throughout Nigeria.

The following table detail the types of established anaerobic digestion systems that can be implemented:

Table 32: Anaerobic digestion system

Anaerobic digestion systems	Description
Wet and dry digesters[144]	This form of digesters is classified either wet or dry depending on the moisture content of the feedstock. Dry anaerobic digesters refer to digesters that use minimal mechanical sorting, with the digestion process taking place from solid waste. On the other hand, wet anaerobic digesters convert waste into a pulp, and thus generally use organic matter in liquid form. Overall, wet digesters are more common than dry globally.
Mesophilic and thermophilic systems[145]	Commonly used in wastewater treatment plants, mesophilic anaerobic digestion system incorporates bacteria that lives optimally at 35-40 degrees Celsius, which makes this system one of the more efficient and cost-effective technologies. An anaerobic digestion system that uses bacteria that lives 55-60 degrees is called a thermophilic anaerobic digestive system. Even though the energy input is higher for this system, higher temperature can facilitate faster gas yields.
Single and multi-stage digestion system	A single-stage digestion system is a system whereby all the digestive process occurs within a single sealed reactor or holding tank, whereas a multi-stage digestion system uses different tanks to optimize the reactions. A multi-stage digestion system can enhance biogas yield and overall reaction rate, making the system more cost-effective. However, a single-stage digestion system

[144] United States Environmental Protection Agency. 2022. Types of Anaerobic Digesters.
[145] United Kingdom Department for Environment, Food and Rural Affairs. 2011. Anaerobic digestion strategy and action plan

	reduces overall construction costs.

The following section identifies key stakeholders instrumental to the implementation of the three prioritized technologies in the agribusiness and agro-allied sub-sector.

Public sector:

To disseminate both advanced milling technologies and anaerobic digestion, the public sector needs to take the lead in establishing the enabling environment. First, it is necessary to install regulations or standards to the industry sector on the amount of GHG emissions as well as the environmental regulations. These regulations or standards can incentivize the industry sector to consider the prioritized technologies. In doing so, the public sector needs financial assistance from international and/or bilateral development partners that will support policy formulation and capacity building activities. Second, the public sector needs to ensure the development of fiscal incentives such as tax credits and loan schemes to promote the technologies. Both advanced milling technologies and anaerobic digestion require significant initial investment, and thus fiscal incentives are essential in reducing the financial burden of the industry sector in adopting the technologies. Finally, the public sector is responsible for coordinating with appropriate institutions including the private sector to scale up and disseminate the technologies nationally. Coordination among stakeholders allows to formulate appropriate gender-responsive policies and strategies for the technologies that would be accepted by general public, and this in turn can accelerate the process of disseminating the technologies.

Technology providers:

Technology providers are contractors that will directly provide the prioritized technologies to the industry sector. The technology providers can also provide technical knowledge and expertise on the prioritized technologies so that the industry sector can utilize the technologies appropriately. Depending on the specific technology, Nigerian SMEs and start-ups can also be involved in the procurement and dissemination process. Yet, given that the implementation of these technologies in Nigeria is still limited, technical and institutional capacity building led by the public sector may be necessary. Working with women or youth-owned or led SMEs will ensure a fair representation of women and youth. Supporting internships or job shadowing programs increases the technical knowledge of women and youth.

Capital providers:

Capital providers are essential in deploying advanced milling technologies and anaerobic digestion as these technologies require significant initial investment. Capital providers need to coordinate with the public sector as well as the technology providers to develop effective financial schemes. Considering that standard business model of the industry sector where revenue from the service users is anticipated, there is significant opportunities of private sector involvement when a sustainable business model is established. Potential capital providers vary such as international and/or bilateral development partners including international climate funds, the Nigerian government, local financial institutions, and private investors. All financing schemes should be gender-responsive, ensuring that women, as well as men, have access to finance despite structural barriers such as a lack of collateral.

Industry sector:

The industry sector will be the main implementer of the prioritized technologies. Prior to installing the technologies, the industry sector needs to be informed about the benefits of each technology.

To stimulate the deployment of the prioritized technologies, as mentioned earlier, capital providers need to develop financial incentives by coordinating with the public sector.

6.5. Overview of the technologies prioritized in solid minerals and metals sectors (including value chain analysis and gender assessment of technologies)

The technologies prioritized under the solid minerals and metals are use of alternative fuels, advanced grinding technologies, and unhydrated cement recycling. This section will provide an overview of the prioritized technologies, including value chains and gender assessment of the technologies.

6.5.1. Use of alternative fuels

Switching to alternative fuels from carbon-intensive, conventional fuels in cement production has the potential to significantly reduce GHG emissions from the cement industry. Globally, coal is the most widely-used fuel in cement production, accounting for more than 70 percent of global cement thermal energy consumption. In addition, oil and gas combined contributes to about 24 percent of global cement thermal energy consumption.[146] Similarly, in the Nigerian cement industry, natural gas, imported and domestic coal, as well as domestic petroleum has traditionally been used for cement production.[147] In this context, switching to alternative fuels has the potential to reduce GHG emissions by 24% in 2050.[148] Since the cement industry is the highest GHG emitting industry in the IPPU sector of Nigeria accounting for 53.4% of emissions in the sector, the importance of switching to less carbon-intensive fuels and reducing GHG emissions in the sector is evident.

In general, alternative fuels can be classified into 5 categories: hazardous waste, non-hazardous industrial and commercial waste, municipal waste, biomass, and other unclassified alternative fuels. Detailed explanation of each alternative fuel is provided in the table below:

Table 33: Alternative fuel types

Alternative fuel types	Description
Hazardous waste	**(a) Spent solvents** Spent solvents are mostly available in the chemical and pharmaceutical industries, as well as in the manufacturing industry that utilizes glues, paints, and varnishes. Spent solvents have been wide used as an alternative fuel due to its high calorific value and its liquid state that allows to be injected to the heating hood. Even though the quantity of spent solvents reduced globally as a result of producers' efforts to decrease the use of solvents at the source, the market for spent solvents remain competitive. **(b) Used oil** Given its high calorific value and its ability to be handled flexibly, utilizing used oil as an alternative fuel is popular, especially in Europe. It can reduce the illegal disposal of used oil that is prevalent in many countries, while contribute to GHG emissions reductions. However, the availability of used oil highly depends on the

[146] International Finance Cooperation. 2017. Increasing the use of alternative fuels at cement plants: international best practice
[147] Carbon Trust. 2021. Bioenergy in cement production in Nigeria
[148] International Energy Agency. 2018. Technology roadmap: Low-carbon transition in the cement industry

	regulatory environment, as some countries' policies prohibits the cement industry to recover used oil as an alternative fuel. **(c) Industrial sludge** Recently, industrial sludge has been used as a substitute to spent solvents because of the recent decline in the total amount of spent solvents in the market. Direct use of sludge in cement kilns is now available given the use of concrete pumps in injection. However, industrial sludge use in direct injection is still limited since it requires to maintain good combustion. **(d) Polluted (wood and plastic) packaging** Polluted packaging generally includes chemical packaging, fertilizer packaging, and oil packaging in garages. This is an emerging alternative fuel especially in developed countries, where selective collection and strict enforcement enables the use of polluted packaging in the cement industry.
Non-hazardous industrial and commercial waste	▪ Although hazardous waste was commonly used as an alternative fuel, demand for non-hazardous industrial and commercial waste increased as governments made regulatory changes that led to an increase in waste disposal costs. Shredded solid waste is particularly used, and unlike hazardous waste, it requires cement producers to deal with waste collection companies as opposed to dealing with producers for hazardous waste.
Municipal waste	**(a) Municipal solid waste** Given its heterogeneity, odor, low calorific value, and different physical states, the use of municipal solid waste as an alternative fuel for cement production was limited. However, emerging technologies to produce refuse-derived fuel (RDF) from municipal solid waste more efficiently has made municipal solid waste as a reliable option for fuel, especially in Central Europe. Yet, it is still a labor-intensive process that requires strict regulations, and thus may not be an economically feasible option. **(b) Municipal sewage sludge** The use of municipal sewage sludge as an alternative fuel has been adopted in several countries like China, Spain, France, Japan, and the United Kingdom. Its use has increased due to the development of communal sanitation and as disposal channels are increasingly becoming more restricted. However, even though sewage sludge can be injected into the back of the cement kiln, its calorific value is too low.
Biomass	**(a) Agricultural and agro-industrial wastes** In the cement industry, rice husk is the most commonly used agricultural and agro-industrial waste as alternative fuel. In addition to its high calorific value, rice husk has a high proportion of reactive silica, which combines well with other raw materials during cement production. Other forms of agricultural biomass that can be used as alternative fuel includes cashew nut husk, oil palm husk, coffee husk, and sunflower husk. **(b) Green wastes** Green wastes refer to byproducts of forest management, such as

	replacement of rubber trees. However, since wood needs to be dried in order to be properly valorized, the economic feasibility of this fuel still needs improvement.
Other unclassified alternative fuels	**(a) Plastic and wood waste from construction sector** Construction and demolition waste is receiving growing attention, particularly in North America, where large quantities of wood materials are used in construction but resulting in significant demolition waste. Recovering waste from the construction sector and turning it into a fuel for cement production has been implemented in several countries; however, it is still an emerging method. **(b) Used tires and rubber waste** Used tires are also often used as alternative fuel for cement production, especially whole tries from light vehicles and small vans. This is particularly evident in countries where uncontrolled disposal of tries is less accepted by the general population. Yet, since used tries can be recovered in various forms, whether used tries will be utilized solely by the cement producers will depend on the country's regulations.

6.5.2. Advanced grinding technologies

In cement production, the grinding process accounts for more than 60% of the electrical power demand during cement production while also being of the greatest importance for the final product quality. [149] As a result, introducing advanced grinding technologies that are more energy efficient than conventional grinding technologies has the potential to save a significant amount of energy while contribute to GHG emissions reductions. As mentioned earlier, since Nigeria's cement industry is responsible for 53.4% of the aggregated emissions from the IPPU sector, improving grinding technologies in cement production is essential for achieving Nigeria's climate change targets. Many of the advanced grinding technologies, however, is still at the research and development phase whereby their applicability and impact on cement production is still being assessed. This technology is also not commercially available yet. Therefore, the technology may not be available in Nigeria until the mid to long term and will require several assessments for the technology to be available commercially in the country.

The table below shows some of the advanced grinding technologies at the research and development phase:

Table 34: Advanced grinding technology

Advanced grinding technology	Description
Ultrasonic comminution	Ultrasonic comminution is based on a high-compression roller mill with ultrasonic characteristics. Using ultrasonic energy allows to diminish the torque required and the stress to the shafts, which results in overall reduction in energy use.
High-voltage power pulse fragmentation	Generally applied in the mining industry, high-voltage power pulse fragmentation uses high voltage power pulse electrical discharges to selectively fragment solid composite materials. This technology is more efficient and environmentally friendly technology compared

[149] European Cement Research Academy "Future Grinding Technologies"

	to conventional methods.
Low temperature comminution	Low temperature comminution allows to reduce particle size by rapidly decreasing the temperature using nitrogen or ice. This allows to use less energy overall, contributing to reduction of GHG emissions.

6.5.3. Unhydrated cement recycling

Cement recycling has recently attracted growing attention as there is considerable interest in establishing 'circular concrete". Given the rise of the circular economy concept, concrete producers have conducted research and development on potential technologies that can contribute to recycling and reuse concrete. Globally, the cement industry emitted 1.4 Gt of CO2 in 2019, which is approximately 4.5% of total global GHG emissions.[150] Similarly, in Nigeria, the cement industry accounts for the highest GHG emissions in the IPPU sector. As a result, addressing GHG emissions from the cement industry is necessary to reduce total aggregated emissions both globally and in Nigeria, and cement recycling can be a technology that can contribute to this.

Among cement recycling technologies, unhydrated cement recycling technology is the technology that is commercially available as most cement recycling technologies are still at research and development phase. In this context, unhydrated cement recycling technology enables unhydrated cement, which can contain up to 50 percent of cement, be recovered and used as new cement. Normally, recovering unhydrated cement from demolished structures and used concrete is a challenge as it is difficult to distinguish with other materials. However, advances in technologies that can separate heterogeneous composite elements from concrete, namely, unhydrated cement, hydrated cement, gravel, and sand, allowed the recovery of unhydrated cement with more accuracy. The advantage of using unhydrated cement is that it can directly be recycled and used as virgin cement, which reduces the need to produce concrete using primary cement, leading to overall decrease in energy use. Furthermore, unhydrated cement can be a substitute to limestone in cement kiln, reducing the process of decarbonizing limestone, which is one of the sources of carbon dioxide emissions in the cement industry. Moreover, most of emissions from the cement industry stems from the use of fossil fuels in heating the cement kiln up to 1,400 degrees Celsius; however, unhydrated cement recycling only needs heating up to 300 degrees Celsius, reducing the amount of energy used. Overall, this technology is more cost-effective and environmentally friendly compared with conventional methods, while having the potential to significantly reduce GHG emissions from the cement industry in Nigeria.

The following section identifies key stakeholders instrumental to the implementation of the three prioritized technologies in the solid minerals and metals sub-sector.

Public sector:

For the prioritized technologies under the solid minerals and metals sub-sector, the public sector needs to emphasize technical and institutional capacity building of relevant institutions as the use of these technologies in Nigeria is still limited. Furthermore, the public sector is expected to create the enabling environment for disseminating these technologies, either by introducing gender-responsive policies, strategies, regulations, or guidelines. In particular, for the use of alternative fuels in cement production, it is essential to not only adopt regulations or policies

[150] UNEP Emissions Gap Report 2020

related to GHG emissions, but also to develop regulations or policies related to waste management. This is because waste needs to be managed and collected systematically in order to be utilized as fuel in cement production. For advanced grinding technologies and unhydrated cement recycling, the public sector may need to introduce financial incentives to promote the technologies. In conducting these activities, the public sector needs financial assistance from international and/or bilateral development partners that will support policy formulation and capacity building activities.

Research institutions:

Since some of the technologies prioritized in the solid minerals and metals sub-sector are not commercially available and still under research and development, research institutions can play a significant role in disseminating the technologies. For instance, research institutions can take the lead in conducting the assessments for advanced grinding technologies and unhydrated cement recycling, to ensure that these technologies can contribute to reducing GHG emissions from cement production in Nigeria. Research institutions can also conduct experiments to determine which form of waste or biomass can be considered as an alternative fuel. It is expected that research institutions coordinate closely with the technology providers.

Technology providers:

The technology providers are contractors that will directly provide the prioritized technologies to the industry sector. The technology providers can also provide technical knowledge and expertise on the prioritized technologies so that the industry sector can utilize the technologies appropriately. Depending on the specific technology, Nigerian SMEs and start-ups can also be involved in the procurement and dissemination process. Yet, given that the implementation of these technologies in Nigeria is still limited, technical and institutional capacity building led by the public sector is necessary. Working with women or youth-owned or led SMEs and start-ups will ensure a fair representation of women and youth. Supporting internships or job shadowing programs increases the technical knowledge of women and youth.

Capital providers:

Developing markets related to the prioritized technologies is possible, and therefore the involvement of the private sector is expected. Capital providers need to coordinate with the public sector as well as the technology providers to develop effective financial schemes. Potential capital providers vary such as international and/or bilateral development partners including international climate funds, the Nigerian government, local financial institutions, and private investors. Considering the fact that standard business model of the industry sector where revenue from the service users is anticipated, there is significant opportunities of private sector involvement when a sustainable business model is established. However, given that some prioritized technologies are still at research and development phase, private sector involvement may be in the medium to long term.

Cement industry:

The cement industry will be the main implementer of the prioritized technologies. Prior to installing the technologies, the cement industry needs to be informed about the benefits of each technology. Furthermore, to stimulate the deployment of the prioritized technologies, capital providers in coordination with the public sector need to develop financial incentives.

6.6. Overview of the technologies prioritized in construction and manufacturing sectors

(including value chain analysis and gender assessment of technologies)

The technologies prioritized under the construction and manufacturing are shifting to renewables sources for electricity, disaster-resilient buildings, and zero energy buildings. This section will provide an overview of the prioritized technologies, including value chains and gender assessment of the technologies.

6.6.1. Shifting to renewable sources for electricity

Since one-fifth of the global carbon emissions come from the manufacturing and production sectors, there is an urgent need for the manufacturing sector to decarbonize its activities. Despite the fact that the IPPU sector is the least emitting sector for Nigeria contributing only 5.3% of total GHG emissions, the total amount of GHG emissions from this sector is expected to grow as the manufacturing sector of Nigeria is estimated to further develop in the next several years. There are several approaches to decarbonize the manufacturing sector, such as improving energy efficiency through energy management systems, substituting low carbon fuels and feedstock for combustion-related activities, and installing carbon capture technologies at the source of carbon dioxide emissions. However, the most common method used in decarbonizing the manufacturing sector is electrification using both on-site and grid renewable generation sources. Specifically, electrification in the manufacturing sector includes electrification of process heating and high-temperature ranges processes, as well as replace thermally-driven processes with electrochemical processes.[151] In this regard, since most of the electricity generated for the manufacturing sector relies on fossil fuels in Nigeria, shifting to renewable sources for electricity generation will be critical. Moreover, procuring electricity from renewable sources will be essential in enhancing the use of renewable electricity in the manufacturing sector.

The following table details procurement options that can be considered in the Nigeria context, which will be a critical component for the manufacturing sector to shift to renewable sources of electricity:

Table 35: Procurement option for renewable electricity

Procurement options for renewable electricity	Description
Onsite owned renewable capacity[152]	Onsite owned renewable capacity refers to renewable electricity developed from installations that are owned by the company, which can be either be connected to the grid or entirely off-grid. This is an attractive option for companies with surplus capital as it can lead to highest return on investment as opposed to onsite systems that involve third parties. Since the assets are owned by the company itself, the electricity produced and used is essentially free to the company. Yet, significant investment is needed initially to install the system and installed capacity is dependent on available space.
Onsite contracted renewables[153]	Onsite contracted renewables are based on power purchase agreements (PPA) between the company and the project developer. In this context, the project developer owns and operates the renewable energy system for a term of 15 – 25

[151] US Department of Energy. 2022. Industrial Decarbonization
[152] International Energy Agency. 2017. Renewable energy for industry
[153] Ibid.

	years. This is an attractive option for companies that prefer to have the renewable energy system financed externally. Moreover, since the company pays for the system at a fixed price, it enables long-term electricity price stability and cost certainty for internal planning. The most common form of onsite contracted renewables is solar PPAs.

6.6.2. Disaster-resilient buildings

Disaster-resilient buildings refer to buildings that are developed to primarily reduce or avoid the impacts of coastal flooding.[154] This may involve measures such as elevating structures above the flood risk zone, incorporating designs and materials to reduce the vulnerability to flooding and prevent the water from entering into the structures. In this context, Nigeria's coastal regions are highly susceptible to flooding, especially due to the rise in sea levels in recent years. Similarly, according to the Nigeria Hydrological Services Agency (NHSA), 27 out of 36 states in Nigeria was considered as substantial risk of flooding in 2021. The severity and the frequency of flood events are expected to increase as a result of climate change, threating Nigeria's path to sustainable development. In this context, introducing disaster-resilient buildings in Nigeria can mitigate the risks associated with flooding that is expected to become more frequent and severe due to climate change.

In general, there are two forms of disaster-resilient buildings:

- Wet-flood proofing structure
- Dry-flood proofing structure

Wet-flood proofing structure has mainly three approaches: (a) install a structure that allows the water to easily enter and exit a building to limit structure damage, (b) use of materials that are flood resistant, and (c) elevation of important utilities.[155] On the other hand, dry-flood proofing structure refers to structures that is constructed to prevent floodwaters from entering the structure by making it watertight below the expected flood level. This is achieved by measures such as installing watertight shields on entrances and sealing the walls with waterproof coating or other supplementary layers.[156]

Even though disaster-resilient buildings are more cost-effective compared to seawalls and dike systems, it requires detailed communication between public institutions and the community through hazard mapping and flood warning systems. In other words, without proper planning prior to the construction of these buildings, the effectiveness of disaster-resilient buildings may be limited. The cost for developing disaster-resilient buildings will depend on several factors including, but not limited to the size of the building, the materials used, and the height of the flood protection elevation.

6.6.3. Zero energy buildings

Zero Energy Building refers to "an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy".[157] It is a structure that "combines energy efficiency and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources over a specified

[154] CTCN. 2022. Disaster-resilient buildings
[155] Federal Emergency Management Agency. 2010. Wet floodproofing
[156] Ibid.
[157] US Department of Energy (2015) "A Common Definition for Zero Energy Buildings"

time period".[158] Zero energy buildings typically combine two strategies, namely, passive and active strategies. Passive strategies are strategies aimed at minimizing energy consumption whereas active strategies are strategies aimed at producing new and renewable energy.

Globally, the construction of zero energy buildings is gaining momentum as several governments have indicated zero energy buildings targets. The Nigerian government has also indicated its stance in the National Adaptation Strategy and Plan of Action (NASPA) to discourage housings and buildings that are maladaptive in the face of climate change, and therefore, deploying zero energy buildings aligns with Nigeria's overall adaptation strategy.

Although zero energy buildings can take different forms, there are several core concepts that can be observed in all zero energy buildings. The core concepts of zero energy buildings are explained in the following table:

Table 36: Core concepts of zero energy buildings

Core concepts of zero energy buildings	Description
Sustainable design (passive)	Passive sustainable design is a design aiming at reducing overall energy consumption. Some methods used to achieve passive sustainable deign are: ▪ Building geometry: A method to reduce overall energy demand by influencing the building's composition and shape. ▪ Natural lighting: A method to determine the optimal orientation of a building to reduce building energy demand by analyzing the sun's altitude, the amount of daylight, etc. ▪ Natural ventilation: A method to determine the architectural design that utilizes effective influx of outdoor air to reduce the building energy demand.
Energy-saving techniques (passive)	Passive energy-saving techniques are aimed at energy conservation in buildings. Some approaches to achieve this are: ▪ Building envelope design: Analyzing the thermal characteristics of building envelopes that would optimize heating, ventilation, and air-conditioning. ▪ Thermal storage system: A method focusing on reducing the heating and cooling demand of a building through the thermal storage function of a thermal mass. ▪ Lighting design: Reducing lighting consumption by incorporating lighting emitting diode (LED), light shelves and lighting control system.
Renewable energy (active)	In zero energy buildings, energy is produced through renewable sources. The main renewable energy systems applied to zero energy buildings are: ▪ Photovoltaic (PV) system ▪ Solar thermal system ▪ Geothermal system ▪ Wind turbine system
Back-up systems for	In recent development, several back-up systems are generally

[158] US Department of Energy "Zero Energy Buildings" Available at https://www.energy.gov/eere/buildings/zero-energy-buildings

renewable energy (active)	installed to support renewable energy systems. These include: ▪ Fuel cell system: electricity power generator that uses electricity produced through the chemical reaction of oxygen and hydrogen ▪ Energy storage system: methods and technologies to store energy to allow energy to be utilized later

The following section identifies key stakeholders instrumental to the implementation of the three prioritized technologies in the construction and manufacturing sub-sector.

Public sector:

Similar to other prioritized technologies, the public sector is expected to provide an enabling environment for the diffusion of the technologies. In doing so, the public sector needs financial assistance from international and/or bilateral development partners that will support policy formulation and capacity building activities. The implementation by the public sector may vary depending on the technology. For instance, to incentivize the manufacturing sector to shift to renewable sources for electricity, policies, or regulations as well as fiscal schemes that would enhance the development of renewable energy production may be needed. On the other hand, for disaster-resilient buildings and zero energy buildings, overall strategies and regulations related to buildings or construction may be needed.

Research institutions:

In the case of disaster-resilient buildings and zero energy buildings, research institutions are expected to play a significant role in the assessment of the technologies. For example, for disaster-resilient buildings, a hazard map needs to be developed in coordination with the public sector to ensure that disaster-resilient buildings are constructed in locations that are prone to floods. Furthermore, for disaster-resilient buildings and zero energy buildings, research institutions can provide information on the local context to the technology providers so that the appropriate materials are used.

Technology providers:

The technology providers are contractors that will directly provide the prioritized technologies to the industry sector. The technology providers can also provide technical knowledge and expertise on the prioritized technologies so that the industry sector can utilize the technologies appropriately. Depending on the specific technology, Nigerian SMEs and start-ups can also be involved in the procurement and dissemination process. Yet, given that the implementation of these technologies in Nigeria is still limited, technical and institutional capacity building led by the public sector may be necessary. Working with women or youth-owned or led SMEs and start-ups will ensure a fair representation of women and youths. Supporting internships or job shadowing programs increases the technical knowledge of women and youth.

Capital providers:

In the case of shifting to renewable sources for electricity, considering that standard business model of the manufacturing sector where revenue from the service users is anticipated, there is significant opportunities of private sector involvement when a sustainable business model is established. However, in the case of disaster-resilient buildings and zero energy buildings, the involvement from the private sector may be limited, as returns cannot be expected under conventional business models. More opportunities for the private sector may exist in zero energy buildings as each component of the structure can provide commercial opportunities.

Community and manufacturing industry:

For disaster-resilient buildings and zero energy buildings, the local communities will be the main user of the technologies. Prior to installing the technologies, the community needs to be informed about the benefits of each technology and be heavily involved in the planning process. On the contrary, the manufacturing industry will be main implementer in shifting to renewable sources for electricity. To stimulate the deployment of the prioritized technologies, however, capital providers in coordination with the public sector need to develop financial incentives.

6.7. Overview of Barriers

Table 37: Barriers in the industry and commerce sector

Types of Barriers	Description
Political	▪ None
Regulatory	▪ Absence of coherent standards and regulations ▪ Lack of quality control measures
Institutional	▪ Insufficient coordination among the stakeholders ▪ Heavy reliance on fossil fuels
Technical	▪ Lack of technical know-how on the prioritized technologies
Financial	▪ Lack of financial resources ▪ High investment costs ▪ Lack of fiscal incentives to implement the technologies
Geographical	▪ Limited geographical assessments
Market	▪ Limited private sector involvement
Information	▪ Lack of information on the latest technologies
Behavioral	▪ Limited understanding on the benefits of technologies

The introduction of prioritized technologies in the industry and commerce sector will require significant financial resources. This is not only needed in deploying the prioritized technologies per se, but also for meeting infrastructure requirements and promoting further investments. In addition, creating an enabling environment for introducing the technologies is necessary, especially by formulating adequate standards and regulations. For instance, environmental standards and requirements on cement production are still limited in Nigeria, which may hinder the deployment of prioritized technologies in the cement industry. Similarly, building standards that consider climate change impacts are still insufficient. Formulating regulations and standards, therefore, can incentive the industry in adopting the prioritized technologies.

To develop appropriate policies and regulations, however, coordination among stakeholders will be critical. Institutionally, the roles and responsibilities of institutions remain unclear, which has contributed to the lack of information on the latest technologies. General awareness and information regarding the technologies, especially on the benefits of each prioritized technology, need to be improved within the sector. The industry sector is poorly informed about the technology characteristics, market opportunities, as well as on their own energy use, which also encourage the industry sector to maintain its conventional methods and dependence on fossil fuels.

The spread of COVID-19 is another challenge that the industry and commerce sector is facing. According to the National Bureau of Statistics in Nigeria, the industry and commerce sector experienced negative growth rates of -12.05 percent in 2020 leading to reductions in

investments.[159] As a result, the industry sector has contracted by 5.9 percent over the course of 2020, with financial reports of all the sub-sectors indicating a decrease in revenue.[160] The financial status of the industry and commerce sector is a significant concern as it may prevent the sector's transition to low carbon production and implementing the prioritized technologies. Therefore, establishing the enabling environment, providing fiscal incentives, and disseminating appropriate information on the technologies will be essential.

6.8. Action Plan 1: Raising awareness

6.8.1. Objectives

Developing awareness of relevant stakeholders including government institutions, potential investors, developers, end-users, and financial institutions, will enable both short, medium and long-term actions on the deployment for prioritized technologies to be implemented efficiently. Combined with capacity building activities of action plan 2, in the short-term, this will support the implementation of policies and standards for the development of the necessary enabling environment. In the medium term, this will support the behavior change to support the shift in the sector, and in the long-term, this will support in achieving the total upgrade of existing systems. The importance of raising awareness on the technologies has been highlighted several times by the stakeholders. To the extent possible, there must be equal representation of women and men in all awareness-raising activities.

6.8.2. Activities (including cost indications)

Activity 1.1 – Awareness raising of industry sector stakeholders

The successful implementation of prioritized technologies of the industry and commerce sector cannot be realized without the acceptance, support, and participation of the industry sector stakeholders since they will be the main implementer and the end-users of the technologies. This can be achieved through the dissemination of information on how implementing the technologies can contribute to mitigating climate change impacts and alleviate environmental, social, economic, safety, and health issues. Information on market opportunities and financial incentives also need be shared with the industry sector to incentivize actions.

Activity 1.2 – Awareness raising of general public and other stakeholders

In several technologies prioritized under the industry and commerce sector, it is also essential to raise awareness of the general public, from individuals to communities. For instance, for the use of alternative fuels, information on how to sort and manage wastes need to be disseminated so that the waste is properly collected to be used in the cement industry. Similarly, understanding the local environment and disaster prevention measures is important for implementing disaster-resilient buildings. This will also include information on general climate change and GHG emissions to promote awareness within the public that would support the shift in their behavior. Awareness raising of financial institutions, public and private sector stakeholders is also needed. In this context, dissemination of information regarding the prioritized technologies can be conducted through various channels, including workshops, seminars, and trainings. To the extent possible, workshops, seminars, and trainings must aim for an equal representation of women and men.

Entity in Charge: The implementing entity for the awareness raising actions is proposed to be

[159] UNDP. 2021. The impact of COVID-19 on business enterprises in Nigeria
[160] Ibid.

spearheaded by the Federal Ministry of Industry, Trade, and Investment in coordination with other relevant stakeholders

Costs: The costs associated with the implementation of this action is estimated at USD 30,000 – 40,000, which involves conducting workshops and trainings, engaging international experts, and deploying public awareness materials.

6.9. Action Plan 2: Capacity building

6.9.1. Objectives

Enhanced institutional and technical capacity for each stakeholder will enable the implementation of policies, standards, and regulations for the development of the necessary enabling environment for deploying the prioritized technologies. Developing institutional capacity, on the one hand, would allow stakeholders to make informed decisions to design related policies and regulations to improve market conditions. On the other hand, enhancing technical capacity would allow institutions to build technical know-how on the prioritized technologies, allowing institutions to develop effective projects. Building partnerships is also emphasized, as stakeholder coordination is critical in disseminating the technologies.

6.9.2. Activities (including cost indications)

Activity 2.1 – Institutional capacity building

This activity aims at strengthening the capacity of relevant government institutions and other stakeholders of the industry and commerce sector to allow them to make informed decisions to design the required policies such as gender-responsive regulations, standards, fiscal instruments and incentives, among others, to support the implementation and dissemination of prioritized technologies. This is especially required for FMITI and FMSTI as these institutions will be the main focal point in deploying the technologies. In addition, the capacity of the private sector and industry sector stakeholders also needs to be enhanced as these could leverage significant investments and develop projects.

Activity 2.2 – Technical capacity building and partnership building

The objective of this activity is to enhance the technical capacity of government institutions responsible for industrial development, technological innovation, and community development. Technical knowledge on the prioritized technologies is required to better assess and effectively implement the technologies. For instance, institutions will be able to assess the appropriate advanced grinding technology needed in Nigeria. Technical capacity building activities will be provided on a recurring basis throughout the implementation period to ensure that technical knowledge is frequently updated and maintained for efficient operation and maintenance of technologies. This activity will also emphasize in developing partnerships and enhancing coordination among stakeholders.

Entity in Charge: The implementing entity for the capacity building activities is proposed to be spearheaded by the Federal Ministry of Industry, Trade, and Investment and the Federal Ministry of Science, Technology, and Innovation. These institutions will closely coordinate with other relevant stakeholders and receive support from international consultants and experts as necessary to conduct the capacity building activities.

Costs: The costs associated with the implementation of this action is estimated at USD 20,000 – 40,000, which involves conducting workshops and trainings, engaging international experts, and deploying capacity building materials.

6.10. Action Plan 3: Development of enabling environment for private sector engagement

6.10.1. Objectives

Establishing the enabling environment and involving the private sector will be critical for disseminating the prioritized technologies under the industry and commerce sector. Once capacities of key government institutions and stakeholders have been enhanced through capacity building activities, they will be well-informed to develop the appropriate policies to promote the technologies. The enabling environment will be developed by formulating policies, regulations, guidelines, strategies, and frameworks that would encourage stakeholder engagement and private sector participation to scale up the technologies.

6.10.2. Activities (including cost indications, entity in charge)

Activity 3.1 – Identifying specific technologies applicable to Nigeria

To establish appropriate policies and frameworks, it is important to identify the gaps and needs of the country. This can be achieved either through baseline studies or feasibility studies of the technologies. During this process, consultations with stakeholders will be important to not only understand the specific needs of Nigeria, but also to strengthen coordination among the stakeholders and determine the roles and responsibilities of each institution. This activity can also identify infrastructure needs that are relevant to the prioritized technologies. The information gathered from baseline studies or feasibility studies will serve as a benchmark in assessing the technologies and determine resource allocation more efficiently.

Activity 3.2 – Natural hazard assessment and mapping

This activity intends to identify and assess risks associated with natural hazards to provide a holistic view of community risk at the national and local levels. This activity is particularly needed for deploying disaster-resilient buildings and zero energy buildings. The information obtained through natural hazard assessment and mapping would allow stakeholders to determine the location in which the technologies can be implemented. Furthermore, this information can be essential for government institutions as well as communities in adopting disaster risk prevention measures.

Activity 3.3 – Policy development and enforcement

To create an enabling environment for the dissemination of prioritized technologies, several key policies and regulations need to be developed. For the prioritized technologies under the agribusiness and agro-allied sectors, gender-responsive policies and regulations related to palm oil production as well as de-risking measures are essential in implementing the technologies. These actions and activities are intended to enhance investment in the agribusiness and agro-allied sectors. For the solid minerals and metals sub-sector, regulations and policies on waste sorting and management is important for utilizing alternative fuels. In addition, for advanced grinding technologies and unhydrated cement recycling, incentive mechanisms to mobilize private sector investment need to be developed. In the construction and manufacturing sector, to incentivize the shift to renewable sources for electricity, potential de-risking measures including the development of grid code to ensure grid stability in integrating renewable energy, implementing the feed-in-tariff for electricity generated through renewable sources, and developing a streamlined licensing and approval procedures for renewable energy producers and their interconnection with the grid. Finally, for disaster-resilient buildings and zero energy buildings, establishing a framework or strategy on urban planning and design, as well as sustainable community development is needed to promote these technologies.

Activity 3.4 – Development of building design guidelines

This activity is particularly aimed at establishing the basis for disseminating disaster-resilient buildings and zero energy buildings. In Nigeria, there is yet a standard or guideline in developing new buildings and presenting sustainable designs that can be used directly by potential developers. These standards or guidelines are important not only to promote sustainable form of buildings, but also to attract much-needed investments and encourage private sector participation.

Activity 3.5 – Development of cement production guidelines

Similar to the previous activity, this activity is aimed at establishing the basis for disseminating the prioritized technologies under the solid minerals and metals sub-sector, namely, use of alternative fuels, advanced grinding technologies, and unhydrated cement recycling. Currently, there is no coherent standard or guideline on cement production in Nigeria, which sets a baseline level on greenhouse gas emissions, promotes sustainable practices and methods, and indicates other environmental standards. This form of guideline or standard can lead to cement production using low-carbon methods and technologies, as well as enhance investment and private sector participation in the sector.

Activity 3.6 – Provision of adequate financing

The objective of this activity is to provide adequate financing to entities in the industry sector to invest in the prioritized technologies. Most of the technologies prioritized under the industry and commerce sector require high initial investment, and thus require financial support. This can be in the form of loans for certain technologies, however, international financial support in the form of grants or concessional loan, as well as private sector initiatives will the main tools utilized to cover the up-front costs of the prioritized technologies. For certain technologies, such as disaster-resilient buildings and zero energy buildings, public private partnerships could be a way to incorporate the private sector in investing in these technologies. To enhance investment from the private sector, it will be necessary to establish financing models and incentives that minimizes the risk for implementing the technologies.

Entity in Charge: The implementing entity for developing the enabling environment is proposed to be spearheaded by the Federal Ministry of Industry, Trade, and Investment in coordination with other relevant stakeholders

Costs: The costs associated with the implementation of this action is estimated at USD 60,000 – 80,000, which involves conducting feasibility or baseline study, workshops and trainings, developing and disseminating regulations and guidelines, and engaging international experts.

6.11. Action Plan 4: Dissemination of technologies

6.11.1. Objectives

The objective of this action plan is to disseminate the prioritized technologies in Nigeria in order for Nigeria to achieve its climate and development objectives. It will provide details on basic components that need to be considered in disseminating each technology. Rather than identifying activities that are applicable to all or most of the technologies, this action plan will discuss per technology, as each technology requires different approaches and methods for its dissemination.

6.11.2. Activities (including cost indications, entity in charge)

Activity 4.1 – Dissemination of modular palm oil mills

The first step in disseminating modular palm oil mills or other advanced milling technologies is to evaluate which milling technology can be applicable to the Nigerian industry sector. This can be achieved as part of Action Plan 3, in particular activity 3.1. Based on the results of this activity, stakeholders are consulted to develop a manageable project design for piloting a specific milling technology, indicating clear goals/objectives and measurable monitoring indices. The pilot project would allow to obtain valuable data that can be used as reference for industry sector stakeholders, as well as to determine how to scale up the technology. In addition, implementing modular palm oil mills or other advanced milling technologies require significant initial costs. Therefore, introducing de-risking measures and requesting external support for financing will be necessary.

Activity 4.2 – Dissemination of anaerobic digester

Establishing an enabling environment will be critical for disseminating anaerobic digesters in Nigeria. This includes the development and establishment of an anaerobic digestion industry and market in the country. This includes but not limited to considerations of logistics for waste to be digested, establishment of market for the co-products such as heat, electricity and fertilizers, and the assessment on odor issue. In other African countries, they have implemented anaerobic digestion technologies mainly in agriculture sector, horticultural sector, food companies using crop production or processing wastes as feedstock.[161] Therefore, it may be a good starting point to install anaerobic digesters in some of those sectors in Nigeria.

Activity 4.3 – Dissemination of alternative fuels

Similar to anaerobic digesters, establishing an enabling environment will be critical for disseminating the use of alternative fuels in Nigeria. Policies and regulations on waste management and waste sorting activities need to be developed, since waste is the primary source being used as alternative fuels in the cement industry. In the short term, implementation of waste sorting could be focused on the community level, while the short to medium-term actions can develop to larger scale sorting activities. The scaling up of waste sorting is expected upon enhancement of the value chain market resulting from the development of the policy environment and incentives as part of government actions. As the market for waste sorting develops in Nigeria, it is expected that it will contribute to dissemination of alternative fuels in the Nigerian cement industry.

Activity 4.4 – Dissemination of advanced grinding technologies

Since many of the advanced grinding technologies are at a research and development phase and not available commercially, it is necessary to identify the advanced grinding technology that might be applicable in Nigeria. This can be achieved either through internal research led by domestic research institutions, or rely on international technology transfers using external financing. This step is essential in choosing the optimal technology for Nigeria. Once the optimal technology for Nigeria is identified, it is necessary to implement a pilot project based on the technology, to gather data that is required in disseminating the technology.

Activity 4.5 – Dissemination of unhydrated cement recycling

[161] Cathy Olphin and Grace Bridgewater (2022). Making the Business Case for Anaerobic Digestion in Africa: Business models from across the continent. RECIRCULATE. Available at: http://recirculate.global/2022/02/ad-business-models-africa/

Similar to advanced grinding technologies, unhydrated cement recycling is an emerging technology with limited commercial use. Therefore, it is necessary to assess whether the technology is adaptable to the Nigerian context. Again, this can be achieved either through internal research led by domestic research institutions, or rely on international technology transfers using external financing. Once the technology's applicability to the Nigerian context is confirmed, it is necessary to implement a pilot project based on the technology, to gather data that is required in disseminating the technology.

Activity 4.6 – Dissemination of renewable sources for electricity

Disseminating the use of renewable sources for electricity is highly dependent on the enabling environment, both in the manufacturing sector and the energy sector. Initially, developing and upgrading the grid is necessary as improving the national grid in Nigeria will be the prerequisite for introducing renewable energy in the manufacturing sector. In this regard, upgrading of the grid system will require significant external support and therefore, this activity will include securing the necessary financial resources. Once the grid system has been upgraded to allow renewable electricity to be used by the manufacturing sector, pilot projects will be prepared to enhance the use of renewable sources for electricity in the sector. Given that the private sector in Nigeria is expected to be instrumental in delivering renewable energy technologies in the long-term, the private sector will be heavily involved in the development of pilot projects. Furthermore, as mentioned earlier, potential de-risking measures including the development of grid code to ensure grid stability in integrating renewable energy also need to be developed.

Activity 4.7 – Dissemination of disaster-resilient buildings

For the dissemination of disaster-resilient buildings, providing technical and institutional capacity building activities, as well as awareness raising of relevant institutions will be critical. These activities will allow the development of appropriate policies, standards, and guidelines that includes best practices on sustainable buildings, which can in turn lead to the promotion of disaster-resilient buildings. Given that disaster-resilient buildings entail high investment costs, financial mechanisms to reduce overall lifecycle expenses and materials cost are also essential.

Activity 4.8 – Dissemination of zero energy buildings

Similar to disaster-resilient buildings, the dissemination of zero energy buildings in Nigeria also require the development of appropriate policies, standards, and guidelines to promote this technology. To be able to develop appropriate policies and standards, however, technical and institutional capacity building, as well as awareness raising of relevant institutions will be important. Furthermore, developing financial mechanisms to reduce overall lifecycle expenses and materials cost to cover for the high investment costs will be equally important.

Entity in Charge: The implementing entity for disseminating the technologies is to be spearheaded by the Federal Ministry of Industry, Trade, and Investment in coordination with other relevant stakeholders

Costs: The costs associated with the implementation of this action is estimated at USD15,000,000 – 20,000,000, which involves project development and implementation, conducting workshops, developing information materials, conducting market research, deploying and disseminating guidelines, and engaging international experts.

6.12. Financing options

As for the industry and commerce sector, the financing approach will aim at attracting climate

finance from international financial institutions and trigger private sector investments from the private sector by developing the enabling environment for the deployment of prioritized technologies.

The first set of activities, which includes the technical and institutional capacity building of relevant stakeholders on the prioritized technologies, will be financed by international organizations or bilateral donors in the form of grants. Furthermore, concessional financing may also be leveraged for private sector stakeholders. Enhancing the capacity of relevant stakeholders is the necessary step in establishing an enabling environment for the prioritized technologies. For developing the enabling environment, even though the costs particularly associated with formulating relevant policies and regulations can be addressed through domestic resources, especially in the form of public funding, domestic sources may be limited for this purpose in Nigeria. As a result, technical assistance from international, multilateral, as well as bilateral sources can be considered. Potential sources of financing include the GCF, GEF as well as international organizations, such as the World Bank, and bilateral donors. United Nations Development Programme (UNDP) has also been very active in the development of projects related to energy, for example as an Accredited Entity to the GCF.

In regard to the dissemination of technologies, it is preferred that the financing will be led by the private sector, including local financial institutions to establish a sustainable business model for the prioritized technologies. In this context, grants and concessional financing from international partners may also be used for blended finance, in order to support local financial institutions in providing financial products which are relevant to the needs of the private sector. Along with concessional financing, climate financing can also be considered for supporting private sector engagement in the dissemination and development of technologies that require high investment costs.

6.13. Potential climate change impact

The successful implementation and dissemination of prioritized technologies will contribute to achieving Nigeria's NDC targets, especially in reducing GHG emissions, while enhance the competitiveness of Nigeria's industries to promote further industrialization and development.

Technologies prioritized under the agribusiness and ago-allied sectors are both mitigation technologies that will contribute to reducing GHG emissions from the industry and commerce sector. Deployment of modular palm oil mills will lead to reducing emissions that are associated with using inefficient, large scale palm oil mills that are mostly used in Nigeria's palm oil production. Similarly, anaerobic digesters can capture and utilize methane, and therefore can contribute to reduction of GHG emissions as well.

Furthermore, all the technologies prioritized under the solid minerals and metals sub-sector, namely, the use of alternative fuels, advanced grinding technologies, and unhydrated cement recycling, also contribute to reducing GHG emissions particularly from cement production. In this context, the cement industry in Nigeria is the highest GHG emitting industry in the IPPU sector accounting for 53.4% of emissions in the sector.

Some technologies prioritized in the construction and manufacturing sub-sector, however, can contribute to enhancing climate resilience. In particular, disseminating disaster-resilient buildings can lead to enhancing the community's resilience to climate change impacts. On the other hand, shifting to renewable sources to electricity has both mitigation and adaptation benefits. On the mitigation side, introducing this technology can reduce emissions from the manufacturing sector while helping Nigeria achieve its renewable energy targets. On the adaptation side, if distributed

renewable energy applications are utilized in the sector, it can make the power system more resilient to extreme climate events.

6.14. Monitoring and evaluation methods

Monitoring will provide routine tracking and reporting of key indicators and information that will allow to measure progress of the technology implementation. It will be essential not only for evaluation but also for adjusting implementation plans during project period to maximize impacts and ensuring accountability to the public and/or financial investors when applicable. People-level data will be sex and gender-disaggregated.

Monitoring will be conducted using participatory methods at outcome, sectoral and portfolio level, against a set of criteria set in advance and revised as required. In the case of the technology action plan, outcome level indicators will contribute to sectoral level impacts, which will contribute to achieving the objectives of the technology action plan.

Table 38: Monitoring and Evaluation framework for the industry and commerce sector

Technology Action Plan level objectives and indicators				Roles and Responsibilities			
The technology action plan will focus on reducing GHG emission from the industry and commerce sector by supporting the introduction of the technologies under each sub-sector.				Federal Ministry of Industry, Trade, and Investment (FMITI) and the Federal Ministry of Science, Technology, and Innovation (FMSTI), as well as Ministry of Environment (FMEnv) will be responsible for the overall monitoring of the technology action plans in the industry and commerce sector.			
Sectoral level objectives							
Agrobusiness and ago-allied sub-sector	The action plan will contribute to improving palm oil production (modular palm oil mills) and management of wastes streams in industrial settings (anaerobic digesters) to reduce GHG emissions from the sector.						
Solid minerals and metals sub-sector	The action plan will contribute to enhancing the use of energy efficient appliances (advanced grinding technology), limiting the use of energy (unhydrated cement recycling, and reducing the reliance on fossil fuels (use of alternative fuels) in cement production. This will overall lead to reduction of GHG emissions from the cement industry.						
Construction and manufacturing sub-sector	The action plan will contribute to reduce GHG emissions from the manufacturing sector (shift to renewables sources for electricity) and promote sustainable buildings in Nigeria (zero energy building). Furthermore, this action will enhance the community's resilience to climate change impacts (disaster-resilient buildings).						
Expected Results (Outputs)	Indicators	Baselines	Targets	Data Source / Means of Verification	Timeline	Roles and Responsibilities	Budget
Action Plan 1: Raising awareness Outcome 1: Raised awareness with acceptance to the technologies, which will supplement for creating enabling environment for the technologies.							
Activity 1.1. – Awareness raising of industry sector stakeholders	Increased understanding on the benefits of the technology by industry sector stakeholders	No awareness campaign executed	At least one gender and disability - responsive public campaign aimed at industry sector stakeholders implemented for each technology	FMITI, FMSTI, and FMEnv records	Q1 2023 – Q4 2023	FMITI, FMSTI, and FMEnv	USD 30,000 – 40,000

Activity 1.2. – Awareness raising of general public and other stakeholders	Increased understanding on the benefits of the technology by the general public and other stakeholders	No awareness campaign executed	At least one gender and disability - responsive public campaign aimed at industry sector stakeholders implemented for each technology	FMITI, FMSTI, and FMEnv records	Q1 2023 – Q4 2023	FMITI, FMSTI, and FMEnv	
Action Plan 2: Capacity Building Outcome 2: Enhanced capacity for each stakeholder which will enable the implementation and scaling-up of the prioritized technologies.							
Activity 2.1. – Institutional capacity building	Capacity building through workshop and use of reference materials delivered to officers of FMITI, FMSTI, FMEnv, and other decision makers	No capacity building activities have been conducted	At least one workshop conducted and reference materials produced At least 35% of workshop attendees are women	FMITI, FMSTI, and FMEnv records	Q3 2023 – Q2 2024	FMITI, FMSTI, and FMEnv	USD 20,000 – 40,000
Activity 2.2. – Technical capacity building and partnership building	Capacity building through training conducted and training manuals produced for technical personnel	No technical training related to the technologies has been conducted	At least one workshop by technology conducted and reference materials produced, updated every 2 years At least 35% of capacity building recipients are	FMITI, FMSTI, and FMEnv records	Q3 2023 – Q2 2024 for the first capacity building recurring every 2 years	FMITI, FMSTI, and FMEnv	

			women				
Action Plan 3: Development of enabling environment Outcome 3: Enabling environment for smallholder producers and private investment as well as for technology implementation is developed and financing available.							
Activity 3.1. – Identifying specific technologies applicable to Nigeria	Feasibility study or baseline study of appropriate technologies delivered	No feasibility study or baseline study on each technology conducted	Relevant technologies have been identified and introduced	FMITI, FMSTI, and FMEnv reports	Q4 2023 – Q3 2024	FMITI, FMSTI, and FMEnv	USD 60,000 – 80,000
Activity 3.2. – Natural hazard assessment and mapping	Natural hazard assessment and mapping conducted	No natural hazard assessment and mapping conducted	At least one natural hazard assessment and mapping report	FMEnv reports	Q4 2023 – Q3 2024	FMITI, FMSTI, and FMEnv	
Activity 3.3. – Policy development and enforcement	Number of policies (including gender responsive policies) and regulations developed	High level policies developed	Policies and binding regulations pertaining to prioritized technologies developed	Policies developed, introduced, and enforced	Q1 2024 – Q4 2024	FMITI, FMSTI, and FMEnv	

Activity 3.4. – Development of building design guidelines	Building design guideline developed	No building design guideline developed	Building design guideline developed and disseminated	Guideline developed	Q1 2024 – Q4 2024	FMITI, FMSTI, and FMEnv	
Activity 3.5. – Development of cement production guidelines	Cement production guideline developed	N/A	Cement production guideline developed and disseminated	Guideline developed	Q1 2024 – Q4 2024	FMITI, FMSTI, and FMEnv	
Activity 3.6. – Provision of adequate financing	Number of new financing schemes	N/A	At least one scheme developed by technology	Financial institution records	Q1 2024 – Q4 2024	FMITI, FMSTI, and FMEnv	
Action Plan 4: Dissemination of technologies Outcome 4: Each technology is implemented with specific targets and objectives.							
Activity 4.1. – Dissemination of modular palm oil mills	Number of new installations	Several related technologies implemented in some states	At least 10 related technologies implemented in first 5 years	FMITI, FMSTI, and FMEnv records	Q4 2024 – 2030	FMITI, FMSTI, and FMEnv	USD 15,000,000 – 20,000,000
Activity 4.2. – Dissemination of anaerobic digesters	Number of new installations	Several related technologies implemented in some states	At least 10 related technologies implemented in first 5 years	FMITI, FMSTI, and FMEnv records	Q4 2024 – 2030	FMITI, FMSTI, and FMEnv	

Activity 4.3. – Dissemination of use of alternative fuels	Number of policies and regulations developed Number of new installations	N/A	Policies and binding regulations pertaining to the use of alternative fuels developed At least 5 related technologies implemented in first 5 years	Policies developed, introduced, and enforced FMITI, FMSTI, and FMEnv records	Q1 2025 – 2030	FMITI, FMSTI, and FMEnv	
Activity 4.4. – Dissemination of advanced grinding technologies	Develop and conduct a pilot project	N/A	At least one pilot project conducted	FMITI, FMSTI, and FMEnv records	Q2 2025 – 2030	FMITI, FMSTI, and FMEnv	
Activity 4.5. – Dissemination of unhydrated cement recycling	Develop and conduct a pilot project	N/A	At least one pilot project conducted	FMITI, FMSTI, and FMEnv records	Q2 2025 – 2030	FMITI, FMSTI, and FMEnv	
Activity 4.6. – Dissemination of shifting to renewable sources for electricity	Develop and conduct pilot projects	N/A	At least two pilot projects conducted	FMITI, FMSTI, and FMEnv records	Q4 2024 – 2030	FMITI, FMSTI, and FMEnv	
Activity 4.7. – Dissemination of disaster-resilient buildings	Number of policies and regulations developed Number of new buildings	N/A	Policies and binding regulations pertaining to the use of alternative fuels developed At least 25% of	Policies developed, introduced, and enforced FMITI, FMSTI, and FMEnv	Q4 2024 – 2030	FMITI, FMSTI, and FMEnv	

			new buildings are disaster-resilient buildings	records			
Activity 4.8. – Dissemination of zero energy buildings	Number of policies and regulations developed Number of new buildings	N/A	Policies and binding regulations pertaining to the use of alternative fuels developed At least 10% of new buildings are zero energy buildings	Policies developed, introduced, and enforced FMITI, FMSTI, and FMEnv records	Q4 2024 – 2030	FMITI, FMSTI, and FMEnv	

6.15. Proposed implementation timeline

The following figure shows the overall timeline for the implementation of the prioritized technologies in the industry and commerce sector.

Action Plan	Activity	2023				2024				2025				2026	""""	2030
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			
Raising awareness	Awareness raising of industry sector stakeholders															
	Awareness raising of general public and other stakeholders															
Capacity building	Institutional capacity building															
	Technical capacity building and partnership building															
Development of enabling environment for private sector engagement	Identifying specific technologies applicable to Nigeria															
	Natural hazard assessment and mapping															
	Policy development and enforcement															
	Development of building design guidelines															
	Development of cement production guidelines															
	Provision of adequate financing															
Dissemination of technologies	Dissemination of modular palm oil mills															
	Dissemination of anaerobic digesters															
	Dissemination of use of alternative fuels															
	Dissemination of advanced grinding technologies															
	Dissemination of unhydrated cement recycling															
	Dissemination of shifting to renewable sources for electricity															
	Dissemination of disaster-resilient buildings															
	Dissemination of zero energy buildings															

7. Cross-cutting issues/opportunities

This section identifies common barriers in implementing the technologies prioritized that cut across the three sectors, agriculture and land use, energy, and industry and commerce sectors, while analyzing the possibility of cross-sectoral opportunities.

7.1. Identified common barriers across the sectors

According to the evaluation of barriers for each sector, there are four main barriers that are evident across all sectors: (a) institutional and stakeholder coordination, (b) information on the technologies, (c) technical capacity and know-how, and (d) financial resources. These barriers are elaborated in detail in the following sections.

7.1.1. Institutional and stakeholder coordination

Limited collaboration and coordination among institutions and stakeholders has hindered the deployment of climate change mitigation and adaptation technologies in each sector, and thus Action Plans 1, 2, and 3 for each sector incorporate activities to address this issue. This issue has been raised by the stakeholders during the stakeholder consultations as well as the regional workshops. In particular, due to the limited coordination among relevant ministries, information exchange has been insufficient. Even though there are relevant policies and strategies that pertains to climate change in each sector, there are no cross-sectoral policies and strategies that promote cross-sectoral collaboration. This has led, for instance, to the lack of collaborative efforts among government agencies, research institutions, and the private sector. Collaborative efforts between stakeholders are important as it can contribute to mobilizing resources and knowledge, as well as reduce duplicated actions and incomplete results, which can accelerate the implementation of climate change mitigation and adaptation technologies. Therefore, it is critical for Nigeria to develop cross-sectoral policies and establish a high-level coordination mechanism for cross-sectoral cooperation. This is necessary for disseminating technologies like waste to energy technologies or alternative fuels, which can impact both energy and industry sectors. Furthermore, given the regional differences in Nigeria, it is equally important to establish regional focal points that can promote coordination among regions.

7.1.2. Information on the technologies

Information on many of the prioritized technologies are still limited in Nigeria, which has been a barrier in disseminating these technologies. This is especially the case for technologies that has yet been introduced in Nigeria, such as unhydrated cement recycling and zero energy building. As a result, Action Plan 1 specifically focuses on awareness raising activities to disseminate information on the prioritized technologies among relevant stakeholders. This will enable a better understanding of the technologies, including its use and advantages, which can contribute to not only developing the necessary technical capacity, but also to enhance the technical and institutional capacity to formulate appropriate polices and standards. Moreover, the dissemination of information regarding the technologies can initiate behavioral change among the general public, which are needed in the transition from conventional methods and technologies. For example, enhanced understanding of energy efficiency or reduced reliance on rain-fed agricultural practices are prerequisite to disseminating some of the prioritized technologies, such as agricultural biotechnology and energy management systems. Therefore, disseminating information through various channels, like workshops, seminars, and demonstrations, will be important for the implementation of the prioritized technologies in Nigeria.

7.1.3. Technical capacity and know-how

As mentioned above, due to the limited information on the prioritized technologies and coordination among stakeholders, insufficient technical capacity of relevant stakeholders and institutions as well as limited human resources are major barriers in developing and implementing certain climate change mitigation and adaptation technologies. This issue is evident for technologies that have not been deployed in Nigeria, like integrated climate change monitoring system and early warning system, carbon capture and storage, and advanced grinding technologies, which require specific technical expertise and skills. As such, Action Plan 2 for each sector addresses this issue and incorporate activities that leads to the enhancement of technical capacities of relevant stakeholders. As part of the technical capacity building of relevant institutions, human resource development programs or coordinating with international experts may be necessary to effectively implement the prioritized technologies. For instance, to implement integrated climate change monitoring system and early warning system, human resource development of personnel with knowledge on meteorology, hydrology, geophysical systems, risks, and communication is required. If the technology is still not commercially available globally, like certain advanced grinding technologies and unhydrated cement recycling, cooperating with international experts is more effective in successfully implementing the technologies.

7.1.4. Financial resources

An obvious barrier to the application of any technology is the insufficient amount of capital that is needed to successfully implement the technologies. This is not only limited to the initial investment required to deploy the prioritized technologies, but also the capital used for operation and maintenance of the technologies. Moreover, financial capital is also essential in developing the enabling environment, as well as conducting awareness building and capacity building activities. Given the limited budget of the Nigerian government to address this and the significance of this issue, financial options are considered in each sector for disseminating the prioritized technologies. In essence, grant financing will be emphasized for activities that require technical assistance while the actual dissemination of the technologies will require some form of co-financing with private sector involvement. The public sector will create the enabling environment to attract the necessary investment from the private sector, while the private sector will mobile funds and establish sustainable business models for the prioritized technologies. As a result, it is important to ensure collaboration and coordination between the public sector and private sector to push forward technology options that are necessary for Nigeria.

7.2. Cross-cutting opportunities

7.2.1. Policy opportunities

As stated earlier, there are limited cross-sectoral policies and strategies that promote cross-sectoral collaboration in Nigeria. Developing cross-sector policies and strategies, therefore, can provide the opportunity for cross-sectoral collaboration, which can in turn accelerate the implementation of the prioritized technologies. This can lead to benefits such as exchange of information and mobilization of funds, which are critical components of disseminating climate change mitigation and adaptation technologies. Moreover, consolidated frameworks or policies for cross-sectoral cooperation is not only important in addressing climate change impacts, but also to achieving sustainable development. As many issues and barriers to sustainable development impact various sectors, it is essential to build a foundation for cooperation among different stakeholders through relevant policies and frameworks. Along with policies and

frameworks, a coordination mechanism should be established to ensure that the necessary activities take place.

7.2.2. Technological opportunities

Several technologies can be implemented across sectors, enhancing the opportunity for the technologies to be deployed at a larger scale. Technologies such as climate smart agriculture, waste to energy, and alternative fuels, have cross-sectoral opportunities. For instance, it may be beneficial for deploying energy management systems into climate smart agriculture practices, to reduce the agricultural sector's reliance on fossil fuels. Synergies between energy and industry and commerce sectors are also possible, such as by installing carbon capture and storage into hard-to-abate sectors like cement, iron and steel industries, and utilizing the electricity produced from renewable industry in the commerce sector. These technological opportunities can have both climate change mitigation and adaptation benefits, which in turn can contribute to achieving Nigeria's climate change targets. Furthermore, projects or initiatives with cross-sectoral impacts are more likely to attract international finance, which can address the issue of limited budget in disseminating the prioritized technologies. It is critical, however, to conduct extensive research and establish pilot projects to gather enough data and to ensure that these cross-sectoral opportunities provide positive impacts rather than negative consequences.