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Climate Technology Centre & Network

Federal Ministry of Environment - Department of Climate Change

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

Mitigation and Adaptation TNA Report

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Contents

1. Introduction/Overview

The objective of this assignment is to develop a comprehensive Technology Needs Assessment (TNA) and associated action plan for Nigeria's climate change mitigation and adaptation. To achieve this objective, it is necessary to identify the relevant technologies that can contribute to Nigeria's climate objectives, especially in the three priority sectors, namely, agriculture and land use, energy, and industry and commerce. From the three priority sectors, sub-sectors were pre-selected and identified for each sector by performing a thorough assessment and desktop review of key national strategies and sectoral policies in Nigeria. In this context, the next step is to identify and confirm the mitigation and adaptation technologies that can be applicable to each subsector, which will be the basis for Nigeria's TNA and action plan.

This report, therefore, will first discuss the sector and subsector prioritization process, including the process taken for sector and subsector selection and the results of the prioritization process. Then, the report will provide a general overview of gender considerations that are relevant to the sectors and subsectors that have been prioritized. It will then shift the focus on each sector and subsector and provide a list of technologies applicable to the subsectors. This section will include an assessment of how the technologies contribute to climate change mitigation/adaptation and identify the barriers and gaps of implementing the technology. Finally, the report will present a summary of mitigation/adaptation technologies that were considered during the process.

2. Institutional arrangement and stakeholder involvement

As part of conducting the TNA, the TNA Project Committee was established representing the key stakeholders from each prioritized sector. The main objective of the TNA Project Committee is to oversee the progress of the TNA and to ensure the engagement of key stakeholders throughout the TNA process. In this regard, to determine the appropriate composition of the TNA Committee, the consulting team conducted a stakeholder mapping for the purpose of identifying key stakeholders in the public sector, private sector, civil society, academia and NGOs to ensure proper sectoral, transversal and climate-relevant representation of stakeholders. The stakeholder analysis was later refined by stakeholder consultations, which was generally conducted bilaterally. In coordination with the National Project Coordinator and the Deputy TNA Project Coordinator of the TNA Project Committee, these stakeholder consultations and analysis supported the finalization of the TNA Committee in Nigeria and assured the full representations of key stakeholders in the TNA process. 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 the empowerment of women (GEEW) and other vulnerable groups. Throughout the TNA process, the consulting team also made sure that there was an engagement and consultation with representations from the private sector.

3. Sector and subsector prioritization process

For Nigeria's TNA, the three priority sectors were selected in the inception workshop led by the Federal Ministry of Science and Technology (FMST), in collaboration with Federal Ministry of Environment's Department of Climate Change (FMEnv – DCC) in September 2018. As mentioned earlier, the three priority sectors for Nigeria's TNA are: agriculture and land use, energy, and industry and commerce. The three key sectors are not only significant for Nigeria's long-term development, but also climate sensitive and vulnerable to the impacts of climate

change. The subsectors, therefore, were identified and pre-selected from the three priority sectors.

To pre-select the subsectors, all key national strategies and sectoral policies were reviewed and analyzed to identify development priorities as well as climate change priorities. In this process, a total of 17 documents were reviewed and assessed, which led to the identification of the subsectors. For the agricultural and land 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 subsectors are agribusiness and agro-allied sectors, solid minerals and metals, oil and gas-related industries, and construction and manufacturing.

Consequently, these subsectors were then pre-scored by the consulting team by using a set of criteria, which included (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, and financial information. The purpose of the initial scoring was to assist the stakeholders in the actual selection and prioritization process that took place in the validation workshop on June 9th, 2021.

The stakeholders' validation workshop was conducted as hybrid meeting in Abuja, Nigeria and on the virtual platform, in which a total of 47 stakeholders participated in the workshop, 26 physical participants and 21 virtual participants. The stakeholders' validation workshop provided an opportunity for the stakeholders to have an overview of the subsector prioritization process, to discuss on issues regarding each subsector, and to revisit the scoring of the subsectors. In this regard, the stakeholders provided valuable inputs or feedbacks including, but not limited to, whether to incorporate the latest political negotiations as well as gender implications in the prioritization process, to add another subsector reflecting the results of agricultural activities, and to change the subsector from "construction, light manufacturing and services" to "construction and manufacturing". In addition, as part of the interactive session of the validation workshop, the initial scoring of each subsector was assessed by the stakeholders, mainly taking into account all discussions raised across the criteria, including the potential for climate change mitigation and adaptation, as well as the role of enabling environment.

The scoring was confirmed as shown in the table below:

Sector	Sub-sector	Potential for climate change mitigation (GHG emissions)	Potential for climate change adaptation (vulnerability)	Relevance to development priorities	Overall enabling environment	Total score
Agriculture and land	Crop production	3	3	3	2	11

Sector	Sub-sector	Potential for climate change mitigation (GHG emissions)	Potential for climate change adaptation (vulnerability)	Relevance to development priorities	Overall enabling environment	Total score
use	Livestock production	3	3	3	2	11
	Fish production	1	3	3	2	9
	Forestry	3	3	3	2	11
Energy	Electricity supply	3	3	3	3	12
	Energy demand	3	3	3	2	11
	Energy efficiency	3	3	3	1	10
Industry and commerce	Agribusiness and agro-allied sectors	2	2	3	1	8
	Solid minerals and metals	3	1	3	1	8
	Oil and gas-related industries	3	2	3	1	9
	Construction and manufacturing	3	1	3	1	8

As a result, the prioritized subsectors 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. Therefore, the preliminary long-list of technologies was prepared by the

consulting team based on the prioritized subsector and the discussions from the validation workshop. In this context, the subsequent sections will identify and assess the technologies for each subsector that can contribute to climate change mitigation in Nigeria.

4. Methodology

After the prioritized sectors and subsectors were confirmed with consensus from the TNA Committee, the consulting team developed the preliminary long-list of technologies.
These technologies were then evaluated against the following criteria:

(a) **Potential impact on climate change mitigation/greenhouse gas emissions reduction** in the context of Nigeria's climate change targets. Indicators may include GHG emission share of sub-sector in which the technology could be applied, and theoretical or practical effects of the technology itself in the reduction of GHG emissions.

3: High	The sub-sector is a major source of GHG emissions, and the technology could bring about a large emission reduction effect.
2: Moderate	The sub-sectoral emission share is moderate, but the technology could bring about a large emission reduction effect. Or, while the sub-sector accounts for a large portion of GHG emissions, the expected emission reduction effect of the technology is not particularly large.
1: Low	The emission reduction effect is negligible.
0: Null	Not applicable.

(b) **Potential impact on climate change adaptation,** if any, in the context of Nigeria's climate change targets. Indicators may include the size of population and economy (e.g., sub-sectoral GDP) which could be affected by the climate change related events that the technology tackles with, and theoretical or practical effects of the technology itself on adaptation to climate change.

3: High	The sub-sector is a major industry and the potential for the technology to enhance climate resilience is expected to be large.
2: Moderate	While the sub-sector is a major industry, the expected impact of the technology on climate resilience is not particularly large. Or, the size of population and/or economy of the sub-sector is moderate, but the technology could bring about a large positive impact on climate resilience.
1: Low	The effect on adaptation to climate change is negligible.
0: Null	Not applicable.

(c) **Alignment with climate change policies and priorities**: Evaluates to what extent the technology aligns with key national strategies and sectoral policies, and climate change priorities. Strategies and priorities to be reviewed are those analyzed for the sub-sector selection. Indicators may include whether the technology is mentioned in the policies or

priorities and whether the technology could be expected to address the major challenges identified in the policies or priorities.

3: High	The technology is mentioned in several (more than one) key policies or priorities.
2: Moderate	The technology is mentioned in one of the key policies or priorities. Or, the technology is related to several focus areas of investment in the key policies or priorities.
1: Low	The technology itself is not mentioned in any policy or priority, but it could be related to one of the focus areas of investment in the key policies or priorities.
0: Null	Implementation of the technology is not necessarily prioritized in the key policies or priorities.

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

i. Environmental: the potential impact on Nigeria's environment

ii. Social: the potential impact on Nigeria's employment/poverty reduction

iii. Economic: the potential impact on Nigeria's economy

3: High	Implementation of the technology could bring about co-benefits in three categories.
2: Moderate	Implementation of the technology could bring about co-benefits in two categories.
1: Low	Implementation of the technology could bring about co-benefits in one of the three categories.
0: Null	Implementation of the technology is not expected to bring about any co-benefit.

(e) **Technological constraints**: Evaluates how practical or realistic the implementation of the technology is in general. Indicators may include the maturity level of the technology, the number of use cases around the globe or in developing counties, and the magnitude of barriers to implementing the technology.

3: High	The technology has already been widely used commercially, and no or only minor barriers are expected in implementing the technology.
2: Moderate	There are some use cases but not yet widely used commercially.
1: Low	The technology is still at the pilot test stage.
0: Null	The technology is still at the research/study stage and is not expected to be used in practice as of now.

(f) **Readiness of Nigeria for the technology**: It evaluates to what extent Nigeria has the appropriate and sufficient environment to implement the technology. The indicators may include the number of use cases in the country, policy environment which could facilitate the implementing of the technology, and acceptability of stakeholders.

3: High	There are several use cases in Nigeria, and no or only minor barriers are expected in implementing the technology.
2: Moderate	There is/are (a) use case(s) in Nigeria. Despite the existence of some challenges in implementing the technology, these could be addressed in the short-term.
1: Low	There is no use case in Nigeria, but there is the environment which could support the implementation of the technology.
0: Null	There is no use case or policy which could promote the use of the technology in Nigeria, and there are many challenges to overcome to implement the technology as of now.

The result from this exercise will provide a total score for each technology, which will be used as a reference to guide the actual section and prioritization of technologies by the stakeholders in the next step.

5. Gender considerations

The UNFCCC and Federal Government of Nigeria recognize the importance of developing national-level climate change policies that are gender-responsive. This section provides an overview of gender priorities, issues and concerns for the prioritized TNA sectors and subsectors. According to the World Economic Forum's 2021 World Gender Gap Report, Nigeria ranks 139 of 156 countries on gender equality.[1] As of 2019, women held 5.6 percent of seats in the lower house of parliament and 6.4 percent of seats in the upper house.[2] A woman has never held the position of governor of any of Nigeria's 36 states. According to the World Bank data for 2019, men's participation in the workforce in Nigeria was 60.89 percent, and women's participation was 48.52 percent.[3]

The majority ethnic groups in Nigeria - the Hausa-Fulani, Igbo and Yoruba – make up around 60 percent of the country's population.[4] Minority groups face political, economic and cultural marginalization.[5]

The population of persons with disabilities in Nigeria was at 3.3 million - 2.32 percent of the population - at the 2006 Nigerian census.[6] Persons with disabilities face environmental,

[1] World Gender Gap Report: http://www3.weforum.org/docs/WEF_GGGR_202117.pdf

[2] Inter-Parliamentary Union, Women in national parliaments: http://archive.ipu.org/wmn-e/classif.htm

[3] https://data.worldbank.org/indicator/SL.TLF.CACT.FE.ZS?locations=NG

[4] The World Factbook: Explore All Countries – Nigeria: https://www.cia.gov/the-world-factbook/countries/nigeria/

[5] An International Journal of Arts and Humanities. Ethnic Minorities and The Nigerian State. Page 90

[6] Nigeria-Population Census 2006 : http://nigeria.opendataforafrica.org/xspplpb/nigeria-census

institutional, and social challenges,[7] limiting their opportunities to actively participate in society in general, and in the workforce in specific.[8]

Almost half of Nigeria's population is under the age of 15.[9] Older adults (65 years and above) make up 3.1 percent of the total population.[10] Seventy-five percent of children live in poverty,[11] while 40.1 percent of Nigeria's total population lives below the poverty line.[12]

5.1. Agriculture and land use sector

Agriculture accounted for 22.35 percent of Nigeria's Gross Domestic Product (GDP) in the first quarter of 2021.[13] The sector employed 35 percent of Nigeria's labor force in 2019,[14] over 75 percent of which were women.[15] 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.[16] Gender, poverty, geographical location and disability status compound these issues.[17] [18] The government of Nigeria has a national gender policy for the agricultural sector. Agriculture, forestry, and land use have been identified as priority sectors for Nigeria's National Action Plan on Gender and Climate Change.

5.1.1. Crop production

While around 54 million of Nigeria's 78 million women live in rural areas and make their living off the land,[19] the fact that men are five times more likely to own land than women significantly limits production among female farmers.[20] Additionally, there is gender and age disparity regarding access to training on crop farming techniques, with women and youth disproportionately affected.[21]

5.1.2. Livestock production

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[7] Nigerian Country Report on Disability: http://www.disabilityrightsfund.org/wp-content/uploads/Country-Report_Nigeria_2018.pdf

[8] Models of Equal Employment Opportunity: https://doi.org/10.1300/J156v02n03_06

[9] UNICEF, Situation of women and children in Nigeria: https://www.unicef.org/nigeria/situation-women-and-children-nigeria

[10] 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

[11] UNICEF, Situation of women and children in Nigeria: https://www.unicef.org/nigeria/situation-women-and-children-nigeria

[12] World Bank data: https://data.worldbank.org/indicator/SI.POV.NAHC?locations=NG

[13] Statista: https://www.statista.com/statistics/1193506/contribution-of-agriculture-to-gdp-in-nigeria/

[14] World Bank: https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=NG&most_recent_value_desc=false

[15] Nigeria Federal Ministry of Environment, National Action Plan on Gender and Climate Change for Nigeria. Page 28

[16] Nigeria Federal Ministry of Agriculture and Rural Development, Gender Policy in Agriculture. Page 45

[17] Ibid. Page 43

[18] Nigerian Country Report on Disability: http://www.disabilityrightsfund.org/wp-content/uploads/Country-Report_Nigeria_2018.pdf

[19] Ibid. Page 39

[20] Ibid. Page 41

[21] Ibid. Page 43

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.[22] 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.[23]

5.1.3. Forestry

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.[24] Studies show that a shortage of forest products would particularly affect women's lives and livelihood, increasing their marginalization and poverty.[25]

5.2. Energy Sector

As an Economic Community of West African States (ECOWAS) member state, Nigeria has adopted ECOWAS's Policy for Gender Mainstreaming in Energy Access and the country is currently drafting its own energy sector gender mainstreaming plan. Energy has also been identified as a priority sector in Nigeria's National Action Plan on Gender and Climate Change.

5.2.1. Electricity supply

There is a dearth of women employees in public energy sector institutions, electric distribution companies and the off grid/renewable sector.[26] The disparity between women and men is most profound in leadership and decision-making positions. Reasons for the lack of female representation are the lack of women in science, technology, engineering and mathematics (STEM) fields; workforce policies that are not women-friendly; a male bias in hiring and retention processes; and cultural norms that discourage women from working in some technical fields.[27] The renewable energy sector has generally been found to be more accepting of women than the on-grid sector.[28]

5.2.2. Energy demand

Inadequate access to energy disproportionately affects women and girls. Exposure to pollution resulting from petroleum products and biomass – which the majority of Nigerians use for cooking

[22] Ibid. Page 43

[23] Ibid. Page 44

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

[25] Ibid. Page 3

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

[27] Ibid

[28] Ibid. Page 11.

– results in an estimated 600,000 deaths per year of mostly women and children across Africa.[29] 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 firewood, for example.[30] The availability of well-lit public spaces can also help prevent gender-based violence and increase mobility.[31]

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.[32]

Inadequate electricity supply is implicated in lower educational outcomes for girls and boys; higher incidences of child marriage;[33] poor healthcare;[34] and insufficient physical, psychological, economic and social services for older adults and persons with disabilities.[35] [36] Location plays an important role in access to electricity, as urban areas in Nigeria are better served by on-grid electricity than rural ones.[37]

5.2.3. Energy efficiency

While women play a key role in energy monitoring and management at the household level,[38] 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.[39] Women or men with disabilities (who are deaf or blind for example) will also be marginalized.

5.3. Commerce and industry sector

There is a lack of women's representation across industry, commerce, and business in Nigeria. 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 policy-making.[40]

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[29] Ngum, Sohna Aminatta Ngum, "Empowering women and girls in the quest for universal energy access for all," AFDB. https://www.afdb.org/en/blogs/investing-in-gender-equality-for-africa%E2%80%99s-transformation/post/empowering-women-and-girls-in-the-quest-for-universal-energy-access-for-all-15625/

[30] 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

[31] Ibid

[32] Ibid

[33] Ibid

[34] Ibid

[35] Ibid

[36] 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

[37] Made for Minds. Living in the Dark in Rural Nigeria. https://www.dw.com/en/living-in-the-dark-in-rural-nigeria/a-46755603

[38] World Bank Group. Gender Equality and Energy. Page 8

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

[40] Ibid. Pages 9-12

5.3.1. Agribusiness and agro-allied sectors

Women's participation in business in Nigeria faces a number of constraints. Some agribusiness subsector policies, such as Presidential Initiative on Cassava, are gender-blind. 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.[41] Education and training play a role; in 2018 the literacy rate for rural women was 35 percent, compared with 60 percent for rural men.[42] Women also spend up to four hours a day less than men on wage-earning activities due to their domestic responsibilities.[43] 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."[44]

5.3.2. Solid minerals and metals

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.[45] This may be one reason for the low representation of women in the solid minerals sector which stood at 6.8 percent for 2019.[46]

5.3.3. Construction and manufacturing

The World Bank has identified construction and manufacturing among the sectors that have the highest employment potential for youth in Nigeria.[47] 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.[48]

5.4. Gender-Responsive Approach to the Implementation of Mitigation Technologies

The aim of implementing gender-responsive technology programming is twofold:

- To prevent existing **gender inequalities** from being exacerbated by climate change and

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

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

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

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

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

[46] 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

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

[48] 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.

- To prevent the exacerbation of **climate change impact** due to existing gender inequalities.

Key tools to address gender in climate change mitigation programs are gender analyses to identify gaps; gender-responsive budgets; gender targets and indicators; and sex-and age-disaggregated data.

When women and men, regardless of age, disability status, ethnicity, or geographical location, participate in decision-making and have equal access to assets, resources, knowledge, and skills they jointly assist in building the resilience of communities.

6. Assessment of technologies in the Agriculture and land sector

6.1. Crop production

1. Agricultural biotechnology

➢ Introduction

Agricultural biotechnology refers to a biological approach that utilizes biotechnological methods and traditional plant breeding to produce crop varieties with enhanced carbon sequestration.[49]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	According to a study conducted by Brookes and Barfoot (2009), genetically modified crops using agricultural biotechnology conserved over 14,200 million kg of CO_2 in the year 2007, which is equivalent of over 6 million cars.[50] Therefore, it can potentially contribute to the reduction of GHG emissions from the agricultural sector, which accounts for the largest GHG emissions in Nigeria.	2
Potential impact on climate change adaptation	Agricultural biotechnology can contribute in 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.	2

[49] UNEP "Technologies for Climate Change Mitigation-Agricultural Sector"
[50] CTCN "Crop varieties with enhanced carbon sequestration"

Alignment with climate change policies and priorities	Although there is no direct reference to agricultural biotechnology in Nigeria's climate change policies, increasing access to drought resistant crops is indicated as one of the strategies for agriculture in the National Adaptation Strategy and Plan of Action for Climate Change Nigeria (NASPA).	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Introducing new varieties and diversifying crop portfolio by using agricultural biotechnology can enhance biodiversity.	
	Social	
	Agricultural biotechnology has the potential of increasing employment, as the creation of new varieties can provide new job opportunities in the agricultural sector. In addition, through crop diversification, it can help to stabilize famers' income and address food insecurity.	
	Economic	
	Cultivating crops that are resistant to droughts and pests can improve the overall agricultural production in Nigeria.	
Technological constraints	Agricultural biotechnology is implemented in many countries, including in several African countries. Yet, agricultural biotechnology requires several years of testing, especially to observe the impact on carbon sequestration, which makes it difficult for the technology to be available in the short term.[51]	2
Readiness of Nigeria for the technology	Several projects using agricultural biotechnology are under implementation in Nigeria (for example, pod borer resistance cowpeas), however, none of the crops have been commercialized.[52] Furthermore, agricultural biotechnology has been generally accepted by the stakeholders since the technology has multiple benefits, such as carbon sequestration and crop diversification (meeting with stakeholders on July 29th, 2021). There is also a policy framework for agricultural biotechnology in Nigeria, creating a more enabling environment for the technology.	3

[51] UNEP "Technologies for Climate Change Mitigation-Agricultural Sector"

[52] USDA "Agricultural biotechnology annual"

2. Cover crop technology

➢ Introduction

Cover crop technology refers to the use of fast-growing crops that can cover the soil surface to protect soil from erosion while reducing emissions and sequester carbon.[53] Examples of cover crops include, but not limited to, winter rye and clovers that are planted between periods of regular crop cultivation and cover the soil surface.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Cover crop technology can assist in reducing GHG emissions from Nigeria's agriculture sector, which accounts for approximately 67 percent of overall GHG emissions in the country.[54] According to a study conducted on an eroded Alfisol in western Nigeria, cover crops can increase soil carbon sequestration with the rates from 0.28 to 2.60 Mg ha-1 yr-1.[55]	3
Potential impact on climate change adaptation	Nigeria's TNC indicates that cover crops such as potatoes and melons can contribute in addressing climate change adaptation as well as soil erosion, which is catastrophic especially in southern parts of Nigeria. Cover crop technology can also contribute in improving soil quality, water, biodiversity, and pest management.[56]	3
Alignment with climate change policies and priorities	Cover crop technology has been identified in Nigeria' s climate change policies, specifically in Nigeria's NDC, TNC, as well as NASPA.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Cover crop technology can contribute in alleviating nutrient deficiencies and reducing the use of artificial fertilizers and pesticides which are harmful to the environment.	
	Social	
	Cover crop technology can improve the overall production and yield of farmers by addressing soil erosion, which can not only help farmers' income, but also food insecurity.	

[53] UNEP "Technologies for Climate Change Mitigation-Agricultural Sector"
[54] FAO "Nigeria at a glance"
[55] CTCN "Cover crop technology"
[56] Federal Ministry of Environment "Third National Communication (TNC) of the Federal Republic of Nigeria"

	Economic Better crop production has the potential to improve Nigeria's agricultural sector, which contributes approximately 27 percent to the GDP between October to December in 2020.[57]	
Technological constraints	Economic costs for planting cover crops can be a burden for farmers, and this fact has hindered the technology's dissemination in many countries.[58] Human capacity development will also be necessary when introducing this technology, as the benefit of cover crops may be limited if the crops are not managed properly.	2
Readiness of Nigeria for the technology	The technology may be available in the short to medium term, given that the production of cover crops such as potatoes and melons is not prevalent compared to other crops such as cassava and maize.[59] The overall policy environment for cover crop technology, however, can be considered favorable, which can facilitate in implementing the technology.	2

3. Conservation Tillage

➢ Introduction

Conservation tillage is a tillage system that conserves soil, water, and energy resources through the reduction of tillage intensity and retention of crop residue.[60] The aim of this technology is to plant, grow and harvest crops with limited interruption to the soil.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Conservation tillage can enhance the soil's ability to sequester carbon. Lu's study (2018) suggests that, conservation tillage has the potential of increasing carbon sinks from 0.84t C ha−1 yr−1 to 2.69t C ha−1 yr−1 compared to conventional tillage.[61] Therefore, conservation tillage has the potential to	3

[57] Statista "Contribution of agriculture to GDP in Nigeria from the 3rd quarter of 2019 to the 1st quarter of 2021"
[58] Ibid.
[59] FAO "FAOSTAT: Crops and livestock products"
[60] Ibid.
[61] Lu (2018) "Conservation tillage increases carbon sequestration of winter wheat-summer maize farmland on Loess Plateau in China"

	address Nigeria's GHG emissions from crop production, which accounted for 8.1 percent of total sectoral GHG emissions in 2016.[62]	
Potential impact on climate change adaptation	Conservation tillage can minimize soil erosion and improve nutrients in the soil, which can lead to reduction in water and energy use as well as increase in yields.[63] Improved soil properties and increased soil organic matter as a result of conservation tillage can also enable farmers to maintain its yields in the case of drought and extreme weather.	3
Alignment with climate change policies and priorities	In Nigeria's NDC, adopting better soil and water management is referred to as necessary to tackle climate change. In this regard, conservation tillage can be considered as one of the technologies to improve soil and water management.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Soil conservation is essential not only in terms of climate change, but also in relation to biodiversity and environmental degradation. *Social* Conservation tillage can minimize soil erosion and has a positive effect on crop yields, which can enable farmers to stabilize or increase their income. *Economic* Conservation tillage has the potential to prevent job losses as a result of decreasing yields. This can also improve the overall agricultural production in Nigeria	3
Technological constraints	The technology is relatively a mature technology that is adopted in many parts of the world, including in African countries.	3
Readiness of Nigeria for the technology	The technology may be available in the short to medium term as the technology is also available in Nigeria[64]. The number of cases using the technology is still limited and many parts of the country still relies on conventional methods. Significant amount of investment and training is necessary when transitioning from conventional methods.	1

[62] Federal Ministry of Environment "Third National Communication (TNC) of the Federal Republic of Nigeria"

[63] UNEP "Technologies for Climate Change Mitigation-Agricultural Sector"

[64] Senjobi et al (2013) "Effects of Tillage Practices on Soil Properties under Maize Cultivation on Oxic Paloustalf in South Western Nigeria"

4. Climate Smart Agriculture (CSA)

➢ Introduction

Climate Smart Agriculture refers to an approach to change the agricultural system to tackle the issue of food security while adapting to the changing climate. This approach has three main objectives: (a) enhance agricultural productivity and increase incomes, (b) adapting to climate change, and (c) reduce greenhouse gas emissions.[65]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	One of the objectives of climate smart agriculture is to reduce GHG emissions in the agricultural sector by promoting renewable energy in agricultural practices, encouraging resource use efficiency, and sequestering carbon from agro-ecosystems.[66] To what extent this technology can contribute to climate change mitigation is yet to be determined. According to Nigeria's NDC, however, climate smart agriculture has the potential to reduce GHG emissions by 74 million tons per year in 2030.	2
Potential impact on climate change adaptation	Another objective of climate smart agriculture is to build resilience and enable the agriculture sector adapt to climate change. This will be achieved, for instance, by diversifying the production system and managing agro-ecosystems. This technology is also identified in Nigeria's NDC as having the potential to build resilience in Nigeria's agricultural and food security systems.	3
Alignment with climate change policies and priorities	As mentioned above, climate smart agriculture is indicated in Nigeria's NDC as both climate change mitigation and adaptation measure.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Climate smart agriculture is designed to reduce the negative impact of agricultural activities to the environment (for example, reducing the amount of toxic substances, waste).	3

[65] FAO, "Climate Smart Agriculture" Available at: Climate-Smart Agriculture | Food and Agriculture Organization of the United Nations (fao.org)
[66] FAO "Climate-smart agriculture and the Sustainable Development Goals"

	Social Climate smart agriculture encourages social protection schemes to increase resilience of farmers, such as cash-for-work and food vouchers. *Economic* The technology also focuses on increasing productivity for sustained economic growth.	
Technological constraints	Even though the technology is implemented in many countries to a certain extent, it is still considered as an emerging technology.	2
Readiness of Nigeria for the technology	Even though the concept is indicated in Nigeria's NDC, the concept is too broad and there are many technologies that can be associated with climate smart agriculture. Thus, it may be difficult to identify the specific technology that is needed. Even though there are some cases using this technology in Nigeria, for the technology to be mainstream, it will require investments that may become a burden in the long-run.	2

5. Alternate Wetting and Drying (AWD) in rice production

➢ Introduction

An agricultural practice that, before irrigation, allows the farmers to dry their rice paddies until the water table is below the soils surface. This has the potential to reduce water use by 25 percent compared with maintaining rice paddies in a continuously flooded state, as well as minimize energy use for pumping the irrigation water.[67]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	AWD technology has the potential to greatly reduce emissions of methane while minimizing energy use. According to a study conducted by International Rice Research Institute (IRRI), AWD technology can reduce the production of methane by 60% to 90%.[68] Thus, AWD technology can address methane emissions from the AFOLU sector in Nigeria, which was about 7% of total emissions (from	3

[67] CCAFS, "Strategies for low-emission cultivation are being explored step-by-step", Available at: Strategies for low-emission cultivation are being explored step-by-step (cgiar.org)
[68] FAO "Climate-smart agriculture and the Sustainable Development Goals"

	the AFOLU sector) in 2015.[69] Furthermore, rice cultivation contributed to approximately 26% of total aggregated emissions from land.[70]	
Potential impact on climate change adaptation	As a result of climate change, water availability will become more challenging in Nigeria.[71] In this regard, AWD technology reduces the use of water which can enable farmers address water scarcity. As mentioned earlier, the technology can reduce of water supply by 25 percent compared with maintaining rice paddies in a continuously flooded state, which is the common practice in rice cultivation.	3
Alignment with climate change policies and priorities	Even though the technology is not specifically indicated in any of the climate change policies, improved resource management is considered as one of the strategies for agriculture in NASPA.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	AWD technology contributes to reducing the use of water resources.	
	Social	
	Since AWD technology decreases energy use, it allows farmers to reduce their overall cost in rice production. Furthermore, it can stabilize or increase farmer's income as the technology has the potential to increase yields.	
	Economic	
	AWD technology can lead to increase in rice production while reducing energy and water consumption.	
Technological constraints	The technology is common globally, however, farmers need to be trained as the timing of the irrigation and water depth in the paddies are crucial components for the technology to realize its full potential.	3
Readiness of Nigeria for the technology	Training may be necessary to utilize this technology. Nevertheless, constraints to implement this technology can be considered as minor, as the technology is generally accepted by the stakeholders. Given that this technology is implemented in other African	3

[69] Government of Nigeria. 2018. "First Biennial Update Report (BUR1) of the Federal Republic of Nigeria"
[70] Ibid.
[71] Federal Ministry of Environment "Third National Communication (TNC) of the Federal Republic of Nigeria"

	countries (such as Tanzania), it can be inferred that the implementation of the technology in Nigeria will not be that challenging.[72]	

6. Crop diversification and new varieties

➢ Introduction

Crop diversification refers to enhancing the resilience of agricultural systems to climate change by increasing the variety of crops by introducing new and improved cultivated species. [73]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Crop diversification and new varieties are mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions. However, new varieties that can contribute in sequestering carbon can potentially address Nigeria's GHG emissions from the agricultural sector.	2
Potential impact on climate change adaptation	This technology reduces 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.[74] Adoption of early maturing crop varieties, for instance, has the potential of addressing water stress and soil deterioration.	3
Alignment with climate change policies and priorities	This technology has been identified in Nigeria's climate change policies, including Nigeria's NDC and TNC.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Crop diversification and new varieties can enhance biodiversity, while minimizing the use of water resources and conserving soil.	
	Social	
	Diversifying the crop portfolio and introducing	

[72] Mboyerwa et al. (2020) "Evaluation of Growth, Yield, and Water Productivity of Paddy Rice with Water-Saving Irrigation and Optimization of Nitrogen Fertilization"
[73] Climate Technology Centre and Network (CTCN), "Crop diversification and new varieties" Available at: Crop diversification and new varieties | Climate Technology Centre & Network
[74] World Bank "Productive Diversification in African Agriculture and its Effects on Resilience and Nutrition"

	new varieties may create new job opportunities. It can also stabilize or increase income for farmers as it reduces farmers' dependence on a single crop.	
	Economic	
	Crop diversification and new varieties can lead to increase in productivity in the agricultural sector.	
Technological constraints	Crop diversification and new varieties is a mature technology and studies regarding this technology have taken place in West Africa.[75]	3
Readiness of Nigeria for the technology	The policy environment for implementing the technology is favorable and studies regarding this technology have already taken place in Nigeria. Even though introducing new varieties may require initial investments and research to assess whether the new variety is applicable to Nigeria, these barriers can be addressed in the short to medium term.	3

7. Drip irrigation

➢ Introduction

Drip irrigation refers to an agricultural system whereby water is delivered directly to plants through a number of emission points called "drippers".[76] 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.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Drip irrigation is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	2
Potential impact on climate change adaptation	Drip irrigation can allow farmer adapt to climate change by enhancing efficient use of water supply. In cases of droughts and extreme heat, drip irrigation can provide water directly to the plants which in turn reduces demand for water resources and water evaporation loss.	3
Alignment with climate change policies and priorities	The technology has been identified in several climate change policies and priorities. In	3

[75] Kevin (2020) "Impact of Climate Variability on Crop Diversification in West African countries"
[76] CTCN, "Drip Irrigation" Available at: Drip irrigation | Climate Technology Centre & Network

	particular, increasing the use of irrigation systems that use low amounts of water is indicated as one of the adaptation strategies for the agricultural sector in Nigeria's NDC.	
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Sustainable water management and water conservation is critical for preserving the environment. *Social* Drip irrigation has the potential to prevent job loss in professions that are dependent on water availability. In addition, it can stabilize or increase farmer's income, as farmers are able to avoid losses due to lack of water resources. *Economic* Drip irrigation can lead to increase in productivity in the agricultural sector.	3
Technological constraints	This technology is a mature technology and is commercially available in many countries.	3
Readiness of Nigeria for the technology	There has been a number of cases using drip irrigation in Nigeria, but overall, still limited and not mainstream. The technology would also require significant investment initially to mainstream. There are several constraints that need to be considered when implementing this technology in Nigeria. First, due to the quantity of materials that need to be put in place, the initial cost is quite high.[77] Second, the technology needs to be installed properly to work effectively and thus the farmers require training. However, these barriers can be addressed in the short to medium term, and the policy environment can enable the facilitation of the technology in Nigeria.	3

8. Integrated Climate Change Monitoring and Early Warning System

➢ Introduction

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. [78]

[77] Ibid.

[78] CTCN, "Integrated Climate Change Monitoring and Early Warning System" Available at: Integrated Climate Change Monitoring and Early Warning System | Climate Technology Centre & Network

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	This technology warns the possible occurrence of a natural phenomenon that could cause disasters. The technology helps 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.	3
Alignment with climate change policies and priorities	Institutionalizing this technology is indicated in both Nigeria's NDC and TNC. In the NDC, early warning systems is highlighted as one of the adaptation strategies in the agricultural sector.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Has the potential to contribute to sustainable environmental management by providing forecasts and monitoring.	
	Social	
	The technology can create new job opportunities, especially by establishing monitoring systems and introducing climate information services. If implemented properly, the technology has also the potential to minimize farmers' losses as a result of floods and droughts.	
	Economic	
	Integrated Climate Change Monitoring and Early Warning System can improve agricultural planning, which in turn can lead to increase in agricultural productivity. In addition, the technology has the potential to minimize the damage caused by natural disaster to the economy. According to Nigeria's NDC, total damage caused by natural disasters amounted to $16.9 billion in 2012, which was equivalent to 1.4% of real GDP.	
Technological constraints	The technology is implemented in many developed countries, However, in the context of Sub-Saharan Africa, it is still considered an emerging technology that is at the planning	1

	stage.	
Readiness of Nigeria for the technology	According to the stakeholders, the technology is still at a planning stage in Nigeria and have not yet received enough support to proceed to the next stage (meeting with stakeholders on July 29th, 2021). Therefore, there is a lack of sufficient environment to implement the technology. Furthermore, the cost of implementing and monitoring the technology is high and the technology requires specialized training to utilize it. Therefore, the technology would require medium to long term waiting period until it is available.	1

9. Rainwater harvesting

➢ Introduction

Rainwater harvesting is defined as "a method of inducing, collecting, storing, and conserving local surface runoff (rain or surface water flow that occurs when soil is infiltrated to full capacity) for agriculture in arid and semi-arid regions". [79]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	Rainwater harvesting gives farmers an alternative way of supplying water and address the demand for fresh water, which is crucial given the fact that climate change may lead to the reduction of water resources available in Nigeria.[80] Similarly, it can enhance people's access to clean and fresh water especially in drought prone areas in south Nigeria.	3
Alignment with climate change policies and priorities	Nigeria's climate change policies indicate the use of rainwater harvesting as an adaptation measure, especially in the NDC.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Sustainable water management and water conservation is critical for preserving the environment.	3

[79] CTCN, "Rainwater harvesting" Available at: Rainwater harvesting | Climate Technology Centre & Network
[80] Federal Ministry of Environment "Third National Communication (TNC) of the Federal Republic of Nigeria"

	Social The technology has the potential to prevent job loss in professions that are dependent on water availability. In addition, it can stabilize or increase farmer's income, as farmers are able to avoid losses due to lack of water resources. *Economic* Rainwater harvesting can lead to increase in productivity in the agricultural sector.	
Technological constraints	Rainwater harvesting is common in many countries and thus can be considered a mature technology.	3
Readiness of Nigeria for the technology	Given the number of cases in implementing the technology and the alignment with Nigeria's climate change policies, the enabling environment for implementing rainwater harvesting in Nigeria is favorable. There has also been studies on rainwater harvesting in Nigeria.[81] Cost of installing and maintaining the system can be considered as barriers (the cost varies depending on the size of the system), however, these barriers can be considered as minor and studies indicate that the technology is beneficial in building resilience against climate change.	3

10. Integrated pest management

- Introduction

Integrated Pest Management refers to managing the development of pest population by considering all pest management techniques so that disruptions to the agricultural system are minimized. [82]

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	A study indicates that integrated pest management can contribute in reducing GHG emissions by 30%, as the method requires less energy use.[83] This can therefore address	2

[81] Lade and Oloke (2013) "Assessment of rainwater harvesting potential in Ibadan, Nigeria"
[82] FAO, "Climate Smart Agriculture Sourcebook" Available at: B1 - 2 Climate-smart crop production practices and technologies | Climate Smart Agriculture Sourcebook | Food and Agriculture Organization of the United Nations (fao.org)
[83] CTCN "Integrated Pest Management (IPM)"

	GHG emissions from Nigeria's agriculture sector, which accounts for approximately 67 percent of overall GHG emissions in the country.	
Potential impact on climate change adaptation	Pests is considered as a significant threat in Nigeria and attacks by pests may become more severe as a result of climate change.[84] In this regard, integrated pest management aims to reduce risk of crop damage associated with pests and enhance crop yield and food security.	3
Alignment with climate change policies and priorities	Controlling pests is indicated as one of the adaptation strategies in Nigeria's TNC.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Integrated pest management is associated with better soil management which can be beneficial for the environment and biodiversity.	
	Social	
	The technology can stabilize or increase farmer's income, as farmers are able to reduce risk of crop damage.	
	Economic	
	Integrated pest management can lead to increase in agricultural production.	
Technological constraints	Despite being implemented in many countries, integrated pest management can be challenging to implement as it requires significant amount of training to understand the methodology.	2
Readiness of Nigeria for the technology	Even though there are a number of cases of applying integrated pest management in Nigeria, it is still not mainstream. In addition, the technology itself is complex and therefore, requires a significant amount of training for the famers. As such, it is possible that the technology will not be accepted by the farmers.	1

11. Soil Moisture Monitoring (SMM) devices

- Introduction

Soil moisture monitoring devices provide farmers the information on the water status of soil.[85] It

[84] Federal Ministry of Environment "Third National Communication (TNC) of the Federal Republic of Nigeria"
[85] CTCN, "Soil moisture monitoring" Available at: Soil moisture monitoring | Climate Technology Centre & Network\

can assist better irrigation management which can lead to development of better crops with fewer inputs.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	SMM devices allow farmers adapt to climate change by enhancing efficient use of water supply. SMM devices can lead to better irrigation management and reduce demand for water while minimizing overall water use. This is crucial given the fact that climate change may lead to the reduction of water resources available in Nigeria.[86]	3
Alignment with climate change policies and priorities	There is no direct reference to the technology in any of the climate change policies. However, enhanced use of irrigation systems that minimizes the amount of water being used is recognized as an adaptation measure in Nigeria's NDC.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Sustainable water management and water conservation is critical for preserving the environment.	
	Social	
	The technology has the potential to prevent job loss in professions that are dependent on water availability. In addition, it can stabilize or increase farmer's income, as farmers are able to avoid losses due to poor irrigation management.	
	Economic	
	SMM devices can lead to increase in productivity in the agricultural sector.	
Technological constraints	This technology is common in many countries. The cost and its availability will depend on the type of device that the country implements. The technology is also more effective and suitable for small-scale farmers.[87]	3
Readiness of Nigeria for the	Given the size of the agricultural sector in	3

[86] Federal Ministry of Environment "Third National Communication (TNC) of the Federal Republic of Nigeria"
[87] CTCN, "Soil moisture monitoring" Available at: Soil moisture monitoring | Climate Technology Centre & Network

technology	Nigeria, it may require significant initial investment in implementing the technology. The policy environment, however, could be favorable in facilitating the technology. Furthermore, even though the technology is still not mainstream, there are several cases in Nigeria using the technology.	

12. Soil moisture conservation techniques

➢ Introduction

The purpose of soil moisture conservation techniques is to "minimize the amount of water lost from the soils through evaporation (water loss directly from the soil) and transpiration (water loss occurring through the plants) – or combined, the evapotranspiration".[88]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	This technology allows farmers adapt to climate change by enhancing efficient use of water supply. It can lead to sustainable resource management and reduce demand for water while minimizing overall water use. This is crucial given the fact that climate change may lead to the reduction of water resources available in Nigeria.[89]	3
Alignment with climate change policies and priorities	There is no specific indication of the technology in any of the climate change policies and priorities. However, it can be considered as part of improved resource management, which is considered as one of the adaptation strategies in Nigeria's NDC.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Sustainable water management and water conservation is critical for preserving the environment. *Social* The technology has the potential to prevent job loss in professions that are dependent on	3

[88] CTCN, "Soil moisture conservation techniques" Available at: Soil moisture conservation techniques | Climate Technology Centre & Network

[89] Federal Ministry of Environment "Third National Communication (TNC) of the Federal Republic of Nigeria"

	water availability. In addition, it can stabilize or increase farmer's income, as farmers are able to avoid losses due to poor water management.	
	Economic	
	Soil moisture conservation techniques can lead to increase in productivity in the agricultural sector.	
Technological constraints	The technology is fully mature and widely implemented in many countries. Depending on the location, the technology may require additional costs for it to work effectively.[90] The technology can be available in the short to medium term, but may require some testing since the technology is not suitable for every location.	3
Readiness of Nigeria for the technology	The number of cases implementing this technology is limited in Nigeria. It will require significant amount of investment and data collection initially for the technology to reach its potential.	1

13. Nutrient management: nitrogenous fertilizers

➢ Introduction

The efficient use of nitrogenous fertilizers can reduce nitrous oxide from agricultural fields while contribute to the reduction of carbon dioxide emissions by minimizing the quantity of synthetic fertilizers.[91]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Using nitrogenous fertilizers can contribute in reducing nitrous oxide from the agricultural sector. For instance, nitrogenous fertilizers like SBT butanoate and SBT fluroate reduced nitrous oxide by 4-5%, which is equivalent to reducing global warming potential by 8.9 to 19.5%.[92] Since the use of nitrogenous	3

[90] CTCN, "Soil moisture conservation techniques" Available at: Soil moisture conservation techniques | Climate Technology Centre & Network
[91] CTCN, "Nutrient management: nitrogenous fertilizers" Available at: Nutrient management: nitrogenous fertilisers | Climate Technology Centre & Network
[92] Ibid.

	fertilizers reduce the quantity of synthetic fertilizers, this technology also has the potential to reduce carbon dioxide emissions.	
Potential impact on climate change adaptation	The technology can preserve ground water quality by preventing nitrate leaching, which can be essential when the availability of quality water reduces.	2
Alignment with climate change policies and priorities	The technology is not indicated in any of the climate change policies and priorities. It can be, however, considered as part of adopting better soil management, which is indicated in the NDC.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	As mentioned above, the technology prevents nitrate leaching which can help preserve ground water quality.	
	Social	
	It has the potential to stabilize or increase farmer's income, as farmers are able to avoid losses due to poor ground water quality.	
	Economic	
	The technology can lead to increase in productivity in the agricultural sector.	
Technological constraints	The technology is common in many countries, however, it requires significant input cost and is relatively expensive. Furthermore, the technology needs to be tested to assess whether the technology is suitable for the location. In addition, capacity building is needed to ensure that the technology is used appropriately.	2
Readiness of Nigeria for the technology	Despite having some cases implementing the technology in Nigeria, the overall cost and the need for testing and training can hinder the process of mainstreaming the technology in Nigeria. As such, it is possible that the technology will not be accepted by the farmers.	2

14. Seed and grain storage

- Introduction

Improved seed and grain storage can allow farmers to increase their resilience to climate-related impacts and rapidly recover from shocks.[93]

[93] FAO, "Appropriate Seed and Grain Storage Systems for Small-scale Farmers"

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	Improving seed and grain storage can enable farmers to reduce their vulnerability from climate change impacts, such as pests and floods. The technology will also allow farmers to quickly recover in the case of disasters.	3
Alignment with climate change policies and priorities	Increasing and upgrading crop storage facilities is identified as an adaptation strategy in Nigeria's TNC.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Improving seed and grain storage has the potential for better resource management as it minimizes the amount of waste.	
	Social	
	It has the potential to stabilize or increase farmer's income, as farmers are able to minimize food loss.	
	Economic	
	The technology can lead to increase in the amount of production.	
Technological constraints	Seed and grain storage are available in many countries. However, for the technology to be effective, it requires to keep low levels of temperature, certain amount of moisture and humidity, which can be challenging in terms of maintenance and costs.	2
Readiness of Nigeria for the technology	The policy environment for implementing the technology is favorable and there are already cases in Nigeria in which the technology has been implemented. Yet, significant initial investment is necessary as installation and maintenance costs can be a burden for farmers.	2

15. Seasonal to Interannual Prediction

➢ Introduction

Seasonal to interannual prediction is a technology that presents forecast of weather conditions

for a period of 3 to 6 months ahead[94]. Weather conditions are forecasted based on existing climate data such as sea surface temperatures, and then developed by using mathematical models.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	Understanding the forecast of weather conditions for a period 3 to 6 months ahead can enable farmers to have better resource management, especially reducing the use of water resources. This technology also helps the farmer's ability to prepare and respond to climate related risks and events, such as flooding and droughts.	3
Alignment with climate change policies and priorities	Even though the technology is not clearly indicated in any of the documents, providing meteorological forecasts are considered as one of the strategies for agriculture in NASPA.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Has the potential to contribute to sustainable environmental management by providing forecasts and monitoring.	
	Social	
	The technology can create new job opportunities, especially by establishing monitoring systems and introducing climate information services. If implemented properly, the technology has also the potential to minimize farmers' losses as a result of floods and droughts.	
	Economic	
	Seasonal to interannual prediction can improve agricultural planning, which in turn can lead to increase in agricultural productivity. In addition, the technology has the potential to minimize the damage caused by natural disaster to the economy.	
Technological constraints	The technology is well known and has been adopted in many countries.	3
Readiness of Nigeria for the	The main constraint of implementing this	1

[94] CTCN, "Seasonal to interannual prediction" Available at: Seasonal to interannual prediction | Climate Technology Centre & Network

technology	technology is the initial investment. Furthermore, a significant amount of training is required, especially in relation to forecasting and climate modelling.	

16. Index-based Climate Insurance

- Introduction

Index-based climate insurance assesses compensation for agricultural, livestock, or fishery production losses caused by extreme weather events using an index that is closely connected to output losses[95]. The insurance payment is made when the index surpasses a particular threshold without an onsite inspection.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	The technology has the potential of protecting farmers' livelihoods and income by providing compensations for productions losses as a result of climate change. Since it is not directed mainly at adapting production to climate change, its long-lasting impact on resilience remains limited to some extent.	2
Alignment with climate change policies and priorities	Increasing support for insurance schemes is considered as an adaptation strategy in Nigeria's TNC.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* No significant co-benefits in terms of environment *Social* The technology can enable affected farmers sustain their livelihoods and income through indemnities paid by insurance companies. *Economic* The technology can prevent loss in production in the agricultural sector as the technology can allow farmers to continue his/her activities.	2
Technological constraints	The technology is adopted in various	3

[95] CTCN "Index-based climate insurance", Available at: Index-based climate insurance | Climate Technology Centre & Network

	countries.	
Readiness of Nigeria for the technology	There is no known case of this technology in Nigeria. This technology requires other technologies like remote sensing and GIS to obtain real-time weather data for it to function, which in turns needs significant amount of initial investment and training,	0

17. Hydroponics/Soilless Agriculture

➢ Introduction

Hydroponics refers to a form of growing plants in a water-based, nutrient-rich solution without soil. An inert medium such as perlite, rockwool, clay pellets, peat moss, or vermiculite supports the root system. It allows farmers with limited access to land and water to do farming, contributing to water and land use savings. [96]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	The adoption of the technology can enable farmers to use water resources and nutrients more efficiently while avoiding uncertainties in the water and nutrient status of the soil. Furthermore, it assists farmers in overcoming issues concerning sanity and pests/diseases.	3
Alignment with climate change policies and priorities	There is no specific indication of the technology in any of the climate change policies and priorities. However, it can be considered as part of improved resource management, which is considered as one of the adaptation strategies in Nigeria's NDC.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* The technology can contribute to sustainable water management and reduce soil degradation, which is critical to preserving the environment. *Social* Can provide job opportunities in the creation and maintenance of hydroponics systems.	3

[96] FAO "Home Gardens/Vertical Farming, Hydroponics and Aquaponics" Available at: http://www.fao.org/land-water/overview/covid19/homegardens/en/

	Economic Hydroponics system can lead to increase in agricultural production.	
Technological constraints	Hydroponics is still considered an emerging technology and requires testing to figure out which crop can be produced through the technology.	1
Readiness of Nigeria for the technology	There is no known application of this technology in Nigeria. High investment is initially required to put in place the necessary modern equipment to function properly. Training for farmers is also needed, and thus the technology may be available in the medium to long term.	0

18. Aquaponics

- Introduction

Aquaponics is a system that combines hydroponics with conventional aquaculture. It can lead to better water management as the fish water is used as fertilizer for the plants, while the plants clean the water for the fish[97].

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This is a technology mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	This technology allows farmers adapt to climate change by enhancing efficient use of water supply. It can lead to sustainable resource management and reduce demand for water while minimizing overall water use.	3
Alignment with climate change policies and priorities	There is no specific indication of the technology in any of the climate change policies and priorities. However, it can be considered as part of improved resource management, which is considered as one of the adaptation strategies in Nigeria's NDC.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* The technology can lead to soil conservation, which is critical for sustaining the environment. *Social*	3

[97] CTCN "Soilless agriculture", Available at: Soilless agriculture | Climate Technology Centre & Network

	Can provide job opportunities in the creation and maintenance of aquaponics systems. *Economic* The technology can lead to increase in agricultural production.	
Technological constraints	Even though there are some commercial applications, similar to hydroponics, this technology is still considered as an emerging technology.	1
Readiness of Nigeria for the technology	There is no known application of this technology in Nigeria. High initial costs may be a barrier in mainstreaming the technology.	0

6.2. Livestock production

1. Straw ammoniation and silage

➢ Introduction

Straw ammoniation refers to the process of adding ammonia sources such as liquid ammonia, urea, or ammonium bicarbonate to low-value forage (examples: corn stalks, rice straw, wheat straw, and straw of other crops). Straw silage is "forage that is prepared through the fermentation of chopped fresh green fodder, forage grass, and all kinds of vines and other materials by lactobacillus in the anaerobic conditions of an airproof silage container (tower or silo)."[98]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Straw ammoniation and silage can contribute in improving feed quality and animal productivity, which in turn leads to the reduction of methane emissions. For instance, a study suggests that feeding the straw treated with ammoniation reduced methane emissions by 16% to 30% compared to that of dry straw.[99]	3
Potential impact on climate change adaptation	The technology allows straws to be stored in large quantities for a long period of time, which enhances farmer's ability to withstand climate change impacts.	2

[98] CTCN, "Straw ammoniation and silage" Available at: **Straw ammoniation and silage | Climate Technology Centre & Network**

[99] Ibid.

Alignment with climate change policies and priorities	There is no reference to the technology in any of the climate change policies.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental* The technology can contribute to sustainable resource management. *Social* Straw ammoniation and silage can reduce feeding costs and increase productivity, which can stabilize or increase income for farmers. *Economic* The technology can lead to increase in the amount of production in the agricultural sector.	3
Technological constraints	The technology is implemented in many countries. However, the procedure in using the technology is complex and may cause environmental degradation if it not used appropriately. Therefore, it requires a significant amount of training. In addition, some materials can be relatively expensive.	2
Readiness of Nigeria for the technology	Significant amount of training and investment cost can be a hindrance in implementing the technology in Nigeria. In addition, there is no known application of this technology in Nigeria. This technology, therefore, can only be available in the medium to long term.	0

2. Manure Management

➢ Introduction

According to the FAO, manure management is 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.[100]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	According to the TNC and BUR1, poor manure management was responsible for approximately 10% of total emissions from livestock in 2016. In this regard, manure management has the potential to reduce carbon dioxide emissions by 4.2% and	3

[100] FAO, "Tackling Climate Change through Livestock: A Global Assessment of Emissions and Mitigation Opportunities"

	methane emissions by 9.2%.[101]	
Potential impact on climate change adaptation	Manure management mainly addresses climate change mitigation and has limited adaptation impact. However, the outputs of manure management (biogas, compost) may have considerable adaptation impact, such as improved access to energy and food security.	1
Alignment with climate change policies and priorities	As mentioned above, the TNC and BUR1 indicates that poor manure management is one of the challenges in the livestock sector. In this regard, improving manure management can be considered as a technology that aligns with Nigeria's climate change priorities.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Improving manure management can lead to sustainable resource management. *Social* Manure management has the potential of reducing farmers' costs, which can enable farmers to stabilize or increase income. *Economic* The technology has the potential improve the amount of production.	3
Technological constraints	Manure management is a mature technology. However, depending on the method, it requires careful assessment as some methods are not suited for certain locations and time (for example, if the manure is applied at the wrong time, it might release nitrous oxide).[102] Training will also be necessary for the technology to be effective.	2
Readiness of Nigeria for the technology	Even though there are a number of cases of applying manure management in Nigeria, it is still not mainstream. Although the policy environment seems favorable, the amount of experiments and trainings required for the technology may become a barrier.	2

3. Fertilizer management

➢ Introduction

[101] Ibid.

[102] CTCN "Manure management" Available at: Manure management | Climate Technology Centre & Network | Wed, 04/05/2017 (ctc-n.org)

Managing fertilizers through measures like increasing nitrogen use efficiency, plant breeding and genetic modification, and using technologically advanced fertilizers.[103]

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Fertilizer management reduces the use of fertilizers in animal feed crops, which is a source of nitrous oxide emissions. Furthermore, the implementation of technologically advanced fertilizers has the potential to decrease GHG emissions in feed production.	2
Potential impact on climate change adaptation	This is a technology mainly aimed at reducing GHG emissions and do not aim at adapting to the impact of climate change.	0
Alignment with climate change policies and priorities	These is no direct indication of the technology in any of the climate change policies. However, Nigeria's BUR1 states that the increased consumption of nitrogen-based fertilizers has led to an increase in total AFOLU emissions. Thus, this technology aligns with Nigeria's climate change priorities.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Reducing the use of fertilizer can be beneficial for maintaining soil and plant nutrients.	
	Social	
	Fertilizer management has the potential of reducing farmers' costs, which can enable farmers to stabilize or increase income.	
	Economic	
	The technology has the potential improve the amount of production.	
Technological constraints	The technology is relatively a mature technology that is available in several countries. The potential of the technology contributing to climate change mitigation is highly dependent on the use of organic fertilizers and technologically advanced fertilizers, which can be relatively costly.	2
Readiness of Nigeria for the technology	The overall cost of introducing this technology can be a barrier to facilitate the implementation of the technology in Nigeria.	1

[103] Rojas-Downing et al (2017) "Climate change and livestock: Impacts, adaptation and mitigation", Climate Risk Management, Vol.16, p145-163

	Furthermore, there is no known application of this technology in Nigeria.	

4. Shifting human dietary needs

➢ Introduction

Changing human dietary needs by moving away from meat consumption and diversify sources of food.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	According to a study conducted by WWF, shifting human dietary needs has the potential to reduce GHG emissions by 30% by 2030.[104] Reliance on carbon intensive meat production and large-scale industrial agriculture can be decreased as well.	2
Potential impact on climate change adaptation	Diversifying the food system can contribute to increasing the resilience of agricultural ecosystems.	1
Alignment with climate change policies and priorities	The technology is not indicated in any of the climate change policies.	0
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Transitioning to diets that have lower environmental impact can have a positive effect on biodiversity and the overall environment.	
	Social	
	Potential of new job opportunities in sectors that does not handle meat. It can also enable farmers to stabilize or increase income as it reduces the reliance on a single crop.	
	Economic	
	The technology has the potential improve agricultural productivity.	
Technological constraints	The technology has not been widely implemented. Moreover, the food supply chain consists of many stakeholders and thus may be difficult to reach an agreement on how to implement the technology.	1
Readiness of Nigeria for the technology	It is questionable whether shifting dietary needs is possible in Nigeria since the	0

[104] Carbon Brief "Experts: How do diets need to change to meet climate targets". Available at: Experts: How do diets need to change to meet climate targets? (carbonbrief.org)

	acceptability for this technology may be low.	

5. Enhance farmers' access to micro-credits

➢ Introduction

Improving access to micro-credits to support famers to gain the necessary tools and resources to tackle climate change

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This technology is mainly considered an adaptation strategy. However, enhancing farmers' access to micro-credits can enable farmers to install technology that contribute to reducing GHG emissions.	1
Potential impact on climate change adaptation	This technology has the potential to increase farmers' resilience to climate change impacts. Through micro-credits, farmers can install adaptation measures such as water conservation and diversification of livestock that can help them better adapt to climate change.	3
Alignment with climate change policies and priorities	There is no specific indication of the technology in any of the climate change policies. However, it can be considered as part of assisting low income farmers, which is mentioned in Nigeria's NDC.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	The technology can support implementing technologies that are less harmful to the environment.	
	Social	
	Depending on how the technology is used, it has the potential to increase or stabilize farmers' income as well as create new job opportunities.	
	Economic	
	It can potentially lead to increase in agricultural productivity.	
Technological constraints	There are several cases of implementing this technology, but still limited. If this technology is implemented by domestic financial institutions, it usually requires capacity building and international support.	2
Readiness of Nigeria for the technology	There is no known application of this technology in Nigeria and may need	1

	international support, in terms of finance and capacity building.	

6. Selective breeding via controlled mating

➢ Introduction

A systematic form of breeding in order to improve productivity and breed animals that are more resilient to climate change impacts.[105]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	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.	1
Potential impact on climate change adaptation	Selective breeding via controlled mating can enhance an animal's tolerance to climate change impacts, such as heat stress, droughts, pests, and diseases. Furthermore, it can increase fertility rates and decrease mortality rates, as well as improve livestock products (such as milk and fiber), which lowers the risk of farmers losing animals due to climate change impacts.	3
Alignment with climate change policies and priorities	This technology aligns with Nigeria's climate change policies and priorities. Developing improved livestock breeds is indicated in the NDC and increasing access to drought resilient livestock is identified as NASPA sectoral strategies.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	This technology can contribute to enhancing and maintaining biodiversity.	
	Social	
	Famers are able to stabilize or increase their income as the technology reduces animal loss.	
	Economic	
	It can potentially lead to increase in agricultural productivity.	

[105] CTCN, "Selective breeding via controlled mating" Available at: Selective breeding via controlled mating | Climate Technology Centre & Network

Technological constraints	This technology is a mature technology that has been implemented in many countries. Depending on the methodology, the cost for the technology can be significant. For instance, methods such as in-vitro fertilization or genetic engineering are high-tech and relatively high cost. Training of farmers is also required for the technology to reach its full potential.	2
Readiness of Nigeria for the technology	Even though there are a number of cases in Nigeria implementing the technology, it is still not mainstream. Significant amount of initial investment and training may be required if the method is high-tech.	1

7. Livestock Disease Management

➢ Introduction

Livestock disease management has two key components: prevention measures (biosecurity) measures in susceptible herds and control measures taken once inflection is observed.[106]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	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.	1
Potential impact on climate change adaptation	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.	3
Alignment with climate change policies and priorities	This technology aligns with Nigeria's climate change policy and priorities as vaccination of livestock is identified as an adaptation strategy in Nigeria's NDC.	3
Consideration of co-benefits	*Environmental*	3

[106] CTCN, "Livestock disease management" Available at: Livestock disease management | Climate Technology Centre & Network

(environmental, social, and economic)	Livestock disease management reduces the transfer of diseases to other wildlife species surrounding the farm, which can help maintaining biodiversity.	
	Social	
	Famers are able to stabilize or increase their income as the technology reduces animal loss.	
	Economic	
	It can potentially lead to increase in agricultural productivity.	
Technological constraints	The technology is still an emerging technology, which is either at a planning or testing stage. Strategies such as antibiotics and vaccines are not biologically sustainable as viruses keep transforming over time. Therefore, the cost of the technology can be high for a long period of time. Depending on the strategy, it might need a long waiting period until the technology becomes available.	2
Readiness of Nigeria for the technology	Initial and maintenance costs associated with the technology can be significant, which can be a burden for implementing the technology in Nigeria. There is also not known application of this technology in Nigeria.	1

8. Diversification of livestock

➢ Introduction

Diversifying the livestock portfolio to enhance the agricultural system's ability to adapt to climate change. Strategies include adopting breeds that are more tolerant to climate change impacts or diversifying into different breeds of the same livestock species.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Livestock diversification is mainly aimed at adapting to the impact of climate change and do not aim at reducing GHG emissions.	0
Potential impact on climate change adaptation	This technology reduces farmers' reliance on a single livestock species for income generation and enhance farmers' ability to adapt to climate change. Livestock diversification can help farmers resist to climate change impacts, such as droughts, flooding, and pests.	3
Alignment with climate change	Diversification of livestock is indicated in	3

policies and priorities	Nigeria's NDC as well as other documents as an adaptation measure.	
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	This technology has the potential to enhance biodiversity.	
	Social	
	Diversifying livestock may create new job opportunities. It can also stabilize or increase income for farmers as it reduces farmers' dependence on a single livestock species.	
	Economic	
	This technology can lead to increase in productivity in the agricultural sector.	
Technological constraints	This technology is implemented in many countries. However, implementing this technology in a large scale can be costly.	2
Readiness of Nigeria for the technology	The policy environment for this technology is favorable. There are also some use cases of this technology in Nigeria. Yet, the technology would require significant investment to mainstream.	2

9. Livestock feed optimization

➢ Introduction

Livestock feed optimization aims to reduce methane emissions by optimizing the concentration of forage ration in diet by controlling the crude fiber content of the diet or the fermentation process[107].

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The technology can reduce methane emissions from ruminant animals, which can contribute reducing emissions from the agricultural sector of Nigeria.	3
Potential impact on climate change adaptation	This is a technology mainly aimed at reducing GHG emissions and do not aim at adapting to the impact of climate change.	0
Alignment with climate change policies and priorities	There is no direct reference to the technology in any of Nigeria's climate change policies and priorities.	0
Consideration of co-benefits	*Environmental*	1

[107] CTCN, "Livestock feed optimization" Available at: Livestock feed optimisation | Climate Technology Centre & Network

(environmental, social, and economic)	No significant environmental co-benefit	
	Social	
	No significant social co-benefit	
	Economic	
	The technology has the potential to improve animal production performance, which can lead to enhancing productivity in the agricultural sector	
Technological constraints	This technology is considered as a mature technology and has been adopted in several countries.	3
Readiness of Nigeria for the technology	No known application of the technology in Nigeria. Training is required as improper concentration of forage ration may result in increase in methane production.	0

6.3. Forestry

1. Agroforestry

➢ Introduction

According to the World Agro-forestry Centre, Agroforestry is "a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic, and environmental benefits for land users at all levels".[108]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The forestry sub-sector is the highest emitter of GHGs in the agriculture and land use sector in Nigeria, accounting for 84 percent of total emissions.[109] In this regard, agroforestry practices can reduce GHG emissions by increasing carbon storage in biomass (both above-ground and below-ground) and in soil organic carbon. According to Nigeria's NDC, agroforestry can contribute to total (lifetime) emissions reductions ranging from 158 million to 712 million tonnes.	3
Potential impact on climate change adaptation	Agroforestry can provide a number of ecosystem services that can enhance	3

[108] CTCN, "Agroforestry" Available at: Agroforestry | Climate Technology Centre & Network
[109] Federal Republic of Nigeria. 2020. TNC.

	resilience to climate change. It can improve water security by improving infiltration to soils and ground water, while trees can act as a buffer against floods, erosion, pests, and storms.	
Alignment with climate change policies and priorities	The technology is identified in many of the climate change policies and priorities of Nigeria.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Agroforestry can support tree-related ecosystem services, such as regulating sediment and water flows, improving nutrient and carbon cycle in soils and creating habitat for biodiversity. This in turn can also reduce soil erosion. *Social* It can reduce the use of external inputs such as conventional fertilizers and chemicals for pest management, which can stabilize or increase farmers' income. May provide new job opportunities in the forest-related industry. *Economic* Agroforestry has the potential to increase farm productivity and develop forest-related industry.	3
Technological constraints	Agroforestry is practiced in many countries to some extent.. The process of realizing the potential of the technology may be slow and careful maintenance is needed. The location needs to be considered thoroughly as studies indicate that agroforestry has led to lower crop yield in drier lands due to tree-crop competition for water.[110]	2
Readiness of Nigeria for the technology	The policy environment is favorable, and the technology is available in Nigeria to a certain extent. Issues regarding land rights and lack of knowledge may be a potential barrier in scaling up the technology.	2

2. Forest management techniques for mitigation (REDD+)

➢ Introduction

Managing forests by either promoting afforestation or reducing deforestation to increase stand-

[110] CTCN, "Agroforestry" Available at: Agroforestry | Climate Technology Centre & Network

level forest carbon stocks.[111]

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This technology can contribute in reducing GHG emissions from the atmosphere by slowing and halting forest loss (deforestation and forest degradation) while also enhance and conserve forest-carbon stocks. As mentioned earlier, the forest subsector is the highest emitter of GHGs in the agriculture and land use sector in Nigeria.	3
Potential impact on climate change adaptation	Activities under REDD+ 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.	2
Alignment with climate change policies and priorities	This technology aligns with Nigeria's climate change policies and priorities as the technology is clearly indicated in Nigeria's TNC.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	This technology can support tree-related ecosystem services, such as regulating sediment and water flows, improving nutrient and carbon cycle in soils and creating habitat for biodiversity. This in turn can also reduce soil erosion.	
	Social	
	It can reduce the use of external inputs such as conventional fertilizers and chemicals for pest management, which can stabilize or increase farmers' income. May provide new job opportunities in the forest-related industry.	
	Economic	
	REDD+ has the potential to increase farm productivity and develop forest-related industry.	
Technological constraints	Even though the technology is implemented in many countries, the technology requires time for it to reach its potential and have an impact on climate change mitigation and adaptation.	2

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

	The technology also requires sufficient financial support as well as capacity building of institutions.	
Readiness of Nigeria for the technology	The policy environment for this technology is favorable and several REDD+ programs has been implemented in Nigeria. However, a significant amount of investment and capacity building is necessary for this technology.	2

3. Sustainable Forest Management

➢ Introduction

Managing forests in accordance to sustainable development and community development principles.[112] This includes the protection, restoration, afforestation, and reforestation of forests while preventing forest degradation.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This technology can contribute in reducing GHG emissions from the atmosphere by slowing and halting forest loss (deforestation and forest degradation) while also enhance and conserve forest-carbon stocks. This technology can address GHG emissions in the forest subsector, which is the highest emitter of GHGs in the agriculture and land use sector in Nigeria.	3
Potential impact on climate change adaptation	Sustainable forest management 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.	2
Alignment with climate change policies and priorities	Incentivizing sustainable forest management is indicated as a measure to reduce GHG emissions from AFOLU sector and thus, the technology aligns with Nigeria's climate change policies and priorities.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental* The technology can contribute in conserving and enhancing biodiversity. *Social*	3

[112] CTCN, "Sustainable forest management" Available at: Sustainable forest management | Climate Technology Centre & Network

	It can reduce the use of external inputs such as conventional fertilizers and chemicals for pest management, which can stabilize or increase farmers' income. May provide new job opportunities in the forest-related industry.	
	Economic	
	Sustainable forest management has the potential to increase farm productivity and develop forest-related industry.	
Technological constraints	This technology is implemented in many countries to some extent. The technology requires the development of regulatory, institutional, technical and information capacity to reach its potential. Management and maintenance cost can be relatively high.	2
Readiness of Nigeria for the technology	There is an enabling environment to facilitate the technology in Nigeria. There are also some cases of sustainable forest management in Nigeria. However, a significant amount of investment and capacity building is necessary for this technology.	2

4. Promote sustainably produced wood products

- Introduction

Promoting the use of sustainable wood products instead of other materials like concrete, plastic, and metals

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Promoting sustainable produced wood products can contribute to climate change mitigation mainly in three ways. First, wood products can physically store carbon and thus expand carbon storage outside of the forest. Second, the production of wood products increases biofuels which can be used in place of non-renewable energy sources. Third, wood can substitute for more energy-intensive and non-renewable materials such as cement, steel, and plastic.[113]	2
Potential impact on climate	This technology is mainly aimed in reducing	0

[113] FAO "Carbon Storage and Climate Change Mitigation Potential of Harvested Wood Products"

change adaptation	GHG emissions.	
Alignment with climate change policies and priorities	There is no indication of this technology in any of Nigeria's climate change policies. It can be, however, considered as part of sustainable management of natural resources, which is indicated in the TNC.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* The technology can lead to conserving forests and biodiversity. *Social* May provide new job opportunities in forest-related industry. It can also be an additional source of income especially for people living in rural areas. *Economic* Has the potential to develop the forest-related industry in Nigeria.	3
Technological constraints	The technology is implemented in many countries, but it requires to put in place environmental regulations (such as labels and monitoring system) for the technology to actually contribute to climate change mitigation. It is also necessary to carefully assess the environment impact of the product.	2
Readiness of Nigeria for the technology	The need to develop environmental regulations and to assess environmental impacts can be considered as barriers when implementing this technology in Nigeria. There is also limited cases of the technology being implemented in Nigeria.	2

5. Ecosystem-based adaptation

➢ Introduction

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.[114]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse	Though primarily an adaptation approach,	1

[114] IUCN, "Ecosystem-based approaches to climate change adaptation" Available at: Ecosystem-based Approaches to Climate Change Adaptation | IUCN

gas emissions reduction	ecosystem-based adaptation has the potential to reduce GHG emissions by halting habitat loss and ecosystem degradation.	
Potential impact on climate change adaptation	There are several ways in which ecosystem-based adaptation can contribute in increasing resilience to climate change impacts. Examples include, but not limited to, maintaining, and restoring mangroves to reduce coastal flooding and erosion, managing upland wetlands to improve water flow and quality, restoring forests to prevent flooding and landslides, and establishing agroforestry systems to provide flexible livelihood options.	3
Alignment with climate change policies and priorities	There is no indication of the technology in any of Nigeria's climate change policies. Nevertheless, it can be considered as part of restoring ecosystems, which is indicated in Nigeria's TNC.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* The technology can contribute in conserving the environment and enhancing biodiversity. *Social* May provide an additional source of income especially for people living in rural areas. *Economic* Has the potential to minimize the impact of natural disasters to the economy and increase agricultural production.	3
Technological constraints	Even though there are some projects under implementation in several countries, it is still considered as an emerging technology, Depending on the activity, the initial and maintenance costs can be relatively high. Starting to be implemented in many countries, but further research and assessment is needed to understand its potential for climate change mitigation and adaptation.	2
Readiness of Nigeria for the technology	Since ecosystem degradation is one of the issues in Nigeria, adopting ecosystem-based adaptation may be necessary in the long run. However, the concept is too broad and sufficient investment is necessary. There is also no known application of this technology in Nigeria.	1

6. Afforestation

➢ Introduction

According to the IPCC, afforestation is "the direct human-induced conversion of non-forest to forest land through planting, seeding, and/or the human-induced promotion of natural seed sources". [115]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This technology can address GHG emissions in the forest subsector, which is the highest emitter of GHGs in the agriculture and land use sector in Nigeria, by enhancing stand-level forest carbon stocks (1 to 1.5tCO2/yr).[116]	2
Potential impact on climate change adaptation	Afforestation 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.	2
Alignment with climate change policies and priorities	Afforesting with suitable species is indicated as an adaptation measure in Nigeria's TNC.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	The technology can contribute in conserving the environment and enhancing biodiversity.	
	Social	
	May provide new job opportunities in forest-related industry. It can also be an additional source of income especially for people living in rural areas.	
	Economic	
	Has the potential to develop the forest-related industry in Nigeria.	
Technological constraints	The technology requires the development of regulatory, institutional, technical and information capacity to reach its potential. Management and maintenance cost can be relatively high.	2
Readiness of Nigeria for the technology	There is an enabling environment to facilitate the technology in Nigeria and some use cases has been identified. However, a significant amount of investment and capacity building is necessary for this technology.	2

[115] IPCC, "9.4.2.2 Maintaining or increasing forest area: afforestation/reforestation" Available at: 9.4.2.2 Maintaining or increasing forest area: afforestation/reforestation - AR4 WGIII Chapter 9: Forestry (ipcc.ch)
[116] Ibid.

7. Assessment of technologies in the Energy sector

7.1. Electricity supply

1. Solar PV

➢ Introduction

Solar Photovoltaic refers to the technology of using solar cells to convert solar radiation directly into electricity[117]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 $MtCO_2e$ 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.	3
Potential impact on climate change adaptation	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. It would allow for more spatial diversification of energy supplies, which reduces the vulnerability of the energy supply from a single event or a single critical location, which increases overall energy system resilience.	2
Alignment with climate change policies and priorities	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 RE (i.e., mini-grids, solar home systems and streetlights, and self-generation) which are more likely to be achieved through Solar PV.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental* A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation. *Social*	3

[117] CTCN, "Solar PV" Available at: Solar PV | Climate Technology Centre & Network

	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.	
	Economic	
	Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.	
Technological constraints	Solar power technologies are overall around the stage of "early adoption", where the technologies are commercially available and becoming widely implemented, according to IEA (2020)[118]. 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.	3
Readiness of Nigeria for the technology	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/m^2/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.[119]	2

2. Concentrated Solar Power (Solar Thermal)

- Introduction

CSP systems generate electricity by concentrating solar energy using mirrors or lenses into a receiver. Electricity is generated when the concentrated energy from the sun heat fluid to superheated steam which is used to turn turbines to generate electricity.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 $MtCO_2e$ in 2018. Of which, electricity generation (on-grid and off-grid) contributes 24% of the sector's GHG	3

[118] IEA (2020) "ETP Clean Energy Technology Guide"
[119] Federal Republic of Nigeria (2020) "Third National Communication of the Federal Republic of Nigeria under the United Nations Framework Convention on Climate Change"

	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.	
Potential impact on climate change adaptation	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.	1
Alignment with climate change policies and priorities	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.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation.	
	Social	
	The expansion of the renewable energy industry contributes to generating more sustainable employment and livelihood. It also increases access to electricity, potentially reducing poverty.	
	Economic	
	Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.	
Technological constraints	CSP technology is at the stage of "early adoption" according to IEA (2020)[120]. In fact, CSP had a total installed capacity of over 6.5 GW globally in 2019[121].	3
Readiness of Nigeria for the technology	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.	0

3. Run-of-river Hydropower

➢ Introduction

Run-of-river hydropower is a generation technology utilizing river flow and micro turbine

[120] IEA (2020) "ETP Clean Energy Technology Guide"

[121] Reve "Concentrated solar power had a global total installed capacity of 6,451 MW in 2019" Available at https://www.evwind.es/2020/02/02/concentrated-solar-power-had-a-global-total-installed-capacity-of-6451-mw-in-2019/73360

generators to produce electricity.[122]

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 $MtCO_2e$ 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. Hydropower generation can greatly contribute to reducing GHG emissions from the existing energy mix or use of diesel gensets.	3
Potential impact on climate change adaptation	Small-scale hydropower generation could make the power system more resilient to extreme climate events compared with conventional power systems, although hydropower in general tend to be more affected to the effects of climate change.	1
Alignment with climate change policies and priorities	Run-of-river hydropower technology was not specifically identified as a mitigation measure in the NDC. However, the TNC includes small-scale hydropower as one of the low carbon development options. The NREEEP priority include fully harnessing hydropower potential and extending electricity to rural and remote areas.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation. *Social* The expansion of the renewable energy industry contributes to generating more sustainable employment and livelihood. It also increases access to electricity, potentially reducing poverty and increasing industrial activity. *Economic* Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.	3
Technological constraints	Hydroelectric power is the most mature, reliable, and cost-effective renewable power generation technology presently commercially viable on a large scale, producing around 16% of the world's	3

[122] CTCN, "Run of river hydropower" Available at: Run of river hydropower | Climate Technology Centre & Network

	electricity and over 80% of the world's renewable electricity.[123]	
Readiness of Nigeria for the technology	Hydropower is the main renewable energy source for Nigeria currently, with over 2,110MW in capacity installed as of 2019. Nigeria has also developed several small-scale hydropower plants.	3

4. Wind Power

➢ Introduction

Wind power is a renewable energy power generation technology using wind turbines.[124] This considers both on-shore and off-shore wind generation.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 $MtCO_2e$ 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. Wind power generation can greatly contribute to reducing GHG emissions from the existing energy mix.	3
Potential impact on climate change adaptation	Wind power could make the power system more resilient to impacts of climate change through the increase of generation capacity from renewable energy source. However, it is more vulnerable to extreme weather events compared with other RE technologies.	1
Alignment with climate change policies and priorities	Wind power has been explicitly identified in the NDC as a key climate change mitigation measure. Specific targets for Wind include a 3.2GW capacity for on-grid electricity., and 5.3GW off-grid RE target for mini-grids, which could be achieved through Wind.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation.	
	Social	
	The expansion of the renewable energy industry contributes to generating more sustainable employment and livelihood. It also increases access	

[123] Guyana Energy Agency "Hydro" Available at https://gea.gov.gy/hydro/
[124] CTCN, "On-shore wind" Available at: On-shore wind | Climate Technology Centre & Network)

	to electricity, especially for off-grid applications, potentially reducing poverty.	
	Economic	
	Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.	
Technological constraints	Wind power technologies are overall around the stage of "early adoption", where the technologies are commercially available and becoming widely implemented, according to IEA (2020)[125]. In fact, both off-shore and on-shore wind power farms have been constructed and operated across the globe. Furthermore, lifecycle cost of wind power generation has been decreasing.	3
Readiness of Nigeria for the technology	Wind power is an untapped renewable energy source in Nigeria. There are no grid-connected commercial wind power plants but an ongoing installation of a 20MW plant as per the TNC.	1

5. Geothermal Energy

➢ Introduction

Geothermal energy is the use of thermal energy that is generated and stored in the Earth.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 $MtCO_2e$ 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. Power generation from geothermal sources can greatly contribute to reducing GHG emissions from the existing energy mix.	3
Potential impact on climate change adaptation	Geothermal energy could make the power system more resilient to extreme climate events. In addition, geothermal technology is 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.	2
Alignment with climate change policies and	Geothermal is not included in Nigeria's climate change priorities, nor in its renewable energy	1

[125] IEA (2020) "ETP Clean Energy Technology Guide"

priorities	development plans. Although, the NREEEP acknowledges the country's potential for geothermal and encourages further development on research and data gathering to be utilized when competitive.	
Consideration of co-benefits (environmental, social, and economic)	*Environmental* A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation. *Social* 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. *Economic* Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.	3
Technological constraints	Geothermal technologies for direct uses (e.g., district heating, geothermal heat pumps, greenhouses, and for other applications) and for electricity generation from hydrothermal reservoirs with naturally high permeability are mature and have been widely used.[126]	3
Readiness of Nigeria for the technology	Geothermal energy is not implemented in Nigeria.	0

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

➢ Introduction

Waste-to-energy technologies refer to the combustion of solid waste as an alternative source to produce heat or electricity.[127] 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.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 $MtCO_2e$ 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	3

[126] IRENA "Geothermal energy" Available at https://www.irena.org/geothermal

[127] CTCN, "Energy supply from waster" Available at: Energy supply from waste | Climate Technology Centre & Network

	fossil-fuel fired thermal power plants. Power generation from renewable biomass sources can greatly contribute to reducing GHG emissions from the existing energy mix.	
Potential impact on climate change adaptation	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.	1
Alignment with climate change policies and priorities	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.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* 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. *Social* 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. *Economic* Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.	3
Technological constraints	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.[128]	3
Readiness of Nigeria for the technology	Nigeria has abundant biomass resources in the form of wood waste, agricultural residues, and municipal solid waste. However, biomass power generation	0

[128] IRENA "Bioenergy for Power" Available at https://www.irena.org/costs/Power-Generation-Costs/Bioenergy-for-Power

	has not been implemented yet in the country.	

7. Co-generation

➢ Introduction

Co-generation refers to the production of heat and electricity from the same primary fuel.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 $MtCO_2e$ 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, mainly from gas-fired plants. Co-generation systems typically achieve overall efficiency of 60 to 80 percent to produce electricity and thermal energy by recovering the wasted heat.[129] Moreover, producing electricity onsite also avoids transmission and distribution losses and thereby contributes to saving energy.	2
Potential impact on climate change adaptation	If installed onsite, co-generation systems could provide electricity to houses/buildings even during a power outage. Therefore, it has the potential to enhance climate resilience of power systems.	1
Alignment with climate change policies and priorities	Nigeria includes in its NDC target, 100% of diesel and single cycle steam turbines replaced with combined cycle.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	2
	Efficient electricity generation improves environmental quality by reducing air pollution emitted from conventional electricity generation.	
	Social	
	No significant co-benefits in terms of employment or poverty reduction.	
	Economic	
	Increased efficiency in energy generation ensures economic growth and development.	
Technological constraints	Co-generation is a mature technology and has been widely used.	3
Readiness of Nigeria for the technology	Nigeria has several utility-scale combined cycle power plants of around 3,000MW installed capacity	2

[129] US EPA "CHP Benefits" Available at https://www.epa.gov/chp/chp-benefits

	in total.	

8. Hydrogen Thermal Power Generation

➢ Introduction

Hydrogen can be used as fuel in gas in turbines, which can reduce carbon emissions compared to traditional thermal power generation using fossil fuels.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Emissions from the energy sector comprise 60% of total emissions in Nigeria, amounting to 209 $MtCO_2e$ 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. According to the paper by Mitsubishi Heavy Industries, a fuel mix of 30 percent hydrogen can reduce GHG emissions by approximately 10 per cent compared to natural gas burning thermal power generation.[130]	3
Potential impact on climate change adaptation	Hydrogen power could make the power system more resilient to impacts of climate change through the increase of generation capacity.	1
Alignment with climate change policies and priorities	Hydrogen thermal power generation is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	The use of hydrogen for electricity generation improves environmental quality by reducing air pollution.	
	Social	
	The expansion of low-carbon industries contributes to generating more sustainable employment and livelihood. It also increases access to electricity, especially for off-grid applications, potentially reducing poverty.	
	Economic	
	Increased generation capacity from low-carbon technologies ensures economic growth and development toward low-carbon economy.	

[130] MHI (2018) "Research and Development on Gas Turbine Capable of Hydrogen Co-firing"

Technological constraints	Technologies for using hydrogen-mixed fuel in thermal power generation is still under development, and there is limited number of use cases around the globe. There is no commercialized case of a complete hydrogen-fired gas turbine.	1
Readiness of Nigeria for the technology	Hydrogen technologies have not been implemented yet in Nigeria.	0

9. Carbon Capture and Storage

➢ Introduction

Carbon Capture and Storage (CCS) is the process of capturing CO_2 from emission sources such as power plants, transporting, and storing it in underground geological formations.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	CCS prevents CO_2 release into the atmosphere. It contributes to GHG emission reduction even in hard-to-abate sectors such as cement industry.	3
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	CCS is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	1
	CCS contributes to improving environmental quality by reducing air pollution from the treatment process.	
	Social	
	No significant social co-benefit	
	Economic	
	No significant economic co-benefit	
Technological constraints	There are 26 large-scale CCS facilities are operating commercially in the world.[131] Yet, it is hard to say that CCS technologies are mature and widely deployed. Several applications of CCS, including chemical absorption of CO_2 from ammonia production and natural gas processing, are already widely deployed today. Many of other applications	1

[131] Statista "Number of large-scale carbon capture and storage (CCS) facilities worldwide as of 2020, by status" Available at https://www.statista.com/statistics/726624/large-scale-carbon-capture-and-storage-projects-worldwide-by-status/

	are still at the early adoption stage, such as chemical absorption from coal-fired power generation and hydrogen production from natural gas, compression of CO_2 from bioethanol production and coal-to-chemicals plants, and CO_2 storage in saline aquifers. Several other applications, including DAC (direct air capture) and CO_2 capture from cement and iron and steel making, are still at the pilot stage.[132]	
Readiness of Nigeria for the technology	CCS have not been implemented yet in Nigeria.	0

10. Energy Storage System

➢ Introduction

Energy storage systems refer to technologies converting electrical energy from power systems into a form that can be stored and converting back to electrical energy when needed. Many storage technologies have been considered for utility-scale use such as pumped hydro, batteries (including conventional and advanced technologies), superconducting magnetic energy storage, flywheels and supercapacitors/ultracapacitors.[133]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Energy storage system allows efficient use of surplus renewable electricity. It plays an important role in integrating large volumes of variable renewable energy sources into the grid system without impacting system stability.	2
Potential impact on climate change adaptation	Energy storage system could make the power system more resilient to extreme climate events as it stores electricity hours or days and provides electricity in the case of a power outage. Furthermore, being installed at the household or community level, it could be an alternative power source for the house or area even when the transmission line is damaged due to, for example, extreme whether events.	2
Alignment with climate change policies and	Energy storage is not mentioned in any of key policies or priorities in Nigeria. However, it could	1

[132] IEA "CCUS technology innovation" Available at https://www.iea.org/reports/ccus-in-clean-energy-transitions/ccus-technology-innovation
[133] CTCN, "Batteries", Available at https://www.ctc-n.org/technology-library/energy-storage/batteries

priorities	contribute to overall goal for CO_2 emission reduction.	
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Energy storage supports the roll out of renewable energy, consequently supporting environmental protection.	
	Social	
	Energy storage supports the roll out of renewable energy, consequently supporting the expansion of RE industry leading to generation of employment and livelihood.	
	Economic	
	Increased generation capacity from renewable energy ensures economic growth and development toward low-carbon economy.	
Technological constraints	Out of the battery technology systems, only the lead acid battery system has reached full commercial maturity and cost certainty. Other technologies are still under development.	1
Readiness of Nigeria for the technology	Energy storage have not been implemented yet in Nigeria.	0

11. Building Climate Resilient Infrastructure

- Introduction

Building infrastructure for electricity supply that are climate resilient and can mitigate damage to electricity supply in the case of disasters, especially in the coastal areas.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	No significant impact on GHG emission reduction	0
Potential impact on climate change adaptation	As electricity infrastructure is an essential foundation for the economy and lives of people, building resilience in it contributes to reducing massive direct and indirect costs of climate change.	3
Alignment with climate change policies and priorities	Climate-resilient infrastructure is not mentioned in any of the key policies or priorities.	0
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	1
	No significant environmental co-benefits	
	Social	
	No significant social co-benefits	

	Economic Resilience of the electricity system ensures economic growth and development, especially during extreme weather events.	
Technological constraints	Examples of adaptation measures for electricity infrastructure include: fortifying coastal, off-shore and flood-prone infrastructure against flooding; locating new facilities outside high-risk zones; increasing transmission tower height to protect substations from flooding; burying distribution lines; and using stainless steel material to reduce corrosion from water damage.[134] These do not require new technologies and is not technically difficult to deploy.	3
Readiness of Nigeria for the technology	There is not much information regarding climate-resilient electricity infrastructure in Nigeria, and adaptation measures in the energy sector in general.	0

12. Micro-grid

- Introduction

Micro-grid systems are local energy grid with control capacity and is disconnected from the larger, main grid.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Micro-grid systems do not result in GHG emission reductions. But in the context of Nigeria wherein priorities include off-grid and mini-grid application of renewable energy technologies, this can contribute to meeting the country's mitigation targets.	2
Potential impact on climate change adaptation	Mini-grids increase resilience of power systems to extreme climate events due to its decentralized nature, and will not be affected by power outages from the main grid.	3
Alignment with climate change policies and priorities	Nigeria have specific targets of increasing off-grid renewable energy capacity to 13GW, which include a target of 5.3GW for mini-grids.	3
Consideration of co-benefits (environmental,	*Environmental* For a renewable energy based mini-grid, it will	3

[134] OECD (2018) "Climate-resilient Infrastructure: OECD Environment Policy Paper No.14"

social, and economic)	improves environmental quality by reducing air pollution emitted from conventional electricity generation.	
	Social	
	For a renewable energy based mini-grid, 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 and increasing commercial activities.	
	Economic	
	For a renewable energy based mini-grid, it Increases generation capacity from RE ensuring economic growth and development toward low-carbon economy.	
Technological constraints	Large variety of technologies are now available for renewable energy based mini- and micro-grids, including small hydro, biomass-to-power, mini-wind, PVs, hybrids, with or without storage.[135]	3
Readiness of Nigeria for the technology	Mini-grid systems have been deployed in Nigeria. In addition, the Rural Electrification Agency (REA) supports the development of private sector mini grids in unserved areas through its Nigeria Electrification Project – Solar Hybrid Mini Grids Component.[136]	3

13. Power to Hydrogen

- Introduction

Electricity produced from renewable energy can be used to produce hydrogen. An electrolyser splits water into hydrogen and oxygen using electricity. In this way, hydrogen becomes a carrier of renewable energy. Producing hydrogen from renewable power can help avoid curtailment, which occurs when there is excess renewable electricity generation in the power system, and thereby contributes to promoting renewable electricity generation.[137]

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change	Like energy storage system, power to hydrogen	2

[135] CTCN, "Green Mini-Grids: Towards financially viable business models", Available at https://www.ctc-n.org/sites/www.ctc-n.org/files/ctcn_cpcs_webinar_towards_financially_viable_business_models.pdf
[136] Rural Electrification Agency, "Solar Hybrid Mini Grids", Available at https://rea.gov.ng/minigrids/
[137] IRENA (2019) "Innovation landscape brief: Renewable Power-to-Hydrogen"

mitigation/greenhouse gas emissions reduction	allows efficient use of surplus renewable electricity by converting power into hydrogen during low energy demand periods and converting back to power. It plays an important role in integrating large volumes of variable renewable energy sources into the grid system without impacting system stability.	
Potential impact on climate change adaptation	Power to hydrogen could make the power system more resilient to extreme climate events as it stores electricity and provides electricity in the case of a power outage. Furthermore, compared to battery storage, power to hydrogen is more suitable for storing large amount of electricity, which in turn enables providing electricity for a longer period during the outage.	2
Alignment with climate change policies and priorities	The technology is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Depending on the sector in which the technology is used, the potential to improve air quality.	
	Social	
	The expansion of low-carbon industries contributes to generating more sustainable employment and livelihood	
	Economic	
	Depending on the sector, it can improve production as well as the economy	
Technological constraints	Even though there are commercial developments in several counties, the technology overall is still at the R&D or pilot stage.	2
Readiness of Nigeria for the technology	Hydrogen technologies have not been implemented yet in Nigeria	0

14. Tidal Stream Generator

- Introduction

Tidal stream generator is a technology that extract the kinetic energy of moving water to move the turbines, similar to the way wind turbine does from wind streams[138].

- Evaluation of the technologies against criteria

[138] UNEP-DTU Partnership "Technology Fact Sheet: Tidal Stream Generator"

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Tidal stream turbines have the potential to reduce emissions by 434 to 975 gCO2 per kWh of electricity produced from natural gas and coal-fired turbines respectively[139]. This technology, therefore, can address emissions from the energy sector, which comprises 60% of total emissions in Nigeria	3
Potential impact on climate change adaptation	Tidal stream generators could make the power system more resilient to impacts of climate change through the increase of generation capacity.	1
Alignment with climate change policies and priorities	The technology is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	It can improve environmental quality by reducing air pollution emitted from conventional electricity generation.	
	Social	
	It can generate new job opportunities as the renewable energy market expands.	
	Economic	
	Increasing generation capacity ensures economic growth and development toward low-carbon economy.	
Technological constraints	Tidal stream generators are still considered as an emerging technology that is still at the pilot stage.	1
Readiness of Nigeria for the technology	There is no known application of this technology in Nigeria.	0

15. Ocean Thermal Energy Conversion (OTEC)

- Introduction

Ocean Thermal Energy Conversion (OTEC) technologies produce energy by harnessing the temperature differences (thermal gradients) between ocean surface waters and deep ocean waters.[140] The temperature difference is used to power a turbine, which is then can be used for supplying electricity.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring

[139] Ibid.
[140] Energy Information Administration “Hydropower explained: Ocean thermal energy conversion”

Potential impact on climate change mitigation/greenhouse gas emissions reduction	OTEC technologies can contribute to reducing GHG emissions by diversifying Nigeria's energy mix, which is dominated by fossil-fuel fired thermal power plants. Nigeria's energy sector is responsible for 60% of total emissions in Nigeria with 209 $MtCO_2e$ in 2018. Of which, electricity generation (on-grid and off-grid) contributes 24% of the sector's GHG emissions.	3
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	The technology is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	OTEC systems can produce desalinated water which can address water scarcity.	
	Social	
	It can generate new job opportunities as the renewable energy market expands.	
	Economic	
	Increasing generation capacity ensures economic growth and development toward low-carbon economy.	
Technological constraints	Even though there are commercial developments and demonstrations in several counties, the technology overall is still at the R&D or pilot stage.	1
Readiness of Nigeria for the technology	OTEC technologies have not been implemented yet in Nigeria. Significant amount of initial investments will be required to implement the technology.	0

7.2. Energy demand

1. Improved Cook Stoves

➢ Introduction

Improved cook stove technologies pertain to cooking stoves with improvement in efficiency (available in different forms and sizes).[141]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring

[141] CTCN, "Improved Cook Stoves" Available at: Improved Cook Stoves | Climate Technology Centre & Network

Potential impact on climate change mitigation/greenhouse gas emissions reduction	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 firewood 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 emission reduction in rural areas.	3
Potential impact on climate change adaptation	Promoting the use of improved cook stoves leads to less use of firewood. This prevents deforestation, which in turn makes the land resilient against flooding.	2
Alignment with climate change policies and priorities	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 LPG. Specific targets include, 48% of population (26.8 million households) using LPG and 13% (7.3 million) using improved cookstoves by 2030.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Improves environmental quality by reducing air pollution. Contributes to forest conservation.	
	Social	
	Improves health, empowers women, and saves lives, especially in rural population.	
	Economic	
	Efficient cooking saves time, in turn, leading to more time for other activities contributing to economic growth.	
Technological constraints	Improved cook stove technologies are mature and widely deployed around the globe, especially in developing countries.	3
Readiness of Nigeria for the technology	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 programme to meet the country's clean cooking targets.	3

2. Demand-side Management

- Introduction

Demand-side management consist of the planning, implementing, and monitoring activities of electric utilities which are designed to encourage consumers to modify their level and pattern of electricity usage.[142] It allows distribution utilities to satisfy power needs of more customers with little to no increase in power supply generation.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	While demand-side management could contribute to GHG emission reduction, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	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.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation. *Social* No significant social co-benefits *Economic* Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.	2
Technological constraints	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.[143]	3
Readiness of Nigeria for the technology	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.	1

[142] U.S. Energy Information Administration, "Electricity Utility Demand Side Management" Available at: Electric Utility Demand-Side Management (eia.gov)
[143] Ikpe, E. and Torriti, J. (2018) "A means to an industrialisation end? Demand side management in Nigeria"

3. Smart Grid

➢ Introduction

Technology for the electrical system that can sensibly execute the operations to all interconnected elements from generator to consumers.[144]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	While smart grid system could contribute to GHG emission reduction, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	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 energy efficiency targets of Nigeria.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	2
	Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.	
	Social	
	No significant social co-benefits	
	Economic	
	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.	
Technological constraints	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.	2
Readiness of Nigeria for the technology	Smart grid technology has not been deployed in Nigeria.	0

7.3. Energy efficiency

[144] CTCN, "Smart grid", Available at: Smart grid | Climate Technology Centre & Network

1. Energy Management Systems

➢ Introduction

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.[145]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	While energy management systems could contribute to GHG emission reduction, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	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.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.	
	Social	
	This technology can create an energy management industry, potentially resulting in job creation.	
	Economic	
	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.	
Technological constraints	Energy management system is mature technology and widely deployed at factories, buildings, households around the globe.	3
Readiness of Nigeria for the technology	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,	2

[145] Republic of Zambia, "Technology Needs Assessment: Mitigation"

	there exist energy management companies providing such service in the country.	

2. Energy Efficient Buildings

➢ Introduction

Buildings that incorporate measures to alter energy-consuming behavior and as a result, reduce overall energy consumption.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Energy efficient buildings could contribute to GHG emission reduction. However, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.	2
Potential impact on climate change adaptation	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.	1
Alignment with climate change policies and priorities	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.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation. *Social* No significant social co-benefits *Economic* Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.	2
Technological constraints	Technologies associated with energy efficient building, including solar power, energy storage system, and energy management system, are mature technology and widely deployed around the globe.	3
Readiness of Nigeria for the technology	While information on energy efficient buildings in Nigeria is limited, it is assumed that Nigeria has the	2

	potential to implement given the government's strategy to promote energy efficiency. In addition, there exist energy management companies providing such service in the country.	

3. Energy Efficiency Standards and Labels

- Introduction

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.[146]

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Energy efficiency standards and labels could contribute to GHG emission reduction. However, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	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.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	2
	Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.	
	Social	
	No significant social co-benefits	
	Economic	
	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.	
Technological constraints	Energy efficiency standards and labelling do not require any sophisticated technologies, while it is required to establish the evaluation and monitoring system, including human and financial resources.	3

[146] Energy Charter Secretariat (2009) "Policies that work: Introducing Energy Efficiency Standards and Labels for Appliances and Equipment"

Readiness of Nigeria for the technology	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.	2

4. Dynamic line rating

➢ Introduction

Dynamic line rating (DLR) systems collects real-time weather conditions as well as line environment, which allows transmission system operators to adapt to shifting conditions, improving transmission efficiency and enhance transmission capacity of transmission lines.[147] In general, transmission lines are operated using static line rating which is based on conservative conditions. However, conservative conditions rarely occur, leading to under utilization of transmission assets.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	While DLR systems could contribute to GHG emission reduction by promoting an efficient use of electricity, 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.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	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.	2
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	2
	Using electricity efficiently contributes to improving environmental quality by reducing emitted air pollutants from electricity generation.	
	Social	
	No significant social benefits	
	Economic	
	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.	
Technological constraints	DLR system is a relatively mature technology that is commercially available in many countries.	3

[147] IEA "ETP Clean Energy Technology Guide: Dynamic line rating"

Readiness of Nigeria for the technology	DLR technology has not been deployed in Nigeria.	0

8. Assessment of technologies in the Industry and Commerce sector

8.1. Agribusiness and agro-allied sectors

1. Modular Palm Oil Mills

➢ Introduction

Small-scale processors contribute about 80% palm oil production in Nigeria. The produced palm oil by this sector contains very high free fatty acids, which is an important quality indicator of palm oil. This is mainly because of the time lag between harvest and processing of fresh fruit bunches occasioned by poor processing techniques. Palm oil produced by these processors has lower storability. The sector depends more on fossil fuel to operate their machines while capacity and efficiency are very low. There are existing technologies for large, medium, and small-scale technologies. The semi-mechanized and smallholder technologies in Nigeria make up the small-scale sector as described above. A modular palm oil mill is an automated mill like industrial (large-scale) mill but with lower capacity (typically from 1-10 tons/hr.). It can operate 24 hours a day like scale-scale plants. Important facilities include reception unit, sterilizer, thresher, digester, press, clarifier, and storage tank. 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.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The large-scale mills emit 468 kg CO2-eq per t FFB to the atmosphere, while small-scale mills emit about 162kg CO2-eq per t FFB. Installation of the cluster automated mills (5-10 tons per hr mills) with composting facilities for empty fruit bunches and palm oil mill effluent will reduce emissions as reported in large scale mills using same technology by over 200% while increasing the quality of palm oil to industrial standard as well as yield per ton of processed fresh fruit bunch. The technology will reduce emissions due to importation of palm oil products and low productivity by small-scale processors.	3
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	The technology is not identified in any of Nigeria's climate change policies and priorities. However, inadequate palm oil processing technology, shortage of high-grade palm oil is mentioned in the	3

	Nigeria Industrial Revolution Plan and it could contribute to overall goal of CO2 emissions reduction. Food security is key area in National climate change Policy for Nigeria	
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	The technology can contribute to reducing air, soil and water pollution from fossil fuel combustion, open burning, and disposal of biomass. It also reduces soil and water pollution from disposal of oil palm mill effluent	
	Social	
	The technology will enhance job security and increase opportunity for women in the industry with the elimination of labor-intensive job.	
	Economic	
	The technology will increase Nigeria palm oil capacity, reduce importation of the product, and increase economic activity in the rural oil palm belt.	
Technological constraints	Large-scale and different levels of mechanized systems are operational in Nigeria. There are several companies around the world with track records in manufacturing of palm oil mills including customized designs. There are experienced local manufacturers	3
Readiness of Nigeria for the technology	Several levels of small-scale fresh fruit bunch processing systems have been deployed in Nigeria. Oil palm processing is traditional to the oil palm producing areas in Nigeria.	3

2. Anaerobic digesters

- Introduction

Wastewater from industrial and agricultural activities emits methane. In anaerobic digesters, the methane (in form of biogas) is collected for use as fuel. The generated carbon dioxide during combustion of methane has lower global warming potential. Biogas (over 60% methane) can be generated from most organic materials in the absence of oxygen. Anaerobic digesters are particularly necessary where fermentation will occur from industrial or agricultural wastes. In anaerobic digestion, microorganisms feed on the organic material at appropriate operating parameters producing biogas and digestate, which can be converted to organic fertilizer. Anaerobic digestion is also part of some industrial processes including waste-water treatment.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Generated biogas from anaerobic digesters can replace fossil fuel. In palm oil mill, biogas from palm oil mill effluent anaerobic digesters can be used to	3

	generate electricity or replace petrol in boiler start-up and can reduce emission by up to 44%.	
Potential impact on climate change adaptation	The technology will increase access to cooking gas for people in the rural area enabling them to be more resilience to impact of climate change on agricultural and availability of firewood.	2
Alignment with climate change policies and priorities	Anaerobic digestion is mentioned as a mitigation measure in the second Biennial Update Report (BUR2).	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental* The technology prevents the uncontrolled release of pollutant from both aerobic and anaerobic digestion of wastewater. Availability of less expensive cooking gas will prevent pollution associated with burning firewood. It reduces odor emissions from direct organic material application in the farm. *Social* The technology could create employment. *Economic* The technology could reduce the cost of cooking gas and the number of people burning wood as fuel. Deployment of anaerobic digester will increase farmers' access to fertilizer and reduce cost of food production.	3
Technological constraints	Different types of technology including conventional, sludge retention and fixed film digesters are widely used around the world. The application varies from crude systems to automated anaerobic digesters.	3
Readiness of Nigeria for the technology	Anaerobic digester is fast gaining popularity in Nigeria for the generation of cooking gas.	3

8.2. Solid minerals and metals

1. Clinker Replacement

➢ Introduction

Applies specifically to the cement industry. This technology involves blending cement with increased proportion of alternative feedstocks (non-clinker) to reduce overall energy consumption in the cement making process.[148]

[148] CTCN, “Clinker replacement”, Available at: Clinker replacement | Climate Technology Centre & Network

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The cement industry is the highest GHG emitting industry in the IPPU sector accounting for 53.4% of emissions in the sector. This technology is an option to contribute to efficient energy use and reduced emissions in the sector. It is also worth considering that emissions from industrial processes and other product use (IPPU) sector is the least emitting sector for Nigeria contributing only 5.3% of total GHG emissions.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	Clinker replacement is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	1
	Improves environmental quality by reducing air pollution from reduced clinker use in cement production.	
	Social	
	No significant social co-benefit	
	Economic	
	No significant economic co-benefit	
Technological constraints	The technology for replacing clinker with alternative non-clinker feedstocks is mature and widely used such as in Europe, US, China and India. There are also several clinker replacement projects implemented under the CDM.	3
Readiness of Nigeria for the technology	Information on clinker replacement in Nigeria is limited, with no indication of implementation in the country.	0

2. Use of Alternative Fuels

- Introduction

Applies specifically to the cement industry. The technology involves the use of waste materials as alternative fuels for clinker production in the cement industry. Waste materials used as alternative fuels include waste tires, sewage sludge, animal residue, waste oil, paper residue,

plastic, textile, and other lumpy materials.[149]

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The cement industry is the highest GHG emitting industry in the IPPU sector accounting for 53.4% of emissions in the sector. This technology is an option to contribute to reduced emissions in the sector. It is also worth considering that emissions from industrial processes and other product use (IPPU) sector is the least emitting sector for Nigeria contributing only 5.3% of total GHG emissions.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	Use of alternative fuels is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	1
	Improves environmental quality by reducing air pollution from reduced fossil fuel use in cement production. Use of waste materials as fuels also decreases the improper disposal of such materials.	
	Social	
	No significant social co-benefit	
	Economic	
	No significant economic co-benefit	
Technological constraints	The technology of using alternative fuel is mature and widely implemented. There are also several alternative fuel use in cement projects implemented under the CDM.	3
Readiness of Nigeria for the technology	Information on use of alternative fuels for cement in Nigeria is limited, with no indication of implementation in the country.	0

3. Direct casting

- Introduction

This is a main technology utilized in the iron and steel industry where iron and steel products are

[149] Ali Naqi and Jeong Gook Jang (2019), "Recent Progress in Green Cement Technology Utilizing Low-Carbon Emission Fuels and Raw Materials"

made based on moulds to shape the molten metal.[150]

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The iron and steel industry is the second highest GHG emitting industry in the IPPU sector accounting for 46.4% of emissions in the sector. This technology is an option to contribute to reduced emissions in the sector. It is also worth considering that emissions from industrial processes and other product use (IPPU) sector is the least emitting sector for Nigeria contributing only 5.3% of total GHG emissions.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	Direct casting is not mentioned in any of key policies or priorities in Nigeria. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	1
	Improves environmental quality by reducing air pollution from energy savings and less materials used.	
	Social	
	No significant social co-benefit	
	Economic	
	No significant economic co-benefit	
Technological constraints	The technology of direct casting in iron and steel is mature, with major producers such as China, Japan and US using the technology.	3
Readiness of Nigeria for the technology	Information on direct casting in Nigeria is limited, with no indication of implementation in the country.	0

4. Molten oxide electrolysis

- Introduction

Molten oxide electrolysis (MOE) is the process of developing liquid metal from oxide feedstocks, which eliminates the need for coking ovens and blast furnaces as well as reduce carbon intensive processes.[151]

[150] CTCN, "Direct casting for iron and steel sector", Available at: Direct casting for iron and steel sector | Climate Technology Centre & Network
[151] IEA "ETP Clean Energy Technology Guide: Molten oxide electrolysis"

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The technology can contribute in reducing carbon dioxide emissions from the iron and steel sector, which is the second highest GHG emitting industry in the IPPU sector accounting for 46.4% of emissions.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	The technology is not mentioned in any of Nigeria's climate change policies and priorities. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	0
	No significant environmental co-benefit	
	Social	
	No significant social co-benefit	
	Economic	
	No significant economic co-benefit	
Technological constraints	Molten oxide electrolysis is still an emerging technology that is still at the research or development phase.	1
Readiness of Nigeria for the technology	Information on this technology in Nigeria is limited, with no indication of implementation in the country.	0

5. Unhydrated cement recycling

➢ Introduction

Unhydrated cement recycling allows unhydrated cement (which some estimates show that 50% of cement can remain unhydrated) to be recovered and reused as new cement.[152]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	A study suggests that unhydrated cement recycling can reduce carbon dioxide emissions by 2.5 Gt CO_2 annually.[153]This can therefore contribute in reducing emission from Nigeria's cement industry, which is responsible for 53.4% of the aggregated	3

[152] IEA "ETP Clean Energy Technology Guide: Unhydrated cement recycling"
[153] Bellona Europa "How can recycling in the cement and concrete sector contribute to climate change mitigation?"

	emissions from the IPPU sector.	
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	The technology is not identified in any of Nigeria's climate change policies and priorities. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental* The technology can contribute to improving environmental quality by reducing air pollution from the cement making process. *Social* No significant social co-benefit *Economic* No significant economic co-benefit	1
Technological constraints	Unhydrated cement recycling is an emerging technology that is still under development.	1
Readiness of Nigeria for the technology	There is no known case of this technology in Nigeria.	0

6. Advanced grinding technologies

➢ Introduction

In cement production, the griding 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. [154] In this context, advanced griding technologies refer to grinding technologies that are more energy efficient, which includes contact-free grinding systems, ultrasonic-comminution, high voltage power pulse gragementation, low temperature comminution.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This technology has the potential of reducing emissions from Nigeria's cement industry, which is responsible for 53.4% of the aggregated emissions from the IPPU sector.	3
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	The technology is not identified in any of Nigeria's climate change policies and priorities. However, it could contribute to overall goal for CO_2 emission reduction.	1
Consideration of co-	*Environmental*	1

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

benefits (environmental, social, and economic)	The technology can contribute to improving environmental quality by reducing air pollution from the cement making process. *Social* No significant social co-benefit *Economic* No significant economic co-benefit	
Technological constraints	Advanced grinding technologies are still under development and have not been implemented commercially.	1
Readiness of Nigeria for the technology	There is no known case of this technology in Nigeria.	0

7. Metal Roofing Sheets Substitute

➢ Introduction

Clay roof tiles are widely used as exterior building components in different parts of the world. The production process includes clay mining, grinding and mixing with water, extrusion or molding, drying and firing in a kiln. The firing temperature can reach 1200oC with a thermal cycle of 24-48 h from cold to cold. The heating can be provided by biomass, LPG, or electricity. Biomass ash can be added to the clay to improve the properties of the tile including 4oC reduction in indoor temperature with 20% ash addition. Some advantages include better appearance, thermal absorption, while one disadvantage is difficulty in handling. The handling challenges increase the flight cost and makes local production and consumption cost effective.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	A life cycle assessment of a metal sheets house demonstrates greenhouse gas emissions of 456 tons CO2eq. in comparison to 453 tons CO2eq. for terracotta roof tiles. The difference will be much greater with production of clay roof tiles in Nigeria replacing importation of aluminum, stone coated, and zinc roofing sheets.	2
Potential impact on climate change adaptation	Clay is a poor conductor of heat and will regulate the internal temperature of the buildings.	2
Alignment with climate change policies and priorities	The technology is not identified in any of Nigeria's climate change policies and priorities. However, it could contribute to overall goal for CO2emission reduction.	1
Consideration of co-benefits (environmental,	*Environmental* No significant environment co-benefit. Though,	2

social, and economic)	mining and manufacturing of clay roof tiles may lead to local water, air and soil pollution, regulatory measures will reduce the environmental impacts.	
	Social	
	A plant of 8,250,000 pieces annual capacity will employ about 48 people. The technology will create jobs and reduce poverty in the rural areas where the clay is mined.	
	Economic	
	The technology will reduce capital flight, spur local economic activities with the potential for export to other African countries.	
Technological constraints	The technology is used in Europe and Asia (particularly China) for many years. Nigeria has abundant clay.	3
Readiness of Nigeria for the technology	There is evidence online of clay roof tiles marketing in Nigeria but no evidence of it manufacturing within the country. With abundant clay in Nigeria, the potential for the production of clay roof tile is evident.	1

8.3. Construction and manufacturing

1. Shifting to renewable sources for electricity

- Introduction

Moving away from reliance to fossil fuels and shifting to renewable energy like hydro power, solar power etc. for electricity.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This technology is an option to contribute to reduced emissions in the sector, as well as contribute to the renewable energy targets. It is also worth considering that emissions from industrial processes and other product use (IPPU) sector is the least emitting sector for Nigeria contributing only 5.3% of total GHG emissions.	2
Potential impact on climate change adaptation	Distributed renewable energy applications could make the power system more resilient to extreme climate events and not fully dependent on grid status.	1
Alignment with climate	Renewable energy is a key climate and	3

change policies and priorities	development priority for Nigeria, with specific targets of 13GW off-grid RE, of which, 5GW are from self-generation.	
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	A shift toward renewable energy improves environmental quality by reducing air pollution emitted from conventional electricity generation.	
	Social	
	Use of renewable energy is still a greenfield area in Nigeria and has the potential for job creation through skilled & unskilled labour requirements.	
	Economic	
	Resilience of the electricity system through self-generation ensures economic growth and development, especially during extreme weather events.	
Technological constraints	Renewable energy technologies for self-generation such as solar PVs and mini-hydro are widely used.	3
Readiness of Nigeria for the technology	Several small-scale solar for commercial and industrial applications have been deployed in Nigeria.	3

2. Waste Heat Recovery (WHR) system

➢ Introduction

Waste heat recovery system captures and reuses the lost or "waste heat" that is intrinsic to all industrial manufacturing, whereby increasing overall energy efficiency.[155]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This technology is an option to contribute to reduced emissions in the sector. It is also worth considering that emissions from industrial processes and other product use (IPPU) sector is the least emitting sector for Nigeria contributing only 5.3% of total GHG emissions.	2
Potential impact on climate change adaptation	No significant impact on climate resilience	0
Alignment with climate change policies and priorities	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	2

[155] Republic of Philippines, "Technology Needs Assessment Report: Mitigation"

	energy efficient measures. This technology can contribute to meeting these targets.	
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	2
	Improves environmental quality by reducing air pollution emitted from reduced fossil fuel use or use of grid electricity.	
	Social	
	No significant social co-benefit	
	Economic	
	Improvements in energy efficiency have positive macroeconomic impacts, boosting economic activity.	
Technological constraints	WHR is a mature technology and has been successfully implemented in industries within developing countries.	3
Readiness of Nigeria for the technology	There are no waste heat recovery power generation systems installed in Nigeria and no evidence of active marketing by the major players.[156]	0

3. Disaster-resilient Buildings

➢ Introduction

Disaster-resilient buildings refer to buildings that are developed to primarily reduce or avoid the impacts of coastal flooding.[157]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	No significant impact on GHG emission reduction	0
Potential impact on climate change adaptation	Disaster-resilient buildings is critical to a country's population and economy.	3
Alignment with climate change policies and priorities	The construction of climate resilient buildings was identified in the TNC as an adaptation strategy and is in line with Nigeria's National Adaptation Plan Framework.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	2
	No significant environmental co-benefits	
	Social	
	Increased resilience leads to better livelihood and reduced poverty.	

[156] IFC (2014), "Waste Heat Recovery for the Cement Sector: Market and Supplier Analysis"
[157] CTCN, "Disaster-resilient buildings" Available at: Disaster-resilient buildings | Climate Technology Centre & Network

	Economic Increased resilience boosts economic activity.	
Technological constraints	CTCN assessed technology maturity of flood proofing as level of 4-5, with 5 indicating that the technology is fully mature and widely used.[158]	3
Readiness of Nigeria for the technology	While information on disaster-resilient buildings in Nigeria is limited, it is assumed that Nigeria has the potential to implement given the government's priority on adaptation.	1

4. Zero Energy Buildings

➢ Introduction

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".[159] In other words, it "combines energy efficiency and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources over a specified time period".[160]

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Zero energy buildings could contribute to GHG emission reduction. However, its impact could be limited in Nigerian context considering the level of electrification in the country, as well as emissions related to household, commercial and institutional use of electricity.	2
Potential impact on climate change adaptation	Zero energy buildings/houses are more resilient to climate change. Being able to generate electricity on site while using it efficiently, the zero energy building/house are less dependent on electricity supplied from the grid which might be damaged in the case of extreme weather events.	2
Alignment with climate change policies and priorities	Although not specifically indicated in any of the climate change policies and priorities, it can be considered as part of "adapting buildings to reduce the impacts of climate change", which is mentioned in Nigeria's TNC.	1

[158] CTCN "Flood proofing" Available at https://www.ctc-n.org/sites/www.ctc-n.org/files/resources/flood_proofing.pdf
[159] US Department of Energy (2015) "A Common Definition for Zero Energy Buildings"
[160] US Department of Energy "Zero Energy Buildings" Available at https://www.energy.gov/eere/buildings/zero-energy-buildings (Accessed: 29 July 2021)

Consideration of co-benefits (environmental, social, and economic)	*Environmental*	2
	Introducing renewables and using electricity efficiently contribute to improving environmental quality by reducing emitted air pollutants	
	Social	
	No significant social co-benefits	
	Economic	
	The technology has the potential to improve productivity	
Technological constraints	Most technologies associated with zero energy buildings are mature and available in many countries.	3
Readiness of Nigeria for the technology	Even though there are some studies on zero energy buildings in Nigeria, it is still limited.	1

5. Absorption chillers

- Introduction

Absorption chillers rely on the relationship between boiling point of a liquid and pressure. Industrial waste heat is used to providing cooling effect instead of the conventional air conditioning systems. It means cooling effect can be achieved with lower energy consumption

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	This technology reduces greenhouse gas emissions associated with operating air conditioners especially if through fossil fuel. It can rely entirely on waste heat and renewable solar energy.	3
Potential impact on climate change adaptation	The technology provides climate resilience due to global warming	3
Alignment with climate change policies and priorities	Vulnerability of increased temperature is mentioned in Nigeria's climate change policies and priorities. The technology is key to climate resilience.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	2
	The technology could reduce pollution from consumption of fossil fuels in powering conventional air conditioning systems. It uses environmentally friendly chillers including water and lithium bromide as "refrigerants".	
	Social	
	There is no significant social impact	
	Economic	
	The technology could reduce the cost of industrial cooling.	
Technological constraints	The technology is adopted in different countries	3
Readiness of Nigeria for	The technology is not widespread in Nigeria.	0

the technology	Investment in this area will be needed	

6. Shifting to wooden buildings

➢ Introduction

Wood as a building material predates cement in blocks and concrete. In different parts of the wood including Germany, the use of wood in modern buildings has been demonstrated with huge success. Carbon sequestration is the process of capturing and storing atmospheric CO2. An important means of sequestering carbon is through trees. When plant in the form of wood is used in construction, the carbon dioxide absorbed by it during growth period is stored in the wood as long as the building stands. The construction of buildings with more wood and less cement and metal utilizations contribute significantly to carbon sequestration. Wood can replace concrete beams, reinforced concrete slabs, walls, and floors in addition to roofing. Walls can be made of glasses instead cementitious block walls. Wooden building emits about 30% less GHG than concrete building

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The technology sequesters carbon and stores it for decades. When the wood is sourced locally, emissions associated with transportation of building materials are reduced. GHG emissions can be reduced on a displacement factor of 1 ton C02 eq. per ton of wood.	3
Potential impact on climate change adaptation	Wooden houses are less responsive to increased temperature and provide resilience to climate induced heat and makes artificial air conditioning less attractive	3
Alignment with climate change policies and priorities	Promoting climate-proofing of construction and infrastructural development is a key policy statement in the National climate change policy for Nigeria. Carbon sequestration is a key technology to support Nigeria's climate targets.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	The technology reduces pollution associated with sand mining, and stone, steel and cements production. This will increase reforestation and the associated environmental benefits.	
	Social	
	The technology will create more jobs in the rural areas especially in sustaining the supply chain.	
	Economic	
	The technology will support the forestry sector and increase economic activity. Rural communities in forested areas benefit a lot from timber sourcing.	
Technological constraints	The world tallest wooden skyscraper of 85 meters is	3

	in Norway while in Germany a proposal for 98-meter skyscraper featuring 29 floors has been approved. The technology is also popular in Austria, France, and Poland. The share of residential wooden multi-story construction is about 5–6% of all residential multi-story buildings.	
Readiness of Nigeria for the technology	Wood is an integral part of building in Nigeria. There is limited report on largescale modern wooden house.	3

7. Promotion of green roof/wall

➢ Introduction

Green roof and wall are roof top and wall gardens, or different kinds of vegetables employed on modern buildings. A green roof/wall typically consists of several components, including vegetation, growing medium, filter membrane, drainage layer, root barrier and water proofing membranes. Interest in green roofs is growing especially in developed countries including Germany, Switzerland, Denmark, Canada, USA, Singapore, Scandinavia, and Japan. Green facades are based on the application of climbing or hanging plants along the wall while living wall system are based on the application of lightweight and permeable screens in which plants are inserted individually.

➢ Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Energy savings of 63% have been reported in tropical climate. Reduction in CO2 concentration of 0.63% near green walls compared to bar wall has been reported.	3
Potential impact on climate change adaptation	The technology can reduce urban heat wave island effect, provide thermal comfort, and improve microclimatic conditions	3
Alignment with climate change policies and priorities	Carbon sequestration is a key technology to support Nigeria's climate targets.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	3
	Reduces urban heat island, stormwater, enhance air and water quality, urban biodiversity, and pollution associated with the replaced roofing material, improve aesthetic value in urban environment. Experiments show green roof can retain runoff by up to 77.2%, noise can be reduced by about 20 dB while a 1000 m2 green roof can capture dust approximately 160–220 kg per year. Roof leakage is an important challenge of green roof.	
	Social	
	The technology would require a new set of skills in	

	the urban areas and is gender freely	
	Economic	
	The technology could increase value of real estate; year sales figure of green roof application in Germany is worth 254,000,000.	
Technological constraints	The technology is popular in developed countries including Austria, Germany, Hungary, Switzerland, United Kingdom, and the Scandinavia with over 90 million square meters green roof. In Japan, public buildings larger than 250 m2 and private buildings larger than 1000 m2 ae required to green 20% of the rooftop or pay 2000USD annually.	3
Readiness of Nigeria for the technology	The awareness of the technology is increasing among stakeholders. There are no reported applications of green roof and green wall technology in Nigeria. However, most of the materials are available locally and being used for other construction works	1

8. Carbon Offset Scheme (cross-cutting)

- Introduction

Carbon offset is the process of compensating carbon dioxide emissions from human activities through equivalent reduction in the atmosphere. The reduction can come through investing in renewable energy sources (including solar power plant), sequestration of carbon through tree planting or sucking CO2 from the atmosphere. This is done through carbon offset scheme. The emitting companies or institutions provide the funding according to their emissions voluntarily or according to limit set by authorities. Corporate organizations and individuals can make donations towards carbon offsetting. Some offsets project includes renewable energy, methane abatement, energy efficiency, reforestation, and fuel switching. The carbon market is supported by certification programme including Verified Carbon Standard, Puro Standard, Gold Standard, Climate Action Reserve. These companies provide standards, guidance, and requirement. These programs generate carbon offset credits when a project leads to emission reduction or removal activity following programme requirements, methodology, and verification. In 2016, about US$191.3 million of carbon offsets were purchased in the voluntary market. About 36% of S&P 500 companies buy carbon offset with the market estimated to reach $1 bn.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	The technology removes equivalent amount of carbon dioxide emitted into the atmosphere through for example tree planting or afforestation or renewable energy projects.	3
Potential impact on climate change adaptation	Distributed renewable energy carbon offset project could make the power system more resilient to extreme climate events.	3

Alignment with climate change policies and priorities	This is mentioned under “Planned Low Carbon Activities in Nigeria” in Nigeria’s Third National Communication.	3
Consideration of co-benefits (environmental, social, and economic)	*Environmental* Carbon offset programmes including afforestation enhances biodiversity and environmental conservation. *Social* It creates source of income for those buying and implementing carbon credit especially in the rural areas *Economic* The technology could lead to development of the forest related-industry, renewable energy and biodiversity projects.	3
Technological constraints	The technology is being implemented between many industrialized nations and developing countries.	3
Readiness of Nigeria for the technology	There is no record of implementation in Nigeria. The technology requires the institutional framework including laws on minimum allowable carbon dioxide emissions per individual process and the associated credit. The enabling environmental for the implementation of the technology is available in Nigeria.	1

9. Shifting to natural paving stones

- Introduction

Natural paving stones are cut from stones using specialized machines and used in road construction. The use of natural stones in road construction predates bitumen (used as binder in asphalt) and concrete stones. Different types of stones including limestone, slate, and granite are available in Nigeria with very limited commercial application. Natural paving stone can replace concrete stone and asphalt in driveways, cycling and pedestrian route and parking lots. Nigeria imports bulk of its bitumen needs.

- Evaluation of the technologies against criteria

Criteria	Evaluation	Scoring
Potential impact on climate change mitigation/greenhouse gas emissions reduction	Nigeria imports bulk of its bitumen needs. Production and utilization of natural stone for road construction will reduce greenhouse gas emissions associated with importation of bitumen in Nigeria. Electricity and diesel consumption in stone cutting and transportation represent over the 70% of the environmental burden of granite utilization in road construction. This can be reduced through the use	2

	of renewable energy sources.	
Potential impact on climate change adaptation	Natural stones are more resistant to climate induced heavy rainfall.	3
Alignment with climate change policies and priorities	The technology is not identified in any of Nigeria's climate change policies and priorities.	1
Consideration of co-benefits (environmental, social, and economic)	*Environmental*	2
	No significant environmental co-benefits.	
	Social	
	The technology will create jobs	
	Economic	
	The technology will reduce capital flight and spur local economic activities.	
Technological constraints	The technology is popular in Europe and North America. The cutting machines are available in Europe and North America.	3
Readiness of Nigeria for the technology	The use of concrete paving stones is very popular in Nigeria. There is no evidence of active production/cutting of natural stones in Nigeria.	1

9. Summary of list of mitigation and adaptation technologies

Technology	(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	(e) Technological constraints	(f) Readiness of Nigeria for the technology	Total
Agriculture and Land Use: Crop Production							
Agricultural biotechnology	2	2	2	3	2	3	14
Cover crop technology	3	3	3	3	2	2	16
Conservation tillage	3	3	2	3	3	1	15
Climate Smart Agriculture	2	3	3	3	2	2	15
Alternate Wetting and Drying in Rice Production	3	3	2	3	3	3	17
Crop diversification and new varieties	2	3	3	3	3	3	17
Drip Irrigation	2	3	3	3	3	3	17
Integrated Climate Change Monitoring and Early Warning System	0	3	3	3	1	1	11

Rainwater harvesting	0	3	3	3	3	3	15
Integrated Pest Management	2	3	3	3	2	1	14
Soil Moisture Monitoring (SMM) devices	0	3	2	3	3	3	14
Soil moisture conservation techniques	0	3	2	3	3	1	12
Nutrient management: nitrogenous fertilizers	3	2	2	3	2	2	14
Seed and grain storage	0	3	3	3	2	2	13
Seasonal to Interannual Prediction	0	3	2	3	3	1	12
Index-based climate insurance	0	2	2	2	3	0	9
Hydroponics/Soil less Agriculture	0	3	2	3	1	0	9
Aquaponics	0	3	2	3	1	0	9
Agriculture and Land Use: Livestock Production							
Straw ammoniation and silage	3	2	1	3	2	0	11
Manure management	3	1	3	3	2	2	14
Fertilizer management	2	0	1	3	2	1	9

Shifting human dietary needs	2	1	0	3	1	0	7
Enhance farmers' access to micro-credits	1	3	2	3	2	1	12
Selective breeding via controlled mating	1	3	3	3	2	1	13
Livestock disease management	1	3	3	3	2	1	13
Diversification of livestock	0	3	3	3	2	2	13
Livestock feed optimization	3	0	0	1	3	0	7
Agriculture and Land Use: Forestry							
Agroforestry	3	3	3	3	2	2	16
Forest management techniques for mitigation (REDD+)	3	2	3	3	2	2	15
Sustainable forest management	3	2	3	3	2	2	15
Promote sustainably produced wood products	2	0	2	3	2	2	11
Ecosystem-based adaptation	1	3	2	3	2	1	12
Afforestation	2	2	3	3	2	2	14
Energy: Electricity Supply							

Solar PV	3	2	3	3	3	2	16
Concentrated Solar Power (Solar Thermal)	3	1	2	3	3	0	12
Run-of-river hydropower	3	1	2	3	3	3	15
Wind Power	3	1	3	3	3	1	14
Geothermal energy	3	2	1	3	3	0	12
Waste-to-energy (biomass power generation)	3	1	2	3	3	0	12
Co-generation	2	1	2	2	3	2	12
Hydrogen Thermal Power Generation	3	1	1	3	1	0	9
Carbon Capture and Storage	3	0	1	1	1	0	6
Energy Storage System	2	2	1	3	1	0	9
Building Climate Resilient Infrastructure	0	3	0	1	3	0	7
Micro-grid	2	3	3	3	3	3	17
Power to Hydrogen	2	2	1	3	2	0	10
Tidal stream generator	3	1	1	3	1	0	9
Ocean Thermal Energy Conversion (OTEC)	3	0	1	3	1	0	8

Energy: Energy Demand							
Improved Cook Stoves	3	2	3	3	3	3	17
Demand-side management	2	0	2	2	3	1	10
Smart grid	2	0	2	2	2	0	8
Energy: Energy Efficiency							
Energy management systems	2	0	2	3	3	2	12
Energy efficient buildings	2	1	2	2	3	2	12
Energy efficiency standards and labels	2	0	2	2	3	2	11
Dynamic line rating	2	0	2	2	3	0	9
Industry and Commerce: Agribusiness and agro-allied sector							
Modular palm oil mills	3	0	3	3	3	3	15
Anaerobic digesters	3	2	3	3	3	3	17
Industry and Commerce: Solid minerals and metals							
Clinker replacement	2	0	1	1	3	0	7
Use of alternative fuels	2	0	1	1	3	0	7
Direct casting	2	0	1	1	3	0	7
Molten oxide electrolysis	2	0	1	0	1	0	4
Unhydrated cement recycling	3	0	1	1	1	0	6

Advanced grinding technologies	3	0	1	1	1	0	6
Metal roofing sheets substitute	2	2	1	2	3	1	11
Industry and Commerce: Construction and manufacturing							
Shifting to renewable sources for electricity	2	1	3	3	3	3	15
Waste Heat Recovery (WHR) system	2	0	2	2	3	0	9
Disaster-resilient buildings	0	3	3	2	3	1	12
Zero energy buildings	2	2	1	2	3	1	11
Absorption chillers	3	3	3	2	3	0	14
Shifting to wooden buildings	3	3	3	3	3	3	18
Promotion of green roof/wall	3	3	3	3	3	1	16
Carbon offset scheme	3	3	3	3	3	1	16
Shifting to natural paving stones	2	3	1	2	3	1	12