Funded by the European Union

EU Support to Circular Economy, Climate Smart Agriculture and Climate Resilience

Potential of Green Technologies and Digital Innovations to Drive Economic Growth, Job Creation and Environmental Sustainability in Nigeria

October 2024

Contract No. 30008595

ACCI ABUJA CHAMBER OF COMMERCE AND INDUSTRY NIGERIA

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DELEGATION OF THE EUROPEAN UNION TO THE FEDERAL REPUBLIC OF NIGERIA AND TO THE ECONOMIC COMMUNITY OF WEST AFRICAN STATES (ECOWAS)

EU SUPPORT TO CIRCULAR ECONOMY, CLIMATE SMART AGRICULTURE AND CLIMATE RESILIENCE

Potential of Green Technologies and Digital Innovations to Drive Economic Growth, Job Creation and Environmental Sustainability in Nigeria

COWI BE / CYE Consult
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V0 18 October 2024

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ABBREVIATIONS AND ACRONYMS

AI	Artificial Intelligence
CE	Circular Economy
CEA	Controlled Environmental Agriculture
CTIP	Clean Technology Innovation Programme
EU	European Union
EV	Electric Vehicle
GPS	Global Positioning System
IEC	Innovation and Entrepreneur Centre
IoT	Internet of Things
LED	Light Emitting Diode
PPP	Public Private Partnership
RE	Renewable Energy
SME	Small and Medium-Sized Enterprise
WtE	Waste to Energy

EXECUTIVE SUMMARY

This research, commissioned by the EU, was at the suggestion of the Abuja Chamber of Commerce and Industry and will go forward to be validated by a specific workshop in November 2024. The study investigates how digital breakthroughs, and green technology can revolutionise the economy of Nigeria, employment market, and environmental sustainability. The nation has several obstacles to development, such as resource depletion, unemployment, and climate change. As a result, adopting sustainable practices through creative solutions becomes essential. Adopting green technologies will have a significant positive impact on the economy of Nigeria.

Renewable energy sources, such as wind and solar power, can reduce energy costs for homes and businesses while diversifying the energy portfolio and reducing dependency on fossil fuels. It is anticipated that the green economy will expand markets and boost industries including waste management, manufacturing, and agriculture, promoting stability and resilience in the economy.

In Nigeria, the transition to a green economy is predicted to provide millions of jobs. Skilled labour will be needed in industries including eco-friendly manufacturing, sustainable agriculture, energy efficiency, efficient resource management, sustainable waste management and renewable energy.

To solve the high unemployment rates, it will be imperative that the Government, educational institutions, and the private sector collaborate on capacity building, training programmes and partnerships to provide youth with the skills they need for optimising job opportunities. Innovations in the digital sphere are essential for improving environmental sustainability.

The Internet of Things (IoT), Artificial Intelligence (AI), and data analytics are examples of technologies that can optimise resource management, minimise waste, and boost productivity across a range of industries.

Precision farming, for instance, can reduce the amount of water and fertiliser used, digitalisation of the transportation network including access to the transit system and smart grid technology can improve the distribution of energy and efficient movement of people, goods and services.

Nigeria can safeguard the sustainable use of natural resources, prevent the effects of climate change, and preserve biodiversity by adopting these ideas.

Nigeria has enormous potential for digital advancements and green technologies. Nigeria may provide job opportunities, stimulate economic growth, and advance environmental sustainability by making smart investments in these sectors. It is imperative that the Government, commercial sector, and civil society work together to create frameworks and regulations that facilitate this shift and guarantee that Nigeria becomes a leader in the green economy both inside and outside of Africa.

In Nigeria, green technologies reveal a multifaceted landscape with promising opportunities for sustainable development. Renewable energy, notably solar, wind, and biomass, has been identified as a key solution to address the national pressing energy challenges and contribute to reducing greenhouse gas emissions. However, studies emphasise the critical need for supportive policies, investment in infrastructure, and capacity building to fully harness this potential.

Another critical area of focus is waste management, this Study features the significant challenges Nigeria faces in this domain and explores the potential of circular economy approaches as a sustainable solution. Researchers have investigated the use of green technologies such as waste-to-energy, waste as a raw material and recycling not only mitigate environmental pollution but also to generate economic opportunities. The sector is currently being explored in these aspects through innovation and creativity using technology and critical success milestones are being achieved in-country.

FINDINGS

These insights collectively paint a picture of a dynamic field with numerous avenues for progress. While challenges persist, the potential of green technologies to catalyse positive change in Nigeria, particularly in the realms of energy, waste management, and agriculture, is evident. The path forward involves concerted efforts from policymakers, industry, and researchers to translate this potential into tangible outcomes that promote both economic development and environmental well-being.

In the context of the **circular economy,** research illuminates the pivotal role of digital platforms in facilitating waste collection and recycling, thereby streamlining the transition towards a more circular model from the linear economy. By enabling efficient waste management and resource recovery, digital solutions can contribute significantly to reducing environmental pollution and promoting resource efficiency, energy conservation and circular economy. Moreover, the integration of green technologies in waste management and industrial processes holds promise for minimising waste generation and optimising resource utilisation, thereby contributing to a more sustainable and environmentally conscious economic model. Within the **agricultural sector,** findings reveal a picture of digital innovations as powerful catalysts for positive change. Precision farming, powered by data analytics and sensor technologies, empowers farmers to make informed decisions regarding crop management, irrigation, and fertiliser application, leading to improved yields and reduced environmental impact. Smart irrigation systems further optimise water usage, enhancing resource efficiency and mitigating the effects of water scarcity. Moreover, mobile applications offer farmers access to real-time market information, weather forecasts, and agricultural extension services, bridging the information gap and fostering greater agricultural productivity and resilience.

Beyond their individual contributions, the integration of green technologies and digital innovations can amplify their positive impacts on both the circular economy and agriculture. For example, digital

platforms can facilitate the traceability and certification of sustainably produced agricultural products, enabling consumers to make informed choices and incentivising farmers to adopt environmentally friendly practices. Furthermore, the data generated through digital agricultural technologies can be leveraged to optimise resource allocation and waste management within the circular economy, fostering a more interconnected and sustainable approach to production and consumption. The waste management sector is undergoing a dynamic transformation, driven by the urgent need for sustainable practices and the transformative power of digital technologies. This evolution is creating a growing source of green and digital jobs, offering a promising pathway for economic growth, environmental sustainability, and social development. By embracing innovation, investing in skills development, and fostering collaboration, Nigeria can unlock the full potential of its waste management sector and create a cleaner, healthier, and more prosperous future for all its citizens.

The synergy between green technologies and digital innovations in the realm of energy efficiency has the potential to revolutionise the energy landscape. By reducing energy consumption and emissions, improving resource efficiency, and promoting sustainable transportation, Nigeria can move towards a greener and more resilient future. These efforts not only benefit the environment but also lead to cost savings, improved air quality, and enhanced energy security.

Harnessing green technologies and digital innovations presents a compelling pathway for Nigeria to achieve sustainable economic growth and generate substantial job opportunities across diverse sectors. The transition to a green economy holds immense potential for creating a multitude of 'green jobs'. These jobs, encompassing renewable energy, waste management, sustainable agriculture, and other emerging sectors, offer opportunities for a wide spectrum of workers, from skilled technical professionals to unskilled labourers. This shift not only contributes to environmental sustainability but also directly addresses the pressing issue of unemployment in Nigeria.

Overall, the outcome strongly suggests that green technologies and digital innovations can act as key drivers of sustainable development in Nigeria, particularly in the context of the circular economy and agriculture. By exploring these potential and fostering their synergistic application, Nigeria can build a more resilient and environmentally conscious economy, while simultaneously addressing critical challenges such as food security and resource scarcity.

RECOMMENDATION

The findings indicate that Nigeria's partnership with international entities such as the European Union is essential to fully realise the full potential of green technologies and digital innovations for sustainable development. The numerous challenges identified, including policy and regulatory gaps, financing constraints, and infrastructure deficits, emphasise the necessity of a comprehensive and collaborative strategy.

The following are recommendations that can be explored and adopted to enhance achievement of the opportunities identified:

1. Strengthen collaboration with international partners, including the EU, to access climate finance, technology transfer, and capacity building support;

2. Promote international transfer of knowledge and technology that can empower Nigerian stakeholders with the tools and expertise needed to implement and adapt these technologies effectively;

3. Develop collaborative capacity building and skills development initiatives that can equip the Nigerian workforce with the capabilities required to navigate the complexities of the green and digital transitions.

4. Financial support from the Government holds the potential to be a game-changer in overcoming the financial hurdles that often impede the widespread adoption of green technologies and digital innovations in Nigeria

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6. Providing access to funding, can stimulate investment in critical areas such as renewable energy projects, waste management infrastructure, and sustainable agricultural practices. This infusion of capital can enable Nigerian businesses and entrepreneurs to adopt cleaner and more efficient technologies, leading to reduced environmental impact and increased economic opportunities

7. Ongoing policy dialogue and cooperation between the relevant stakeholders can foster a shared understanding of the challenges and opportunities associated with sustainable development. By working together to develop and implement coherent and supportive policies, all entities can create an enabling environment for the flourishing of green technologies and digital innovations;

8. Integrate green technologies and digital innovations into mitigation and adaptation strategies in the National Circular Economy Road Map and the comprehensive National Climate Action Plan

9 Provide financial and tax incentives and support for the adoption of clean energy technologies and sustainable practices

10 Invest in research and development to develop innovative climate solutions tailored to Nigeria's specific needs

11 Strengthen technical assistance and capacity building efforts to equip individuals, communities, and institutions with the knowledge and skills to adapt to climate change and utilise green technologies effectively

12 Raise public awareness about the impacts of climate change and the benefits of green technologies and digital innovations

13 Participate actively in international climate negotiations and initiatives to promote global action on climate change.

In conclusion, this review highlights a compelling case for collaboration between relevant stakeholders including the EU and Nigeria in the realm of green technologies and digital innovations. By leveraging their respective strengths and resources, both entities can unlock the transformative potential of these technologies and forge a path towards a more sustainable, inclusive, and prosperous future for Nigeria.

1 Overview of Global Trends in Green Technologies and Digital Innovations

1.This research, commissioned by the of the Abuja Chamber of Commerce and will go forward to be validated by a workshop in November 2024.

2. Nigeria, Africa's most populous nation and largest economy, faces the dual challenge of fostering economic growth and ensuring environmental sustainability. This research aims to explore the potential of green technologies and digital innovations to address these challenges, particularly in the context of the circular economy and agriculture. The Study will analyse the opportunities and challenges associated with these technologies, identify barriers to adoption, and provide policy recommendations for the Nigerian Government and EU stakeholders.

3. It has the potential provide valuable insights into role of green technologies and digital innovations in promoting sustainable development in Nigeria. The findings and policy recommendations can inform decision-making by the Federal Government and EU stakeholders, leading to increased investment in green technologies, improved environmental outcomes, and enhanced economic growth and job creation. The potential of green technologies and digital innovations to serve as catalysts for economic growth, job creation, and environmental sustainability in Nigeria will be a central focus.

4. There has been geometric rise in world population over the last few decades resulting in increased agricultural activities, urbanisation and industrialisation culminating in severe and detrimental impacts on the environment. With a 1^{O}c rise in global atmospheric temperature leading to a phenomenon known as climate change, there is the need for a global approach to sustainable environmental protection strategies, biodiversity preservation and management of natural resources.

5. The global needs: clean energy, feeding the rising human population (access to safe and quality food at all times) continues to rise, yet the agricultural sector appeared to be most vulnerable to climate change (Henri-Ukoha, 2019). According to UNCTAD (2021) more than 690 million persons are estimated to be exposed to hunger globally. The global food crises may worsen as the world population has been estimated to rise above 9.8 billion by 2050 (Trendov et al., 2019). Increasingly, the need for universal access to quality health services and strengthened healthcare systems, that are pandemic-prepared becomes an imperative.

6. Furthermore, the need for global access to safe and clean water cannot be undermine. To have a peaceful world, social justice and equity, Inclusive growth where wealth is distributed equitably among all, there is the need for job creation among different strata of the society. No society can grow beyond the limits of its educational system, therefore, the need for equitable quality education and skill development among the citizen should attract greater premium.

7. The global needs highlighted above cannot be achieved without the incorporation and adoption of advance sustainable eco-friendlier technologies.

8. To live up to the expected global need for clean energy, climate resilience, food security, vibrant education for all, vibrant health care services and stable economy, several transformative green technologies and digital innovation approaches have evolved. These technologies have stimulated economic growth, environmental benefits, improved energy efficiencies, enhanced resilience and adaptability, innovation and competitiveness, health improvements, social equity and global collaboration.

9. There is a need for a comprehensive mapping of the current state of green technologies and digital innovations in Nigeria, encompassing the identification of key players and an assessment of adoption levels and impact across diverse sectors.

10. The combined effect of financial and technical assistance can act as a powerful catalyst, attracting further investment from both domestic and international sources. The demonstration of successful projects and the establishment of a favourable investment climate can create a positive feedback loop, fostering a thriving ecosystem of green technologies and digital innovations.

11. The potential of green technologies and digital innovations to serve as catalysts for economic growth, job creation, and environmental sustainability in Nigeria will be a central focus. The research goes beyond mere potential, delving into real-world examples and case studies to illustrate the transformative power of these technologies.

12. The key areas where green and digital innovations have brought significant transformation include

(a) Digital Agriculture

13. Leveraging technology in agriculture has significantly enhanced productivity, profitability, and sustainability, through optimisation of resource use and better adaptation to climate challenges.

(i) Precision Farming: This is a data-driven modern agricultural practice which involves the use of technologies such as Global Positioning (GPS), sensors, drones and satellite imagery. Its operations require software and hardware integration to collect real time information on soil, crops, and weather conditions on ground, aerial and satellite spatial levels (Sishodia et al., 2020). Data-driven decisions are made on the use of farm inputs and farm operations such as fertilisers and pesticides applications and irrigation scheduling (Erion et al., 2022). Precision agriculture has the benefit of improving crop yields and assisting agricultural management decisions using high technology sensor and analytical tools. The overall benefits include prevention of wastage, early warning signs, timely interventions and reduction of agricultural sector vulnerability to climate change.

(ii) Vertical Farming: Vertical Farming and Controlled Environment Agriculture which involves growing crops in stacked layers indoors using LED lighting and controlled climate conditions, is gaining traction, especially in urban areas. Hydroponics and aeroponics are soil-less farming techniques where less water is used and allows for year-round crop production in controlled environments. LED lighting innovations. Energy-efficient LED lights are used to simulate sunlight, optimising plant growth and reducing energy consumption. These soil-less farming techniques use nutrient-rich water solutions (hydroponics) or mist (aeroponics) to nourish plants. They minimise water use and eliminate the need for soil, reducing pests and diseases and encourages automation and AI, robotic systems for planting, tending, and harvesting crops. AI algorithms optimise environmental conditions and resource use, enhancing productivity and reducing labour costs.

(iii) Biotechnology and Genetic Engineering: The transfer of genetic material of a desired trait into another organism has arrived as an emerging tool at attaining food sustainability (Biotechnology). Breeding tools which include CRISPR gene editing,

marker-assisted selection, tissue culture, in-vitro mutagenesis and genetic transformation have assisted tremendously in improvement programmes such as bio fortification, development of pests and diseases resistance and abiotic stress-tolerant crop varieties (Bouis, 2011; Babar et al., 2015).

Genetically Modified Organisms, a product of genetic engineering, continue to play a significant role at crop productivity and reducing reliance on chemical inputs. Weed control had been made more simple and more efficient through genetic engineering such as in glyphosate-resistant (Dill, 2005). Rubisco engineering methods have been used to enhance yield of cereals (Ogbaga, 2018).

Early maturing and high nitrogen use efficient rice have been developed using OsDREB1C gene (Wei, 2022). Insect-resistant transgenic plants have been developed across different crops to combat insect pest damage (introgression of Bacillus thuringenesis, bacterium genes) a remarkable achievement in agricultural biotechnology. Golden Rice is an example of genetically-modified rice which is capable of bio-synthesising beta-carotene (precursor to vitamin A) valuable for tackling the problem of malnutrition within the population.

(b) Sustainable Transportation

14. Leveraging technology, cities and businesses can reduce their carbon footprints, improve air quality and enhance the overall efficiency of transportation.

(i) Electric Vehicles (EVs): There has been a surge in EV technology and adoption driven by improved infrastructure and better battery technology. Presently, China has the leading market in EV other players include, Norway, Germany, United States of America and others.

(ii) Mobility-as-a-Service: Digital platforms integrating various transportation modes are promoting sustainable commuting options. The shift by these countries is governed by a combination of government policies, technological advancements, and changing consumer preferences.

(iii) Smart Traffic Management and Transit Access: Investing in and expanding public transport systems can reduce reliance on private vehicles, leading to decreased congestion and emissions. Digital innovations can further enhance the efficiency and appeal of public transportation. Real-time tracking and scheduling apps can provide commuters with accurate information, improving the overall experience. Additionally, digitalised traffic management systems can optimise traffic flow, reducing congestion and emissions. Digital platforms can facilitate ridesharing and carpooling, encouraging shared mobility and reducing the number of vehicles on the road.

(c) Circular Economy

15. Green and digital innovations are pivotal in driving the transition to a circular economy. By leveraging technology and sustainable practices, businesses and communities can minimise waste, optimise resource use and foster a more sustainable business model.

(i) Waste Management Sector has recorded many breakthroughs as there has been increased focus on recycling and reusing materials, production of biodegradable materials and adoption of waste-to-energy technologies such as pyrolysis, incineration and gasification.
Closed-loop systems where livestock and crop production are being integrated to recycle nutrients and reduce external inputs (Owais, 2018) and manufacturing industrial waste serves as raw material for other production processes.

(ii) Water Resource Management: a crucial concern in a changing climate, also stands to benefit immensely from digital innovation. Smart irrigation systems, powered by sensors and data analytics, can optimise water usage in agriculture, ensuring efficiency and minimising waste in the face of increasingly unpredictable rainfall patterns. Digital platforms can further empower communities to conserve water and manage this precious resource effectively, promoting sustainable practices and reducing the risk of water scarcity.

(iii) Resource Optimisation: Efficient use of the energy, resources and raw material for production to valuable materials as well as incorporating recycling and re-use models in the process, contributing to a more sustainable and resource-efficient economy.

(iv) Waste Management Platforms: Digital platforms can facilitate waste collection, recycling, and trade opportunities, connecting waste generators with recyclers and creating transparency in the waste management process.

(v) Product Lifecycle Tracking: Digital technologies can enable tracking of products throughout their lifecycle, promoting responsible production and consumption and facilitating recycling and reuse.

(vi) Circular Economy Marketplaces: On-line marketplaces can connect buyers and sellers of recycled and re-purposed products, creating new markets and economic opportunities for the waste value chain.

(d) Green Building Technologies

16. There has been rapid surge in adoption of smart building systems for energy efficiency such as; Energy-Efficient HVAC Systems, Photovoltaic (PV) panels for electricity and solar thermal systems for water heating. Green Roofs and Living Walls, Smart meters, LED Lighting and the use of eco-friendly building materials (smart materials) such as recycled steel, bamboo, reclaimed wood, and low-volatile organic compound) paints and finishes.

(e) Renewable Energy Integration

17. Energy use is fully optimised such that renewable energy solutions are fully integrated into the energy system to reduce emissions. Irrigation has been achieved with fuzzy logic and cloud technology using solar panels assembly (Sudharshan et al., 2019). Solar dryers (for drying), thermal energy for storage (Qu et al., 2022). Solar energy propelled tractors (energy from solar cells from solar radiation) (Vogt et al., 2018), vapour compression cycle derived from photovoltaic panels for refrigeration (Fekadu and Subudhi, 2018), while seed sowing machine operating on a certain radio frequency (powered with solar energy) (Devaraj et al., 2020). The monitoring/ regulating systems (using principles of precision agriculture), wireless sensor networks, IoT are powered with energy derived from solar-powered prototype nodes (Sadowski and Spachos, 2018).

(f) Climate Tech Innovations

18. Carbon Capture and Storage technologies developed to capture CO2 emissions from industrial processes while exploration of large-scale interventions to counteract climate change, such as solar radiation management (Geoengineering Research) have evolved.

(g) Digital Health Platform

19. There has been a promising solution to the escalating burden of climate-sensitive diseases by enabling the collection and analysis of health data. These platforms can facilitate the early detection of disease outbreaks, enabling timely and targeted interventions. This proactive approach reduces the strain on healthcare systems and protects vulnerable populations from the adverse health impacts of climate change through efficient and timely access to healthcare facilities.

1.1 Current State of Green Technologies and Digital Innovations in Nigeria

20. The application of green technologies in Nigeria is rapidly evolving, though some of these technologies are not totally new especially in the agricultural sector. These technologies enhance agricultural productivity, farmer's profit, environment friendly and highly sustainable. There has been increasing traction in the utilisation of solar resources in Nigeria through off-grid solar solutions. Nigerians access to electricity had increased significantly generally, and more specifically on solar energy.

(a) Improved Agricultural Practice

21. The state of green technologies and digital innovations in agricultural practices in Nigeria is still at the early stage, however there is a drive for quick intervention driven by a need for sustainable food production and improved efficiency.

(i) Sustainable Farming Practice: There has been increase adoption of many agro friendly practices among Nigeria farmers. Such practices which help to enhance biodiversity, soil health, and resilience to climate change include mixed farming, organic farming crop rotation, Zai pits, agroforestry and integrated pest management practices.

(iii) Genetic Engineering and Biotechnology: Advancement in genetic manipulations through conventional breeding procedure and biotechnological tools has led to the enhancement of crop nutrition, crop and animal productivity and tolerance to environmental stressors e.g., Tela maize.

(iv) Irrigation Technologies: The adoption of drip and sprinkler irrigation systems and water harvesting are growing among farmers in Nigeria as the need to feed the rapidly growing population in the face of increasing impact of climate change increases.

(v) Waste-to-Fertiliser Initiatives: There has been rapid evolvement of several projects concerning conversion of organic waste to fertiliser. Waste Management and Recycling Waste-to-energy projects are being developed in cities such as Lagos to convert municipal waste into energy by the establishment of Waste-to-Energy Plants (incineration and anaerobic digestion processes).

Landfill Gas Recovery; captured methane generated from decomposing waste in landfills are converted into electricity or used as a fuel source. These recycling initiatives are also growing, particularly for plastics and e-waste.

The use of digital technologies in agriculture is gradually evolving and still at an early s**tage in Nigeria (Farayola, et al., 2020)**

(b) Public Transportation

22. Nigeria's public transportation system is gradually embracing green technologies and digital innovations, contributing to more sustainable and efficient urban mobility.

(i) Bus Rapid Transit Systems: Expanding and improving these systems has offered a more efficient and reliable public transportation, reducing reliance on private vehicles. This requires investment in dedicated bus lanes, modern buses, and integrated ticketing systems. The Lagos system is being expanded to cover more routes and improve service quality.

(i) Electric Vehicles (EVs): Electric buses and trains are at the forefront of this transformation, offering zero-emission transportation and reduced noise pollution. Advancements in battery technology are increasing the range and affordability of EVs, making them a viable option for public transit in Nigeria.

(ii) Intelligent Transportation Systems: these systems such as GPS tracking, google maps, traffic monitoring systems, and adaptive traffic signals, has optimise traffic flow, reduce congestion, and improve the efficiency of public transit operations. Also, the introduction of Uber, Bolt and In-drive has created better access to transportation services with tracking services to enhance the security of the transport service.

(iii) Rail Networks: Nigeria is currently in a state of rapid ongoing development and challenges in the rail system and networks in Nigeria. There has been the shift from narrow gauge to standard gauge. Modern trains with improved safety features, comfort, and speed are being procured to replace aging stock. Modern rail operations are increasingly incorporating digital technologies, such as GPS for real-time tracking, automated ticketing systems and online booking. The recently-launched red lines and blue lines in Lagos have been able to link long-distance transit networks effectively thereby reducing commute time, eliminating carbon emissions and easing the stress on passengers by providing a comfortable and reliable means of transportation

(c) Mobile Technology and Data Services

23. There has been significant growth and innovation, in Mobile Technology and Data Services in Nigeria, the success observed could be attributed to rapid expansion of the telecommunications sector.
(i) Nigeria has the highest mobile penetration in Africa with over 200 million mobile subscriptions, this widespread adoption has facilitated access to communication and information.

(ii) There is high digital inclusion of Nigerians because of high smartphone growth, because of availability and affordability thereby facilitating increase internet access which has enable a range of mobile applications and services.

(iii) Major operators such as MTN, Airtel, Glo, and 9mobile dominate Nigeria market. The Mobile Network Operators continue to invest in infrastructure to improve coverage and service quality across Nigeria.

(iv) High mobile phone penetration using voice calls and SMS-based services facilitate enhances improved access to real-time weather data, market prices and extension information dissemination services.

(v) Digital innovations has facilitated the emergence of Mobile Health (mHealth) Solutions and Telemedicine Platforms where consultations have been made remotely, via video calls and messaging connecting healthcare providers with patients. Such platforms include DoctorNg, MyClinic.

(d) Digital Payment Systems and Financial Technology (Fintech)

24. Fintech is making access to credit easier; Nigerians now receive payment and transactions using financial technology platform such as Moniepoint, Opay and others. These platforms have assisted tremendously in cashless economy and promote financial inclusion

(e) E-Commerce and Market Linkages

25. The use of online E-commerce platforms such as Jiji and Growsel have provided direct link and virtual trading platform between sellers and buyers locally and internationally while eliminating the activities of intermediate brokers

(f) Smart Grids

26. Smart grids can optimise energy distribution, balancing supply and demand, and integrating renewable energy sources into the electricity grid. This ensures a reliable power supply for electric vehicles and enhances the efficiency of the entire transit system. The electricity distribution in Nigeria has been enhanced with the use of pre-paid meter where energy can be utilised on a pay-as-you -go service; this has further enhanced the efficient management of the distribution and the payment system.

(g) Technological Innovations in the Waste Management Sector

27. The use of technology to enhance the waste management value chain has improved the sector and provided more visibility and traceability of material collected, sorted and transported for processing and recycling. The use of waste collection apps such as PAKAM, Trashcoin, WasteBazaar and Trashpays serve as a service provider for individuals to access waste collection and recycling services close to their location. The recent launch of locally designed Reverse Vending Machine in Abuja serves as innovative approach where waste has become a currently and individuals can get incentives for segregating their waste and taking to the waste “ATM Machine’ in exchange for a voucher with cash awards. Other platforms such as the Dutch sponsored Circularly in Nigeria serve as a marketplace for trading of waste

1.2 Opportunities and Challenges for Nigeria to leverage Green and Digital

28. Significant opportunities exist in leveraging green technology and digital innovations in Nigeria, as indicated below:

(a) Rich Natural Resources

29. Nigeria is endowed with abundant natural resources which include sunlight and wind resources. The rich renewable energy source (solar and wind) has immense potential for sustainable bioenergy for socio-economic and agricultural productivity for Nigerians, if fully explored. Nigeria has a landmass of 923,768 km2 and being sited near the equator, has an impressive solar energy resource that ranges between 3.5–7.5 kWh/m2/day (145.83–312.50 Wm2) (Figure 1)
30.

(Toğrul et al.,2000), 1770 thousand TWh/year (Ohunakin et al., 2014). The Northern part of Nigeria has higher radiation compared to the Southern areas (Agbo et al., 2021).

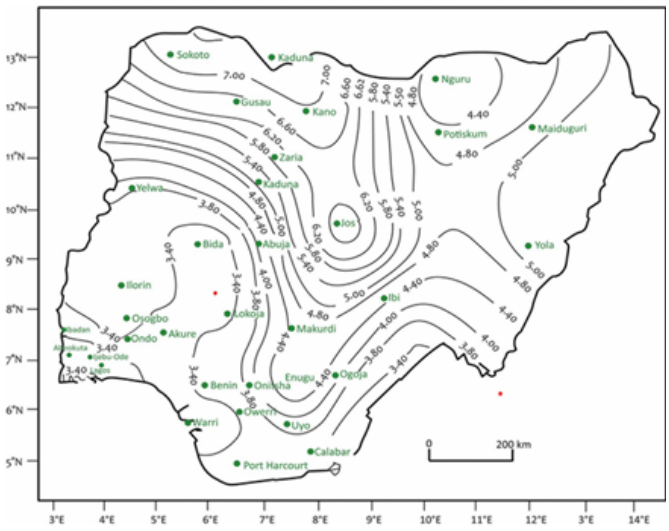
31. Similarly, the nation has great potential in the onshore and offshore wind potentials which have not been fully explored. Reports from NIMET, (2009) and Ahmad, (2016) showed that some states in the Southern part of Nigeria (Lagos through Ondo, Delta, Rivers, Bayelsa to Akwa Ibom) have great prospect for harvesting (offshore) strong wind energy throughout the year (Figure 2). While onshore high wind speed is prevalent in Jos, Katsina and Maiduguri in the Northern part of Nigeria amidst condition such as topography and roughness of surfaces. Considering the rising population growth and increasing demand for energy, there is the need to tap into these abundant renewable natural resources (solar radiation and wind).

(b) Youthful Population

32. According to National Population Commission 2019 data, Nigeria has 60% of population below 25 years of age. Young people account for a significant portion of users (Internet World Stats, 2021). Nigerian youth digital presence can be attributed to proliferation of affordable smartphones and the surge in internet connectivity (Olafare & Hamsat, 2024). Nigeria youths are generally tech-savvy and always ready to adopt new technologies. Dramatic expansion of Nigerian youth footprints present tremendous opportunity for digital agricultural transformation in Nigeria, if adequately harnessed.

(c) Growing Tech Ecosystem

33. Lagos is the only African city ranked in the Global Top 100, Startup Ecosystems (2023), while out of seven tech unicorns identified in Africa, five are from Nigeria. The technology industry has made significant contributions to the Nigerian economy, driving economic growth, job creation, innovation, entrepreneurship, and Financial Digital Innovation. An emerging start-up scene is focused on fintech, agritech, and clean tech, attracting investment and fostering innovation.



(d) Increasing waste generation

34. Nigeria with a population of over 230 million people have a potential for a geometric waste generation which serves as a resource for circular economy if extensively explored. According to the World Bank, Nigeria currently generates at least 32 million tonnes of solid waste annually, and this number is projected to rise to 107 million tonnes by 2050 with a Daily per capita waste generation rate in Nigeria is around 0.79 kg/person/day. The mining of the waste generated for resource use can serve as raw material for other industries through green technology such as use of organic component for biogas, fertilisers and animal feed and the use of the inorganic for recyclable material to keep the resources in circulation. This has a huge potential to contribute significantly to the economy.

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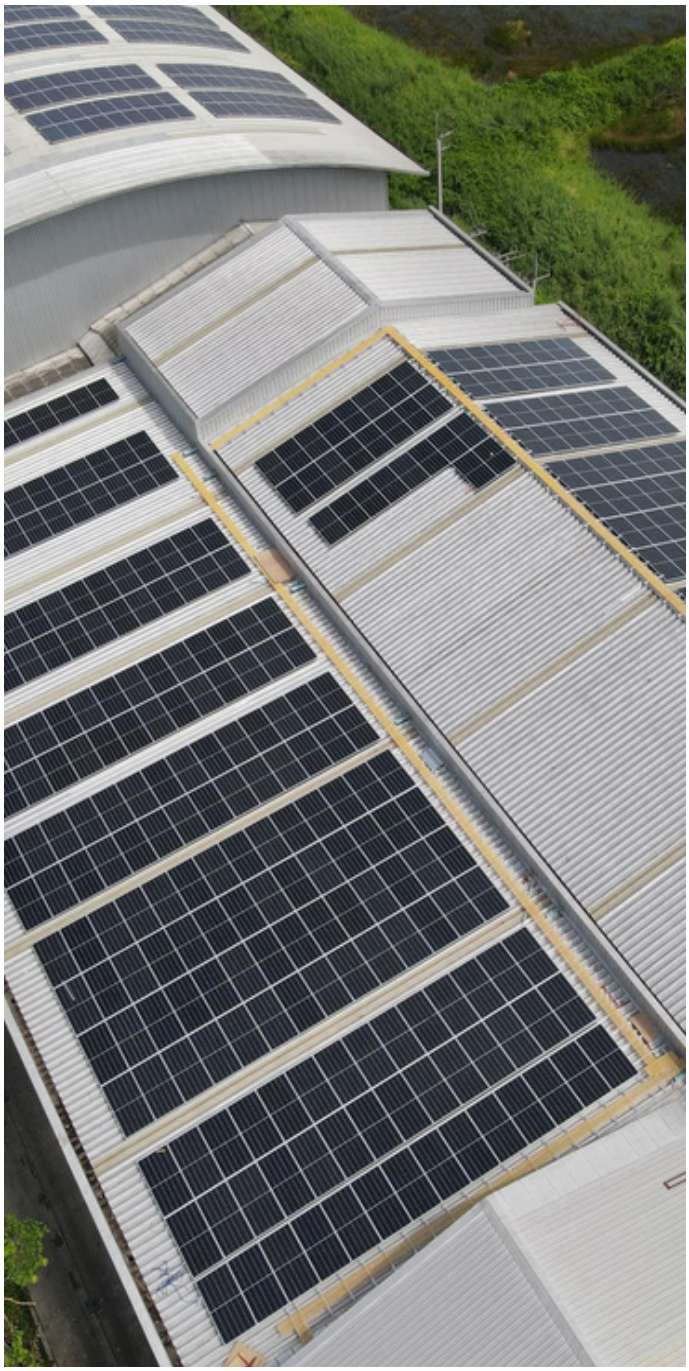

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(e) International Support

35. Nigeria has access and enjoys global funding and partnerships aimed at climate change mitigation and sustainable development from the International Communities such as EU-Nigeria (Support on Circular Economy, Climate Change Agriculture and Climate Resilience).

((f) Policy Framework

36. There has been increasing Government focus on renewable energy and sustainability, Digital technology through initiatives and policies supporting Green Tech and Digital Innovation Adoption in Nigeria as provided by Government agencies, ministries and parastatals such as, National Information Technology Development Agency, Nigeria Digital Agriculture Strategy, Nigeria Smart Initiatives Policy Framework, Federal Ministry of Agriculture and Food Security and the Federal Ministry of Environment.

(g) Digital Transformation

37. There is huge and rapid expansion rate in the access to the internet and mobile technology by Nigerians. Presently, "Nigeria ranks eleventh in internet penetration and seventh in mobile phone usage globally"-NCC (Premium Times, 2024). This knowledge base can facilitate the anticipated green tech and digital transformation of Nigeria agricultural system. According to Malabo Montpellier Panel Report (MMPR, 2019), Nigeria was considered to have prospective robust supporting sphere for digitalisation in agriculture with a score of 4.5 out of 9 in the World Banks' Ease of Business in Agriculture (EBA), Information and Communications Technology (World Bank, 2019) as well as access to affordable phones and mobile-specific taxation (Global System for Mobile Communications (GSMC, 2019)).

38. Significant challenges exist in introducing or scaling up green and digital technology in Nigeria as indicated below:

(a) Air Pollution from Organic Manure

39. Bulkiness and cost of transportation has appeared as a major limitation to organic farming.

(b) Lack of Technical Know-How

40. Most innovations in green technologies require some level of literacy which are lacking among most Nigerian farmers and waste pickers because the sector is majorly informal. So also, skilled workers and professionals in the areas of data science, AI, and machine learning are lacking.

(c) Economic Dependence on Oil

41. A heavy reliance on oil revenue can slow the transition to sustainable alternatives and create resistance to change

(d) Policy and Regulatory Barriers

42. Certain part of the laws, regulations and Government policies may constitute hindrance or complicate the successful introduction, implementation, or scaling of innovation and growth in green and digital technologies. Some of these may include:

(i) Lack of Comprehensive Policy Framework: Absence of a clear and consistent policy framework for green technologies and digital innovations can create uncertainty and discourage investment.
(ii) Regulatory Hurdles: Complex and inconsistent regulatory environments can deter investment and innovation in green sectors.

(iii) Inconsistent Implementation and Enforcement: Even when policies exist, their implementation and enforcement can be weak, leading to a lack of confidence among investors and technology developers.

(iv) Limited Incentives and Subsidies: Inadequate financial incentives and subsidies for adopting green technologies and digital innovations can make them less attractive compared to traditional alternatives.

(e) Economic and Financial Barriers

43. Access to adequate funding and associated market risk may be linked to poor scaling up of green and digital technology in Nigeria: These include:

(i) High Upfront Costs: Green technologies and digital innovations often require significant upfront investments, which can be a barrier for individuals, businesses, and communities with limited financial resources. Initial cost for installation of solar energy (cost of panels and other accessories) and cost of digital tools, software and gargets could make these technologies inaccessible to many.

(ii) Limited Access to Finance: Access to affordable financing options, such as loans and grants, can be challenging, particularly for small and medium-sized enterprises (SMEs) and start-ups. Funding gaps due to limited access to capital for startups and projects focused on green tech can slow down progress.

(iii) Perceived Risks and Uncertainties: The perceived risks and uncertainties associated with new technologies can deter investment and adoption, especially in sectors with low-profit margins.

(f) Social and Cultural Barriers

44. These are obstacles arising from societal norms, values, beliefs, and behaviours to the acceptance and adoption of new technologies or practices. These include:

(i) Lack of Awareness and Understanding: Limited awareness and understanding of the benefits and potential of green technologies and digital innovations can hinder their adoption.

(ii) Public Awareness: Low awareness and understanding of green technologies can limit adoption among consumers and businesses.

(iii) Resistance to Change: Traditional practices and cultural norms can create resistance to adopting new technologies, especially in rural and conservative communities.

(iv) Limited Skills and Capacity: The lack of adequate skills and capacity to operate and maintain green technologies and digital innovations can limit their effectiveness and sustainability.

(g) Infrastructural Barriers

45. These are limitations or deficiencies in physical and organisational structures hindering the implementation and scaling of new technologies and services in green and digital technology

(i) **Inadequate Power Supply:** Unreliable/ inadequate power supply can significantly hamper adoption of digital innovations/some green technologies especially in rural areas.

(ii) **Limited Internet Connectivity: Poor internet** broadband connectivity, especially in remote or rural areas, can restrict access to digital platforms and services, hindering the adoption of digital innovations.

(iii) **Lack of Supporting Infrastructure:** The absence of adequate infrastructure, such as charging stations for electric vehicles or recycling facilities, can limit the adoption of certain green technologies.

(iv) Infrastructure Deficiencies: Inadequate power and poor transportation infrastructure can hinder the deployment of green technologies.

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(iv) Infrastructure Deficiencies: Inadequate power and poor transportation infrastructure can hinder the deployment of green technologies.

(h) Other Challenges

46. These are other factors that may hinder successful scaling up of green and digital technologies in Nigeria.

(a) Corruption and Weak Governance: Corruption and weak governance can create an unfavourable environment for investment and technology adoption, leading to inefficiencies and missed opportunities.

(b) Security Concerns: Security challenges, such as insurgency and banditry, can disrupt the deployment and operation of green technologies and digital innovations.

(c) Global Market Dynamics: Fluctuations in global commodity prices and trade policies can impact the adoption of green technologies and digital innovations.

1.3 Recommendations/Policy Statements on Green Energy and Digitalisation

47. The following recommendations and policy statements on green energy and digitalisation Technology are noted:

(a) Improvement on present renewable energy policy;

(b) Formulation of appropriate financial system for green and digital technology;

(c) Collaboration on research and development and the willingness by the Government to explore renewable energy source and putting necessary steps to actualise Nigeria vision on renewable energy deployment;

(d) Development of comprehensive data repository for solar energy assessment for easy access for Government, scholars, developers and investors;

(e) Incorporation of renewable energy into the national educational curriculum;

(f) Community sensitisation and awareness should be programmed by the relevant agencies;

(g) An extensive tariff system should be designed by energy commission of Nigeria;

(h) Existing policy need to be tailored towards achieving rapid development on renewable energy system;

(i) Public private partnership engagement on green energy;

(j) Subsidies and incentives from Government for investors and users of green and digital technologies;

(k) Integration of renewable energy sources with digital technology to optimise energy distribution and consumption (smart grids); and

(l) Growth of financial technologies that focus on green investments and sustainable finance (Sustainable Fintech).

2 Sustainable Agriculture and the Digital Transformation Technology

2.1 Role of Digital Technologies in Improving Agricultural Productivity and Sustainability

48. The use of digital technology, though still evolving, is changing the face of agricultural practice in Nigeria, with remarkable successes being recorded across the value chain, such as:

(a) Electronic extension

E-extension systems (tools, software, platforms and devices) provide diverse sources of information. Extension agents could reduce travelling to visit farmers by making use of a combination of voice, text, videos, and internet, to decrease operational costs and increase the rate of interaction with the farmer.

(b) Mobile Applications

Timely access to information via electronic extension (e-extension) services on best farming practice can be made available via combinations of voice, text, videos, and internet, reducing operational cost, reduced physical visits to farmers and increase farmers interaction and decision-making.

(c) Financial Services

Mobile banking (bank products on the phone), through joint ventures between mobile network operators has potential to offer efficient financial services to stakeholders along the agricultural value chain. Providing financial access to farmers at reduced cost and financial inclusion to the un-banked rural farmers. Many mobile platforms facilitate access to microloans and insurance, supporting smallholder farmers in managing risks.

(d) Precision Agriculture

Technologies such as GPS, sensors, and drones provide real-time data on soil health, crop status, and weather patterns, enabling farmers to make informed decisions and optimise resources/inputs. Technologies that monitor animal health and behaviour such as wearable sensors, automated feeding systems, behaviour monitoring cameras, can optimise livestock production and welfare.

(e) Remote Sensing and Monitoring

The use of Satellite Imagery and Drones assist in crop health, soil moisture and pest infestations monitoring which allow for timely interventions and maximising resource inputs. Remote sensing can assist alerts for early warning systems especially for adverse weather conditions or pest outbreaks, informing early decision-making.

(f) Digital Platforms and Market Access

E-commerce/digital marketplaces platforms connect farmers directly with consumers, reducing intermediaries and increasing profit margins. Farmers can access market prices, weather forecasts, and best practice through, improving their decision-making.

(g) Automation and Robotics

The application automation through robotics for important farm operations such as planting, weeding, application of pesticides and harvesting has the potentials to enhance the efficiency of labour by reducing the cost of labour and increase efficiency.

(h) Climate-Smart Agriculture

Digital tools help adaptation in farming to changing climate conditions, improving resilience through data provision on climate trends/crop suitability.

(i) Collaboration and Knowledge Sharing

Digital innovation has potential to engage farmers in knowledge sharing.

2.2 Opportunities for Waste Management and the Circular Economy

49. Leveraging on digital and technology innovation can help to minimise waste emanating from the agricultural sector. Agricultural waste are by-products from various agricultural activities and if not properly manage could lead to environmental pollution. For reference, agricultural waste are classified as follows:

- Crop waste (rice husk, wheat straws);
- Animal waste (animal excreta and dead animals);
- Processing waste (packaging material, fertiliser cans); and
- Hazardous waste (pesticides and insecticides).

(a) Precision Agriculture

Artificial intelligence, machine learning, drones and IoT sensors offers predictive analytic and data driven decisions on crop yield, pest outbreak and optimisation of farm inputs and resources. Waste from excessive application of fertilisers, over irrigation and pesticides could be averted.

(b) Waste Reduction Technologies

Agricultural waste could be converted into biogas (biowaste utilisation) for renewable energy source using anaerobic digester while reducing landfill waste. Similarly, digital platforms can connect farmers to the source of organic waste for compost preparation which would help to enhance soil fertility and reduce the use of inorganic fertilisers.

(c) Supply Chain Transparency

Blockchain technology could be leveraged to minimise food waste by ensuring agricultural products are traced and tracked from the farm to the consumers. Market Access: Producers can be connected directly via digital platforms thereby can connect producers with consumers directly, reducing food waste associated with overproduction and unsold goods.

(d) Resource Recovery

Production of new products: Innovations in technology are employed in the upcycling of resources, producing new products from agricultural by-products such as animal feed from spent grains, biochars and bio-based products.

(e) Nutrient Recycling

Technologies such as composting where organic waste can be composted to create organic fertilisers (recovering nutrients from waste streams can enhance soil fertility without synthetic fertilisers, promoting a circular approach).

(f) Education and Training

Digital technology provides online learning platforms where farmers could be empowered on circular economy principles through training on sustainable and waste management practices.

(g) Community Engagement

Digital technology innovation could present platform for farmers community engagement networks and forums where knowledge on best practices and innovations in sustainable agriculture are shared.

(h) Vertical Farming and Urban Agriculture

Innovations in urban agriculture and vertical farming offer smart systems of agriculture and space optimisation in an urban setting reducing land, water and transportation waste.

3 Financing Green and Digital Innovations

3.1 Financing mechanisms for renewable energy, cleantech, and digital startups in Nigeria

50. As the nation is making significant stride towards growth in the renewable energy, cleantech, and digital sectors, there is the need to deploy Government initiatives, private investments, and innovative funding models and effective stakeholder collaboration to foster sustainable development.

The key financing options available include:

(a) Government Subsidies and Incentives

51. There are quite a number of incentives are available for the adoption of renewable energy in Nigeria, such as;

(i) Nigerian Renewable Energy Action Plan: the Government's strategy put up to increase the share of renewable energy in Nigeria's energy system. Incentives are provided as subsidies for solar, wind, and biomass projects;

(ii) Feed-in Tariff: is Government initiative that ensures fixed payments to renewable energy producers for electricity generated, this mechanism ensures long-term revenue stability for solar and wind energy producers. (Tax Incentives);

(iii) **Solar Power Naija Initiative:** This initiative aims to provide solar power solutions to households and small businesses across Nigeria. Incentives: Subsidised solar home systems and financing options for small-scale solar projects;

(iv) **Nigerian Electricity Regulatory Commission:** Encourage private investment in the renewable energy sector by providing necessary frameworks and regulations. Incentives: Streamlined licensing processes, off-grid renewable energy projects support;

(v) **Energy Efficiency and Renewable Energy Programme:** Promotion of energy efficiency and renewable energy technologies in Nigeria. Incentives: Grants and technical support for renewable energy projects; and

(vi) **National Economic Council Initiatives:** Support initiatives to enhance renewable energy development, especially in the rural areas. Incentives: Financial support for community-based renewable energy projects.

(b) Development Finance Institutions

These institutions provide funding to support Infrastructure and development projects, including renewable energy and cleantech are funded and Examples: African Development Bank (AfDB): Offers loans and grants for renewable energy projects. World Bank: Provides financing through programmes such as the Nigeria Electrification Project.

(c) Crowdfunding

Online funding platform from many individuals, example: Platforms such as Jumpstart Africa and Thundafund facilitate crowdfunding for innovative projects.

(d) Debt Financing

Loans are offer to renewable energy projects and tech startups, by traditional banks and financial institutions.

(e) Public-Private Partnerships

Funding for large-scale renewable energy projects could be accessed through collaborations between Government and private sector can Example: The Solar Power Naija initiative encourages partnerships for solar installations.

(f) International Donor Agencies

Donor agencies provide funding and technical assistance for renewable energy and digital innovation projects. Examples: USAID and UNDP have funded various renewable energy initiatives in Nigeria.

(g) Accelerators and Incubators

Funding mentorship, and resources for Startups are facilitated by business incubators and accelerators. Examples: CCHub Accelerator and FATE Foundation support cleantech and digital startups.

(h) Private Sector Financing

This is available from the industry where funds are earmarked for funding renewable energy or circular economy projects such as use of solar, emission reduction machines and waste management and recycling programmes through their sustainability or the Corporate Social Responsibility programmes.

(i) Climate Funds or Green Financing

At the international level, there are some green finances provided by international development partners or international agencies to support adoption of green technologies such as carbon trading funds, carbon or plastic credits funds, green bonds etc.

3.2 Potential Roles of Public & Private Sectors Catalysing Investment in Green & Digital

52. The potential role of the public sector may be framed as follows:

(a) Regulatory /Policy Framework

53. It is the responsibility of the Government to regulate and design clear policies that facilitate investments in green and digital technology.

(b) Funding and Grants

54. The Government can facilitate funding, grants, or low-interest loans to encourage startups and companies focusing on green and digital technologies.

(c) Research and Development Funding

55. Provision of direct funding for Research and Development by the Government is very vital to spur innovation in green and digital technologies.

(d) Public Procurement

56. By prioritising sustainable and digital solutions in public contracts, the Government can create a stable market for these technologies, encouraging private investment.

(e) Infrastructure Development

57. Provision of necessary infrastructure and renewable energy facilities, transportation, digital communication networks are very vital growth to the growth of these sectors.

(f) Capacity Building

58. The role of Government at developing skills through vocational training has the capacity to enhance workforce and industrial growth.

(g) International Partnerships

59. Collaborating with international organisations and Governments can provide access to funding, technology transfer, and expertise in green and digital technology.

60. The potential role of the private sector may be framed as follows:

(a) Innovation and Entrepreneurship

61. Nigerian businesses can drive innovation in green and digital technologies, developing solutions tailored to local needs and conditions

(b) Investment in Start-ups

62. Venture capital firms and private investors can provide crucial funding to startups focused on sustainable and digital solutions

(c) Corporate Social Responsibility

63. Companies can integrate sustainable practices into their operations and invest in local communities to promote environmental awareness and digital literacy

(d) Collaborative Ventures

64. Private companies can engage in partnerships with public entities and Non-Governmental Organisations to share resources and knowledge, enhancing the impact of their initiatives

(e) Market Development

65. By creating products and services that address local challenges, private companies can stimulate demand for green and digital technologies

(f) Consumer Engagement

66. Educating consumers about the benefits of green and digital solutions can drive adoption and increase market demand

(g) Sustainable Production

67. Ensuring that the products put on the market are sustainable and does not contribute to pollution is a responsibility of manufacturers therefore there should be investment is sustainable packaging and the products and its entire lifecycle. They meet with this obligation through the Extended Producer Responsibility model.

(a) Public-Private Partnerships (PPPs)

68. Potential Collaborative Efforts would include:

69. These can leverage the strengths of both sectors to fund and implement projects in renewable energy, digital infrastructure, and sustainable practices.

(b) Joint Research Initiatives

70. Collaborative research projects can lead to innovative solutions that address specific challenges in Nigeria, such as energy access and digital inclusion.

(c) Knowledge Sharing Platforms

71. Establishing platforms for sharing best practice, research findings, and success stories can facilitate collaboration and accelerate investment.

(d) Localising Global Technologies

72. Both sectors can work together to adapt global technologies to the local context, ensuring they meet the specific needs of Nigerian communities.

3.3 Innovative Funding Models and their Applicability

73. Innovative Funding Models include:

(a) Green Bonds

74. These are a type of fixed-income financial instrument specifically designed to fund projects that have positive environmental impacts. The proceeds from these bonds are used exclusively for projects related to renewable energy, energy efficiency, sustainable waste management, clean transportation, and other environmentally friendly initiative. The three biggest issuers of green bond market are the United States, China and France. The Government or private firms could issue green bonds to finance renewable energy projects, such as solar farms or energy-efficient housing. This could attract institutional investors focused on sustainability. Nigeria has started exploring the use of green bonds to finance climate related or circular economy projects through the FMDQ Group which is a financial market infrastructure group warehousing entity.

(b) Microfinance and Cooperative Models

75. Small loans provided to individuals or small businesses, often in cooperative settings. These models can empower local communities to invest in green technologies, such as small-scale solar systems or community-driven digital solutions. Cooperative societies can pool resources to finance projects.

(c) Impact Investing

76. Investors provide capital to businesses with the expectation of both financial return and positive social/environmental impact. Nigeria has a growing interest in sustainable investments, particularly in renewable energy and digital solutions that address local challenges. Impact investors can support

4 Green Jobs and the Future of Work

4.1 Insights on Emerging Green and Digital Job Opportunities in Nigeria

77. Emerging green technologies for job creation and sustainable development in Nigeria include:

(a) Renewable Energy

78. This aspect offers tremendous opportunities to investment in facilities that derive energy from natural sources.

(i) Manufacturing: Establishing local manufacturing facilities for solar panels, wind turbines, and other renewable energy components can create numerous jobs in production, assembly, and quality control.

(ii) Installation and Maintenance: The deployment of renewable energy systems will require a skilled workforce for installation, maintenance, and repair services, creating opportunities for technicians, electricians, and engineers.

(iii) Research and Development: Investing in research and development can lead to innovation in renewable energy technologies, creating high-skilled jobs for scientists, engineers, and researchers.

(b) Jobs in Sustainable Agriculture

79. The trending global advocacy for farming practices that prioritise environmental health, economic profitability and social equity offers jobs / career opportunities in aspects as shown below:

(i) Agroecology: Job opportunities for skilled workers who would implement sustainable farming practices, such as organic farming.

(j) Precision Agriculture: There is a need for skilled workers that would be using technology to optimise farming practices.

(ii) Environmental Conservation and Climate Change: This aspect also offers job/ career opportunities to specialists who will assess climate impacts and develop coping strategies.

(c) Circular Economy Jobs in Waste Management

80. The shift towards sustainable waste management practices is creating a diverse range of green job opportunities across various segments of the sector:

(i) Collection and Sorting: Efficient waste management starts with effective collection and sorting. This involves not only traditional roles such as waste collectors and truck drivers but also specialised roles such as those who operate advanced sorting machinery, utilising optical sensors and AI-powered robotics to separate recyclables with greater efficiency and accuracy.

(ii) Recycling and Resource Recovery: Nigeria is witnessing a surge in recycling initiatives, driven by both environmental concerns and the economic potential of resource recovery. This creates jobs for recycling technicians who specialise in processing different materials, such as plastics, paper, and metals.

It also fuels opportunities for upcycling entrepreneurs who transform waste into valuable products, fostering a culture of creativity and resourcefulness.

- **Plastic Recycling Technicians:** Operating and maintaining machinery for sorting, shredding, washing, and pelletising plastic waste for use in new products
- **Paper Recycling Technicians:** Processing wastepaper into pulp through cleaning, de-inking, and pulping processes for manufacturing recycled paper products
- **E-waste Recycling Technicians:** Safely dismantling and recovering valuable materials from electronic waste
- **Glass Recycling Technicians:** Sorting, cleaning, and crushing glass for reuse in manufacturing new glass containers or as construction aggregate.
- **Metal Recycling Technicians:** Sorting and processing various metals, including aluminium, copper, and steel, for smelting and reuse in manufacturing.
-

(d) Waste-to-Energy

81. Waste-to-energy technologies are gaining traction in Nigeria as a sustainable way to manage waste and generate clean energy. This creates jobs for engineers, technicians, and plant operators involved in the design, construction, and operation of WtE plants. Moreover, it necessitates specialised roles such as process engineers who optimise energy conversion, environmental engineers who monitor emissions, and maintenance technicians who ensure the smooth operation of these plants.

(e) Composting and Organic Waste Management

82. Composting and other organic waste management techniques are being promoted to reduce the amount of waste sent to landfills and enrich agricultural lands. This creates jobs for composting specialists who manage composting facilities, technicians who monitor the process, and agricultural professionals who utilise compost to improve soil health and promote sustainable farming practices.

(f) Environmental Monitoring and Compliance

83. Ensuring that waste management practices comply with environmental regulations is crucial for protecting public health and the environment. This creates job opportunities for environmental monitoring officers who conduct inspections, compliance officers who ensure adherence to regulations, and environmental consultants who advise businesses on sustainable waste management practices.

(g) Opportunity for Digital Jobs

84. As the nation is gradually embracing digital technology, significant opportunities abound for specialists in various field digital innovations: These include:

(i) Software Developers: These are trained professionals who design, create, test, and maintain software applications or systems that run on computers or other devices.

(ii) Cybersecurity Experts: These are professionals who are trained to protect computer systems, networks, and data from cyber threats and attacks.

(iii) Data Analysts and Scientists: Professionals that are involved in data interpretation and analysis and prediction. The assist the organisations to understand trends, patterns and insights.

(iv) Business Intelligence Analysts: professionals who leverage data analysis and visualisation tools to help organisations make informed business decisions.

(v) Search Engine Optimisation and Search Engine Marketing Specialists are digital marketing professionals focused on improving a website's visibility in search engines.

(vi) Content Creators and Social Media Managers: They develop various forms of content, including articles, videos, images, podcasts, and social media posts to engage and inform social media audience.

(vii) E-commerce Managers: are responsible for overseeing and optimising online sales strategies and operations for retail businesses.

(viii) Logistics and Supply Chain Specialists: are professionals who manage and optimise the flow of goods, information, and resources throughout the supply chain.

(ix) Remote Work Coordinators: are professionals responsible for managing and facilitating remote work arrangements within an organisation.

(x) Virtual Assistants: are remote professionals who provide administrative, technical, or creative support to businesses, entrepreneurs, and executives.

(xi) Remote Work Coordinators: are responsible for managing and facilitating remote work arrangements within organisations.

4.2 Strategies for Re-skilling and Up-skilling the Workforce for the Green Economy

85. Re-skilling and Upskilling refers to the process of learning new skills or updating existing ones to adapt to changing job requirements, technologies, or industry demands. Transition of workers into sustainable jobs involves several strategies which include:

- Intensive Awareness Campaigns on green careers;
- Educational Curriculum should be updated to include sustainability and environmental studies;
- Vocational Training Programmes and mentoring that are focused on green skills, sustainable management, waste management and renewable energy should be encouraged;
- Effective collaboration with renewable energy company to accommodate training and apprenticeships;
- Government and private should work out funding to support training programmes and workshops;
- The skill acquisition training should be scaled down to the community level inform of workshops, seminars where local community leaders are actively involved;
- Green businesses should be adequately incentivised (tax breaks or grants), while Startups businesses should receive support inform of funding;
- Adequate funding into green technologies, collaboration among research centres and the universities for innovations and demand driven adaptable technologies;

- All-inclusive skill acquisition training programme and should be tailored towards the needs of marginal groups and the specific need of each group;
- The training should be properly monitored; and
- Sustainable agricultural practices should be promoted.

4.3 Policy recommendations to promote green job creation

86. Policy recommendations to promote green job creation include:
- Intensive sensitisation and awareness and community engagement on green technology;
- Provision of incentives for Investment in green technology (solar, wind, and biomass) inform of tax breaks, grants and subsidies;
- Establishment of reasonable pricing for renewable energy producers to encourage investment and development (Feed-in Tariffs);
- Green jobs and businesses operation should be guided by regulatory framework;
- Integration of sustainability and green skills into the curricula at all levels of education;
- Effective collaboration between public and private sectors on funding and training programmes on green technologies and practices;
- Funds should be created specifically for projects and startups in the green economy (Green Finance Initiatives);
- Research into innovations in green technology should be well funded;
- Sustainable agricultural practices should be supported;
- Policies on waste management and waste recycling should be enforced;
- Effective monitoring and evaluation to track progress of green jobs, while channels for feedback for all stakeholders should be created; and
- Policies on green technology should be inclusive such that will focus on vulnerable groups and gender, supporting women.

5 Green Mobility Solutions for Nigerian Cities

5.1 Electric Vehicles, Smart Transportation, and Sustainable Urban Planning

87. Key findings on electric vehicles (EVs), smart transportation, and sustainable urban planning include:

(a) Electric Vehicles (EVs)

88. The rise in the cost of fossil fuel has greatly inspired Nigerians to consider other available cheaper options. The use and investment in EVs in Nigeria is gaining popularity. Startups such as Stallion Group and GIGM are investing in electric mobility solutions. Similarly, the Government of Nigeria has introduced policies (such as National Electric Vehicle Policy) to promote EV adoption which aimed at reducing over dependency on fossil fuel and reducing carbon emission.

Some challenges to EV use in Nigeria include:

- High initial costs of EVs
- Importation (High forex)
- Lack of charging infrastructure

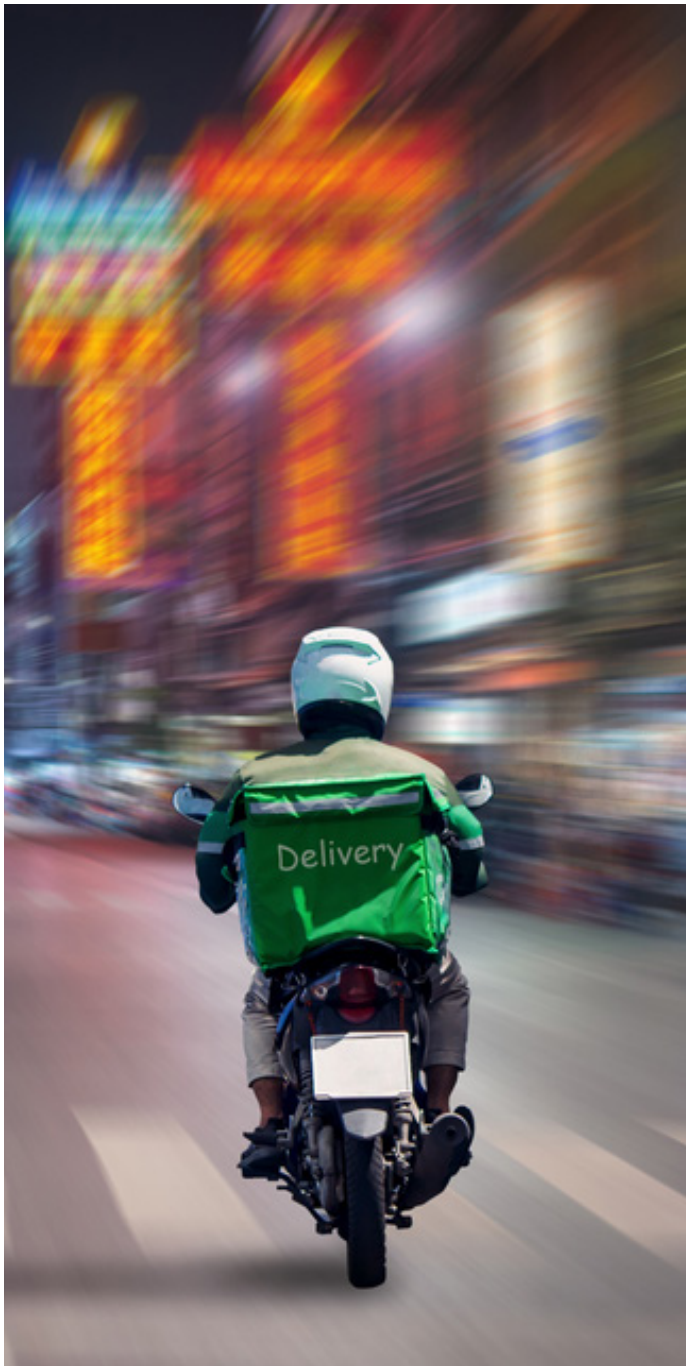
* These challenges also present opportunities for manufacturers of EVs to explore solar-powered vehicles

(b) Smart Transportation

89. Significant success stories have been recorded in the transportation sector following the integration of digital/smart transport solutions such as can be seen in ride-hailing services (e.g., Uber, Bolt) in the urban areas. Traffic management using real-time data analytics to optimise traffic flow is gradually evolving (Lagos State). Challenges do exist such as:

Some challenges include:

- Poor road infrastructure
- Traffic congestion and
- Limited public transport



(c) Sustainable Urban Planning

90. There are sustainable development policies outlined by the Government to promote environmentally sustainable urban growth e.g., National Urban Development Policy. There has been an increasing number of sustainable urban planning initiatives are being adopted, which focuses on integration of green spaces, mixed-use developments, and improved public transportation networks. Similarly, the adoption of climate resilience strategies by some states has indicated some success. Some of strategies have been employed to address flooding and other climate-related challenges, sustainable drainage systems and green roofs have been employed to address flooding and other climate-related challenges.

5.2 Integrating Renewable Energy and Digital Technologies in Public Transport

91. Integrating renewable energy and digital technologies in public transit would greatly contribute to sustainability and the overall efficiency and user-friendly transit and environmentally friendlier transportation systems. This could be achieved by:

- Establishment of Solar-Powered Charging Stations where solar panels are installed at bus stops to generate electricity for charging electric buses, this would assist those in the remote areas and forestall total reliance on the National grid (Off-Grid Solutions);
- Electric and Hybrid Buses: Renewable energy can be used to power electric cars, this help to reduce greenhouse gas emission associated with fossil fuel;
- Alternatively, introduction of hybrid vehicles that uses fossil fuel with electric power would enhance fuel efficiency and lower emissions;

92. Digital Innovation Integration would need to consider:

- **Smart Grids:** Implementing smart grid technologies can optimise energy distribution and management, creating jobs in software development, data analytics, and system integration;
- **Remote Monitoring and Control:** Digital tools can enable remote monitoring and control of renewable energy systems, improving efficiency and creating opportunities for IT professionals and technician;
- **Energy Access Platforms:** Digital platforms can facilitate access to renewable energy for underserved communities, creating jobs in customer service, marketing, and technology development. Contribution to Sustainable Development;
- **Reduced Carbon Emissions:** Shifting towards renewable energy sources can significantly reduce Nigeria's carbon footprint, contributing to global efforts to combat climate change;
- **Energy Security:** Reducing dependence on fossil fuels can enhance Nigeria's energy security and resilience to global price fluctuations; and
- **Rural Electrification:** Renewable energy technologies can provide access to electricity for rural communities, improving living standards and promoting economic development.

5.3 Developing the necessary supporting infrastructure

93. Building the necessary and robust infrastructure to support effective integration of energy and digital technologies would enhance the sustainability, efficiency and user experience in public transit system in Nigeria.

This would involve enabling infrastructure:

- Fast-charging points/stations along major transit routes in urban areas to support electric buses and vehicles should be established;
- Provision of battery swapping station to reduce electric vehicles downtime;
- Solar powered facilities (such as solar panels) should be installed on bus depots and transit hubs to generate clean energy for operations (renewable energy);
- transit infrastructure can also be powered from energy derived from wind energy source especially in the onshore and offshore wind zones in Nigeria;
- The deployment of GPS-enabled tracking systems for buses and other public transit would allow for real-time update or users which can be accessed on the mobile application;
- A unified electronic integrated payment system should be developed for all mode of public transit;

IoT Sensors can be deployed on vehicles and infrastructure to collect data on ridership patterns, vehicle health, and energy consumption;

- To achieve smart traffic management, traffic signals can be optimised by implementing traffic signal systems that adjust based on real-time traffic conditions to minimise traffic congestion;
- To achieve smart traffic management, traffic signals can be optimised by implementing traffic signal systems that adjust based on real-time traffic conditions to minimise traffic congestion;
- To enhance speed and reliability, dedicated lanes should be created for public transit.
- Operate a Public Information Systems with digital displays such that announcements at transit stations to keep passengers informed about schedules and delays;
- Public education on the benefit of technology while workers should be trained on proper use of the technology;
- Install CCTV and security systems at transit stations and on vehicles to enhance passenger safety;
- Emergency Response Infrastructure should be developed for quick response in emergencies;
- Standard and guideline for the integration of digital technology should be developed; and
- The adoption of sustainable transport technology should be incentivised.

6 Entrepreneurship and Innovation Ecosystems

6.1 Successful case studies of green and digital startups in Nigeria

Startups	Function	Impact	Achievements:
Solar Nigeria	Provision of affordable solar energy solutions to under privileged Nigerians, through provision of solar home systems that cater to households with no access to reliable electricity	Low-income families have access to clean energy, improving living standards and reducing reliance on fossil fuels. (Using pay-as-you-go models)	Thousands of solar systems installed, significantly reducing carbon emissions and improving energy access
Paystack **Flutterwave**	Digital Payments Online payment platform for business transaction in Nigeria Financial technology platform for business transactions across Africa. It allow companies to accept payment in multiple currencies	Boosting e-commerce in Nigeria through empowerment of several SMEs Easy cross-border transactions for African businesses and the global markets	Acquired by Stripe in 2020, Paystack has become a leader in the payment solutions space, processing millions of transactions The startup has processed billions in transactions and partners with major companies to enhance payment solutions across Africa
Farmcrowdy	While primarily a digital platform, Farmcrowdy operates in the green tech space by connecting farmers with investors who fund their agricultural projects	Impact: The platform enhances food production while providing investors with returns on their investments.	Achievements: Farmcrowdy has funded numerous agricultural projects, boosting local food production and creating jobs in the agricultural sector
WeCyclers Waste Management	Incentivises recycling through a reward system. They provide a service for households to collect and recycle waste materials.	Promotion of recycling and sustainable waste management practices, Improved environmental sustainability, and job creation in the urban areas. Encourage awareness about waste management.	WeCyclers has diverted tons of waste from landfills and educated communities on the importance of recycling.
Hello Tractor	Provides a platform for farmers to rent tractors and other agricultural machinery through a mobile app	This service enhances productivity by giving smallholder farmers access to essential machinery without the burden of ownership costs. It helps reduce land degradation and promotes efficient farming practices	Hello Tractor has helped increase crop yields and income for farmers, contributing to food security
The Yield	Uses of predictive analytics and big data to provide farmers with weather patterns and crop management	Impact: Helping farmers to make data-driven decisions,	Waste reduction and improved crop yields, enhancing sustainability in agriculture
Wavetra	Innovative recycling technologies for agricultural waste management. They focus is on turning agricultural waste into biofuels and organic fertilisers	Reduce environmental impact while Provision of value-added products to the farmers while reducing negative environmental impacts	Significant contributions to a circular economy model

6.2 Incubators, Accelerators and Support Programmes for Green Entrepreneurs

94. These are initiatives and concept design to nurture entrepreneurs in Nigeria. These include:

(a) Incubators

(i) Green Innovation Hub: This initiative offer supports (mentorship, and technical resources) on renewable energy, waste management and agriculture startups with innovative solutions.

(ii) Nigerian Renewable Energy and Energy Efficiency Project: This offers training, technical assistance and funding opportunities to local startups working on renewable energy solutions.

(b) Accelerators

(i) Clean Technology Innovation Programme: This accelerates the growth of clean tech start-ups by funding, mentorship, trainings and access to markets.

(ii) Greenpreneurs Nigeria: Intervention is on entrepreneur development of sustainable business models through training, mentorship, and funding in agriculture and waste management.

(iii) StartUp Nigeria: The Government initiative that supports entrepreneurs (training, funding, and networking with investors and mentors) with innovative ideas, including green technologies.

(c) Support Programmes

(i) Various Government programmes focusing on providing funding and resources for green projects, such as the Nigeria Energy Support Programme and Nigerian Climate Innovation Centre.

(ii) Non-Governmental Organisation focusing on sustainability can provide funding technical support, training, and access to networks for green entrepreneurs.

(iii) Regular Sustainable and Innovative workshops that educate entrepreneurs on sustainable practices, eco-friendly technologies, and business model innovation.

(iv) Microfinance institutions that offer low-interest loans specifically for green initiatives can help startups overcome funding barriers

(v) Online Platforms for Resources and Networking for knowledge sharing and connection with investors

6.3 Bridging Gap Between Research, Innovation and Commercialisation

95. This is vital for translating scientific discoveries into viable products and services.

- Adequate market research and analysis to determine area of research intervention;
- Feedback mechanism from potential users should be created during the development process;
- Working partnership between the research institution and the industry;
- Advocate for policies that incentivise research commercialisation;
- Establish office for Licensing and Patenting in academic and research institutions to manage intellectual property;
- Researchers should be supported on innovation commercialisation;
- Establish incubators and accelerators that focus on early-stage ventures, providing mentoring, resources, and networking opportunities;
- Facilitate Conferences, Meetups and online platforms where researchers, entrepreneurs, and investors can connect, share ideas and collaborate; and
- Develop Incubators and Accelerators who provide resources, mentoring on early- startups.

7 Policy, Regulations, and Partnerships for Sustainability

7.1 Aligning Policies and Regulations to enable Green and Digital Innovations

96. Adopting these recommendations, policymakers can create a conducive environment for sustainable and digital innovation to thrive.

Some of the recommendations include:

- Reduce bureaucratic barriers for startups and SMEs focusing on green and digital innovations;
- Increase funding and grants for R&D in green technologies and digital solutions;
- Invest in education and training programmes that prepare the workforce for green and digital jobs;
- Incentivise Sustainable Practices such that companies that adopt green technologies or digital tools receive incentives (tax incentives, subsidies, or grants);
- Promote and Invest in digital infrastructure (e.g., broadband access);
- Clear Standards and Certifications should be developed standards for green technologies that encourage innovation;
- Regulations that support recycling, waste reduction, and sustainable product design, should be implemented;
- Establish metrics to assess the effectiveness of policies on promoting green and digital innovations (Monitoring and Evaluation);

7.2 Strengthening Public-Private Partnerships for Sustainable Development

96. Adopting these recommendations, policymakers can create a conducive environment for 97. Strengthening public-private partnerships (PPPs) for sustainable development in Nigeria can significantly enhance the country's ability to address various social, economic, and environmental challenges.

Here are several strategies to foster effective PPPs:

- There is the need to develop comprehensive policies and regulatory framework that would outline the responsibilities and benefits of PPPs;
- Create standard contracts and templates to streamline negotiations and reduce the complexity of forming PPPs;
- The public should be properly educated on PPPs benefits for sustainable development;
- Platform for dialogue on the needs, challenges, and opportunities for collaboration among the stakeholders should be established;
- Public and private sectors have a shared vision and understanding of sustainable development goals to facilitate alignment in projects;
- Capacity building and training programmes for both public and private on managing PPPs effectively;
- Digital platforms should be fully explored for collaboration, information sharing, and project management among stakeholders;
- Digital platforms should be fully explored for collaboration, information sharing, and project management among stakeholders;
- Institutional Frame work can be strengthened by creating sustainable development focused PPP units within Government ministries;
- Provide access to capital and innovative financing; and
- Implement robust monitoring and evaluation frameworks to assess the impact of PPP projects, ensuring accountability and transparency.

7.3 International cooperation and knowledge-sharing opportunities

98. There are many opportunities for international cooperation and knowledge-sharing:

- Global events such as UN Climate Change Conference, International Trade shows and Expos present avenues for dialogue, partnerships, best practices sharing and showcase innovative solutions and technologies;
- Joint Research Programmes and Partnerships between universities and research institutions across countries are very germane in driving innovation in sustainable practices;
- Data Sharing from established databases for climate data, best practices, and sustainability metrics enhances collaborative problem-solving;
- Enhancement of formidable collaboration, sharing of strategies and resources on specific SDGs among countries;
- Knowledge exchange forum for mentoring, experiences and sharing lesson learned in sustainability;
- Exchange Programmes: Facilitate exchanges for practitioners to learn from different cultural and operational contexts;
- Collaborate to align policies that support sustainability goals, making it easier for businesses and communities to implement sustainable practices;
- Advocacy for Global Standards where stake holders work together to advocate for international standards in sustainability that can guide practices across borders;
- Innovative Technologies Sharing: this promote access to sustainable technologies and practices, particularly in developing countries; and
- Open-Source Solutions: Encourage the development and sharing of open-source technologies that can be adapted to local contexts.

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*A Collaboration between the National Policy Advocacy Center(**NPAC**) of*
*The Abuja Chamber of Commerce & Industry(**ACCI**) and the European Union(**EU**)*

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