CHAPTER 11

Technology and Green Tech in Africa

Marvel Ogah

Introduction

Technology holds the key to the future; it has evolved, is still growing, and will continue to meet future needs regarding its adaptation and applications. The technological revolution is geared towards creating radically new opportunities that would ubiquitously impact individuals, organisations, communities, and nations vis-à-vis the yawning need to engage and collaborate in innovative ways. This trend inherent in technology abounds in both developing and developed economies globally. However, a peculiar aspect of this technological evolution and adaptation is its impact on the environment, planet, and humankind. Aside from the effects on other parts of humanity such as work and digitisation, technology has influenced the environment, social, and governance spheres of nations both in the emerging and developed climes in recent times. Most developing countries in Africa have been hitherto contending with the inherent challenges of developing resilient economies through emergent measures such as expanding sustainable energy supply vis-à-vis improving supply

M. Ogah (✉)
Lagos Business School, Pan-Atlantic University, Lekki, Nigeria
e-mail: mogah@lbs.edu.ng

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value chains encompassing raw material sourcing manufacturing, logistics, and distribution hinged on technological advancement towards green technology. However, this striving by African leadership towards green technology and poverty alleviation does not necessarily entail a trade-off but rather constitutes a lead-in to the valuable synergies of keying into evolutionary aspects of technology, barriers, and the drive towards green technology and its long-term implications.

Concept of Technology

Technology has different meanings and connotations to different people in different climes. Some perceive technology as an enabler, others perceive it as an enigma, while others perceive it as a challenge. Thus, the concept of technology is amorphous and ubiquitous in several aspects. For the developed economies, technology is both an enabler and an enigma. In contrast, technology can be perceived and experienced as both an enabler and a challenge (UNIDO/UNU-MERIT, 2014). However, whatever flipside the argument favours, the advantages outweigh the disadvantages in the short and long terms. Technology can be defined as applying science, arts, and mathematical domains to humankind and society (Monu Bhardwaj et al., 2015).

A school of thought posits that technology integrates the physical objects or artefacts vis-à-vis making objects and the meaning associated with the physical objects (MacKenzie & Wajcman, 1985). A different school of thought considers technology a chaotic process with some aspects of disorderliness groups and individuals with diverse views regarding its values and potentials (Gibson & Smilor, 1991). Among other things, this school of thought also asserted that technology has no definitive meaning or value. Based on this line of reasoning, technology and technology transfer concepts encompass many different interpretations and views depending on the organisations' objectives, research background, researchers, developers, users, research areas and disciplines, and underlying perspectives. However, technology implementation entails an inventive process encompassing diverse actors and varied forms of coordination and learning process architecture (UNIDO/UNU-MERIT, 2014).

Technology can either be adopted or diffused. These two aspects of technology are used to describe the decision alternatives either for use or not use, and to disperse the type of technology among economics as

a function of time. However, the options of the adoptive and diffusive characteristics of technology hinged on innovation do not guarantee the successful integration by a body or community as a function of need. According to Rogers (1995), the adaptive nature of technology is hinged on behavioural choice, while its diffusive nature is hinged on a pattern experienced as a function of time. In line with this school of thought, five characteristics of innovation with a tandem impact on its speed of adoption have been identified. These are compatibility, complexity, divisibility, observability, and relative advantage. The adoption nature of technology relates to other changes within an organisation that intends to sell or adopt an innovative drive within and outside the organisation in question. This development does manifest itself as a function of both adoptions and adaptation or imitation of technological development. Smith (2000) posited that technological innovations derive from the essence of life and fruition via the interactive factors of actor-networks to provide the required platform on which social interaction and learning diffuse and create a needed systemic platform for innovation. Another school of thought espoused by Compton (2004) indicated that technological innovation and adoption are based on a set of principles: modification, adaptation, user-friendliness, fail-safe features, the flexibility of use, reliability, fitness for purpose, efficiency, ergonomics, aesthetics, and optimisation. The selection and application of these principles depend on the technology receiver's environment, purpose, and exigency.

In a similar vein, Kumar, Kumar, and Persaud (1999) stated that technology possesses two primary components, viz—(a) physical components comprising of products, tooling, equipment, blueprints, techniques, and processes; (b) an informative component consisting of management know-how, marketing, production, quality control, reliability, skilled labour, and functional sub-component. In contrast, Sahal (1981) stated that technology could be viewed as configurational architecture that systematically transfers the object to determine a specific set of processes and products. However, emerging studies on technological transfer have connected technological innovations with knowledge in tandem with the process flow of research and development (Dunning, 1994). From the preceding discussion, two fundamental thought divides have been identified and emerged: firstly, that technology is a unique set of knowledge or technique; secondly, technology is about doing things. To this end, technology, as a function of organisational or national imperatives, can be connected with obtaining certain results, resolving peculiar problems,

completing specific tasks by using particular skills, and recourse to knowledge deployment and asset exploitation (Lan & Young, 1996). Albeit an emergent school of thought believes that the concept of technology is an integration that embodies the product and association with the inherent knowledge or residual information intended for usage, application, and process architecture in developing a product, service, or hybrid of product and service (Bozeman, 2000; Lovell, 1998).

Technology is an enabling and facilitating agent that drives new structures; it innovates the organisational and geographical flow of economic activities; this characteristic elicits new processes and products while making new outcomes possible (Dicken, 2015). Inherently, technology is advancing the frontiers of most value chains globally and transferring its impact on nature concerning the environment. An aspect of evolution, as it were.

Technological Evolution in Africa

Technological evolution in Africa is still slow in most sub-Saharan countries. The ability to develop robust manufacturing and service sectors relevant to a dynamic global economy focusses on cost advantages in tandem with developmental pathways that would allow governments, especially within the emerging context, to accumulate capital and deploy technology optimally (Schwab, 2016). This evolutionary trend is hinged on technology; however, developing counties in sub-Saharan Africa are in dire need of this occurrence. Aside from the incidents of disruption, inherent value chain architectures domicile in organisations across Africa are envisaging the creation and introduction of new technological evolution that will elicit the design of new ways of driving value-add towards serving existing human needs and disrupting existing value chains. This forms the crux of a developmental issue.

Regarding the future of some countries in sub-Saharan Africa, it is an emergent imperative that a technological transformation inclusive of renewable energy (RE) and energy efficiency (EE) is leveraged as an essential element of a green growth strategy aimed at reducing the impact of environmental degradation (UNIDO/UNU-MERIT, 2014). Although most parts of Africa are already experiencing this developmental epoch, some have hitherto perceived this situation as a mirage. On the flipside, some sectoral innovative systems domicile in these African countries would help to address the nature, structure, organisation, and

dynamics of innovation and production as applicable to the different sectors of the economies in these countries; this trend would occur in alignment with green technological needs, three critical elements of sectoral systems are applicable: actors, knowledge base, and institutions (Malerba & Nelson, 2012). These sectoral systems would influence the innovative frontiers in the future.

Evolving frontiers of innovation drive technology in varied ways. This wave of borders account for about $350 billion and may attain a growth margin of approximately $3.2 trillion by 2025; this development provides an opportunity for countries in sub-Saharan Africa to tap into this technological wave, but most of them are unprepared to adopt and adapt to the emerging technological revolution (UNCTAD, 2021).

Drivers and Barriers Inhibiting Technology and Its Impact in Africa

A myriad of barriers inhibits the deployment and impact of technology in Africa. However, most developing countries in sub-Saharan Africa are confronted with the twin challenge of developing stronger economies through measures such as energy supply expansion, increasing agricultural production capability, and improving infrastructural system gaps while still playing and retaining an active role in global efforts to reduce the impact of greenhouse gas emissions on the environment (UNIDO/UNU-MERIT, 2014). Lim (2011) indicated that green technological growth and poverty reduction do not necessarily entail a trade-off but may lead to valuable synergies in all ramifications if well leveraged for the benefits of relevant stakeholders. This implies poor economies of sub-Saharan Africa.

Another critical challenge of green technology is how the production and consumption of green technology can be based on designing eco-solutions that would minimise the impact on the environment and consequences (Sabban, 2020). This situation can be considered from its effects in sub-Saharan Africa from three dimensions: adaptation, adoption, and diffusion. Some barriers to adopting technology in sub-Saharan Africa include lack of leadership and poor infrastructural framework. At the same time, adoption issues encompass lack of technical competence, skill gap, and high cost of technology transfer. The aspect of diffusion entails challenges of developing alternate raw materials and producing emergent technologies such as green cars and aeroplanes. Also, the adoption

is fraught with issues of information asymmetries and low technological awareness. Despite these barriers, the adoption of green technology in some sub-Saharan Africa, such as Nigeria and Kenya, has focussed on small and medium-size agro-based industries (Sabban, 2020). A study on some countries in sub-Saharan Africa has revealed that the diffusion of green technology depends mainly on the policies and regulatory frameworks as a function of governmental influence. Thus, the resultant impact of this situation is that the market for green technology in Africa is relatively underdeveloped, and government policies do not create an enabling environment for the diffusion of green technologies geared towards the mobilisation of critical resources for private institutional collaboration and as a catalyst for developmental cooperation (UNIDO/UNU-MERIT, 2014). To this end, to foster enhanced adaptation of green technology for sub-Saharan Africa, there is a need to elicit and upscale the technical difficulties and requirements. Conversely, other factors that inhibit the adoption of green technology include unfavourable business climate, lack of technical competence, high initial setup cost, and high cost of finance; these are peculiar to most countries in the sub-Saharan region (UNCTAD, 2021).

However, experience has indicated that new technologies are likely to permeate various sectors of the economy and social activities. In these circumstances, developing countries should deliberately adopt and use automation to increase productivity, promote economic diversification, and create jobs (UNCTAD, 2021). According to UNCTAD (2021), developing nations, inclusive of countries in sub-Saharan Africa, may have to establish the policy framework that would enable them to overcome some challenges; these challenges include the following:

Demographic changes: Countries that belong to the low-income and lower-middle-income groups have expanding and young populations that are characterised to increase the supply of labour and depress wages in tandem with reducing the incentives for automation as a dominant tendency.

Lower technological and innovation capabilities: The gap inherent in skilled population and dependence on agriculture, to a large extent, tends to slow the drive to adopt and adapt to new technological opportunities.

Slow diversification: Countries in this clime are characterised by the slow rate of leveraging technical opportunities to diversify

their economies, absorbing and adapting new technologies for local intent due to the absence of leadership and lack of infrastructural architecture.
Weak financing mechanisms: Most countries in sub-Saharan Africa are saddled with a weak financial framework that limits the adoption and adaptation of new technologies for commercial and industrial purposes.
Intellectual property rights and technology transfer: Limitations posed by the restrictive use of emergent technologies vis-à-vis the needs relating to agriculture, health, and energy.

Aside from these challenges, countries in sub-Saharan Africa are also confronted with practical difficulties in promoting equal access to emergent technologies (UNCTAD, 2021). Some of these beneficial challenges include.

Income poverty: A large percentage of the sub-Saharan African population is limited by income. This population in these developing countries cannot access new and emergent technologies due to the low-income. This situation is socially economical primarily to a large extent.
Digital divide: An essential requirement for the growth of emergent technologies is the reliance on the availability of steady and high-speed fixed internet connections, but most countries in sub-Saharan Africa lack adequate digital infrastructure, and where this is available, the cost of accessing such facilities is highly prohibitive.
The absence of skills: The lack of technological literacy and numeracy is another pain point for most countries in sub-Saharan Africa. Thus, emergent technologies require relevant skills to deploy value and communication with others in the technological value chain.

Drivers of Green Technology in Africa

Several factors drive the advancement of green technology in Africa (Guo et al., 2020). These include the following:

- Innovation and investment parameters: These are spring-boards for incremental productivity and innovative impetus for goods, the

different range of ecological framework, biodiversity, and incidents of the famine that stunt growth both at national and regional levels. These also constitute the framework for sustainable development and green growth.

- Stimulation of sustainable development: This entails the identification of environmentally friendly sources of change to create eco-friendly industrial communities, related technologies, and employment.
- Investment incubators: Incidents of investment are inherent in green tech roll-out, and these drive new frontiers of economic opportunities leveraging on conditions for national sustainable development platforms.
- Knowledge management: This aspect entails the creation, acquisition, exchange, and use of knowledge to drive socio-economic dimensions of sustainable development. Among other things, knowledge management help curate the innovative pipeline, which, in turn, helps organisations be at par with technological advancement. A measure of this trend generates high-quality, innovative products and services that reduce environmental footprint.

Intuitively, green technology elicits sustainable frameworks that indirectly promote a sustainable society while fostering environmental protection and economic development (Guo et al., 2020).

The Concept of Green Tech, Renewable Sources, and the Evolution of Green Tech in Africa

Green technology refers to a field of emergent innovative ways geared towards attaining environmentally friendly changes in daily life (Shafiei & Abadi, 2017). Green technology constitutes an alternative source of energy that reduces the usage of fossil fuels with less impact on man, animals, and the environment, as well as less harmful to the world. Among other things, the consummate goal of green technology is to reduce waste and pollution that are inherent during production and consumption emanating from the designated value chains; this is why green technology is also referred to as clean technology. Although green technology leverages the development and application of products, equipment, and systems geared towards conserving the natural environment

and resources, it minimises and reduces the negative impact on man and the environment (Shafiei & Abadi, 2017). Thus, another definition of green technology is an emergent technology that meets present needs without reducing the ability of incoming generations to meet their own needs.

To this end, the concept of green technology is geared towards green purpose and the production of environmentally friendly inventions which encompass energy efficiency, recycling health, and safety concerns; its essence is to meet the needs of a society without affecting or impacting the earth's natural resources (Iravani et al., 2017).

Green technology is environmentally friendly technology that supports sustainable production; green and sustainable technologies are beneficial for protecting the environment (Usmani et al., 2021). Green-tech is hinged on renewable sources of energy. According to Sabban (2020), renewable energy sources convert natural resources such as light and wind into electrical power; renewable energy sources include solar, wind, water, and biology. On the flip side, non-renewable sources include nuclear, hydrogen, coal, natural gas, and oil. Each of these sources of renewable green tech energy has its advantage and disadvantages (Sabban, 2020), which are enumerated as follow:

Solar: This green tech converts natural light into electrical energy through photovoltaics. Advantages include cleanness, environmental-friendly, non-degradable, and realistic; its disadvantages include dependence on weather and sunlight as a primary source, being expensive, requiring a large area for setup, and having a high maintenance cost.

Wind: This type of green tech uses wind kinetic energy to operate electric turbines and windmills towards the energy generation; however, it cannot be performed in a residential. This is a critical consideration for this type of green tech. The advantages of this type of green tech include its cleanliness, non-degradability, natural, and cheapness. In contrast, its disadvantages include a large expanse of land is needed for its operation. It is expensive since it requires substantial capital to acquire land and generation for consumption.

Water: Waterfalls and water flow generate this type of green tech energy. Despite its natural source of generation, its advantages include greenness, cheap, non-degradable, and natural. In contrast,

its disadvantages include dependence on weather and water stream, limited to waterfalls location, cannot be operated in residential areas, requires a large expanse of land, and expensive.

Biomass

Biomass is a form of energy derived from organic matter sources such as animal wastes, wood, crops, and seaweed; it constitutes about 10.2% of the global annual energy supply (IEA, 2010). However, despite these vast untapped energy reservoirs that abound in the African continent, recourse to the green technological applications in Africa are yet to be fully utilised on a large scale. Harnessing this potential will not only beget an economic fulcrum that would propel economic development in diverse spheres, but it would serve as a hinge that would drive the usage of renewable energy (RE) and energy efficiency (EE) technologies (UNIDO/UNU-MERIT, 2014). This technological advancement would provide a plank for Africa's long-term green tech strategy.

Implications for Green-tech in Africa Continent with a Focus on Some African Countries

Green technology has vast implications for the African continent, with an elemental focus on sub-Saharan Africa. Globally, the acceptance and deployment of green technological practices are gaining more ground due mainly to their mitigative impact on environmental issues and concerns (Heal, 2012). To this end, environmental issues are becoming significant causes for concern, and their ecological dimensions have constituted an integral aspect of organisational strategy, planning, and operations. Incrementally, due to pressure from multiple stakeholders in the various supply value chains, coupled with the emergent need for economic and environmental performance metrics, there is an overwhelming outcry for leaders in the operations and supply chain ecosystems to seek innovative solutions towards mitigating their negative environmental impact and are socially responsible (Handfield et al., 2005; Ho & Lin, 2008; Niehaus et al., 2018).

The incremental investment in renewable energy has alleviated the situation in developing economies over the years (UNIDO/UNU-MERIT, 2014); this trend will continue in the future. Despite this development,

the capital requirement for Africa's infrastructure outweighs the FDI inflows; this depicts a yawning existential gap for affected countries in sub-Saharan Africa.

Annually, from 2006 to 2015, the projected infrastructural requirement for Africa was about USD 47 billion; among other things, there exists a significant nexus between sources of funds and developmental path regarding green tech initiatives in Africa (UNIDO/UNU-MERIT, 2014). This development accounted for about 70% of how projects are funded in some parts of Africa. The developmental impact of green tech as a source of renewable energy is indicated in the table below:

Scenario	*Year*	*Share (%)*
Greenpeace (2011) energy revolution (South Africa)	2030	50
IRENA (2012) renewables	2030	50
IRENA (2012) renewables	2050	73
Greenpeace (2012) energy revolution (all Africa)	2050	92
GEA (2012) global energy assessment (sub-Saharan Africa)	2050	34–92

Source Adapted from REN21, Renewables, Global Futures Report

Sub-Saharan Africa has a population of about 883 million people; almost five hundred eighty-five million had no access to electricity in 2009, but those who can access electricity would grow to about 652 million by 2030 (UNIDO/UNU-MERIT, 2014). In tandem, demand and sources for green technology are expected 15% in 2020 to 18% by the end of 2035 as occasioned by global energy demand; sub-Saharan Africa is expected to change this global energy emergent change. Despite the inherent competition for fossil fuel technologies driven by the overall global energy demand, there abound remarkable new technologies vis-à-vis the traditional demand for fossil fuel as a function of the overall evolution of the market (UNIDO/UNU-MERIT, 2014).

Solar and biomass constitute the biggest RET markets in Africa; however, while the former is based on foreign technology, the latter is driven by domestic technology and know-how. Hitherto, in sub-Saharan Africa, the adoption of green technology is not based on the inherent benefits of greenness or social inclusion but its economic benefits. In some instances, specific technologies provide inherent dividends for the local populace based on their locations. For example, in some sub-Saharan African agricultural settings, higher yields are harvested from green biotechnology. At the same time, electricity is generated from

renewable sources, which allow farmers to pump water for irrigation and enhance the processing of agricultural produce. In areas with geothermal heat and good conditions for creating hydropower stations, green technology in renewable energy is potentially cheaper, thus giving it an advantage over fossil fuel-based power. Several opportunities abound in sub-Saharan Africa regarding how RE can enhance energy supply and improve labour productivity in the agricultural sector. Aside from these consummate benefits accruing from green technology, energy savings in energy-dependent industries will produce economic benefits through lower energy costs (UNIDO/UNU-MERIT, 2014). As advancement is made regarding a shift to modern conventional energy sources, it is expected that considerable incipient benefits would also be leveraged in this direction. In the short term, this paradigm shift is maybe costly, but its adoption process may also be long and complicated mainly due to leadership will and ensuing situational factors.

Although sub-Sahara Africa is well-endowed with renewable energy resources, adoption and diffusion of green technological capabilities on the supply and demand sides may be saddled with a lack of supportive developmental and institutional framework required for renewable energy resources (UNIDO/UNU-MERIT, 2014). Aside from these inherent surmountable challenges, varied sources of Renewable Energy Technologies (RETs) abound in most parts of sub-Saharan Africa.

Green Tech Scenarios on Two Sub-Saharan Countries: Nigeria and Kenya

The green tech situation in Nigeria and Kenya is characterised by the usage that is driven by economic benefits instead of environmental necessity, as it were. A significant reason for this situation is the low energy access in both sub-Saharan countries in Africa. However, the use of energy-efficient technology occasioned by green technology has the enormous potential to support the efficient use of diminishing natural resources, clean energy and promote cleaner production and greenhouse gas mitigation inherent in the production of goods and service delivery in both countries. Regrettably, this has not been the case for these countries and is more significant for Nigeria than Kenya. The key parameters that have influenced the adoption of green technology in both countries include (UNIDO/UNU-MERIT, 2014):

1. In-house knowledge about energy management.
2. Availability of technical expertise.
3. Desire and need to save and reduce energy cost.
4. Lack of technical competence by potential adopters of green technology.

Green Tech in Kenya

In Kenya, most rural populations and a significant share of the urban poor rely on biomass for their energy needs. This pervasive situation has accounted for the challenge of deforestation and the decline of water resources. It accounts for the causes of respiratory diseases and economic loss through labour and time used to collect fuelwood in this emerging sub-Saharan Africa. At the same time, this option may be attractive for the large population of most sub-Saharan countries because Africa has a reservoir of endowed natural resources that provide a source for green technology and help save cost in the long run as a measure of developmental benefit for Africa. Africa has a large expanse of renewable energy resources, which hitherto, has remained underutilised, accounting for about 7% of its hydro energy, being currently harnessed; Kenya, as a typical example, has only about 60 MW of its geothermal power being exploited as it were (Karekezi et al., 2003); this instance depicts a typical incident of untapped energy potentials domicile in sub-Saharan Africa.

The table below gives the types of renewable green technology in Kenya.

Renewable Green Technology Energy Sources in Kenya:

Type of resource	*Potential*	*Current capacity*
Hydroelectric power	– 3,000 MW in small hydro – – 6,000 MW comprising of large and small hydro plants	– Large hydropower: 807 MW – Small hydropower: 25 MW
Solar energy	4–6 KWh/m2 /day	– Small systems with a capacity of 12–50 W – PV systems: 1,450 KW in 450 institutions
Wind	– 346 W/m2 – wind speed ranges 8–14 m/s in some areas and have the potential to produce over 1,000 MW	5.45 MW (June 2010), and an additional 20 MW (2013)

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Type of resource	*Potential*	*Current capacity*
Geothermal	7,000–10,000 MW in 14 potential sites in Rift Valley	212 MW
Biomass	– co-generation using sugarcane bagasse up to 193 MW – more opportunities up to 300 MW	
Biogas	1,000 MW	

Adapted from Renewable Energy Portal, Energy Regulatory Commission; Institute of Economic Affairs, Kenya

Green Tech in Nigeria

The advent of green technology has a great potential for the growth of Nigeria from all ramifications. Hitherto, this harnessing the potential of green technology, despite its consequence for Nigeria as one of the major emerging countries in sub-Saharan Africa, seems elusive. With a population approaching about 200 million and saddled with a host of policies and regulatory frameworks, Nigeria generates close to 32 million tonnes of solid waste annually, with only 20–30% of this amount is collected (Chioma, 2020). This situation poses a pressing issue of environmental degradation in Nigeria's urban and rural areas. However, despite its precarious environmental implications, solid waste also provides a viable source of electricity generation and minimises greenhouse gas emission; this forms a formidable platform for green technology in Nigeria, aside from other sources of green technology such as solar and wind. Although these aspects of green technology as a renewable energy source remain untapped, there appears to be a growing incident of solar usage across Nigeria, especially in the urban areas. At the same time, wind power has enormous potential in the northern part of Nigeria.

Nigeria's primary source of electricity supply emanates from natural gas and hydro at a ratio of 70–30%, respectively (Oyebanji et al., 2017). However, re-occurring issue in the Nigeria energy value chain is characterised by incessant incidents of sabotage and the impact of harsh weather conditions leading to an inadequate power supply occasioned by low gas supply and lack of proper maintenance of power plants, with a resultant effect of high energy cost and recurrent crises in the

southern oil-producing region of Nigeria; this situation is in tandem with growing demand for electricity alongside Nigeria's increasing population (Oyebanji et al., 2017; Sambo, 2008). Despite the availability of electricity, a substantial population in the rural areas of Nigeria cannot access it and thus have recourse to fuelwood as a source of energy (Akinbami, 2001; Oyebanji et al., 2017); this situation has dire environmental implications. On the flip side, Nigeria has the potential of solar radiation the reservoir of about 5.5 Whm-2 days-1; this situation translates into about 1% of Nigeria's land area of 923,773 km^2, 1850GWh by 103GWh solar electricity that can be generated annually (Oyebanji et al., 2017; Sambo, 2009).

Aside from the need to navigate the issues of poor infrastructure occasioned by the dire economic downturn, Nigeria stands in good stead if it embarks on policy reforms that would elicit a strategic shift from quantitative gross domestic product to qualitative green growth (Oyebanji et al., 2017). This shift is imperative in all its ramifications because it would help Nigeria to contend with the emergent environmental challenges such as environmental degradation, oil spillage, environmental disruptions, carbon emission, and health-related hazards resulting from over-dependence on oil as a mono source of energy with all its attendant environmental impacts. This situation would serve as an impetus for the growth of green tech as a viable source of energy that would also reduce the increasing concerns for greenhouse emissions, the reliance on importation of fossil fuel, issues of subsidy management, and vagaries of global oil price fluctuations (Oyebanji et al., 2017). This opportunity would, amply, provide enablement for the adaptation, adoption, and diffusion of green technology in Nigeria. According to Sabban (2020), green technology would not provide the platform for the creation of environmentally friendly products, it would also provide the catalyst for future green technologies and innovations such as the development and production of green cars and aeroplanes but it would give explorable options for contending with issues of environmental waste arising from non-green tech sources of energy. Here lies the future of green tech in Nigeria.

Conclusion and Recommendations

The advent of green technologies has enormous implications for humanity, mainly due to global concerns about environmental degradation and a means to an alternative energy source. For developed

economies, so much has been achieved regarding awareness creation and reducing the environmental impact; however, green technology for developing countries in sub-Saharan Africa possesses an incredible pack of solutions for individuals, communities, and governmental institutions. Globally, green technologies imbibe environmental awareness into their design and usage features towards reduction in waste and pollution also reduces over-dependence on fossil fuel with its attendant economic and environmental implications (Chioma, 2020); these have dire consequences for most developing countries in sub-Saharan Africa. To this end, there is a need to foster a culture that would subsist both at global and national levels towards planning, transforming, and implementing policies that would drive imperatives that would incubate a sustainable framework for green technology (Chen et al., 2019; Usmani et al., 2021; Shafiei & Abadi, 2017). Among other things, extracting from this school of thought, the following recommendations would be helpful, especially for developing countries in sub-Saharan Africa:

- There is a need to recalibrate the impact of green technology impact on relevant stakeholders;
- Governments at national and global levels should develop policies that undergird the establishment of green infrastructure, awareness campaigns, and the adequate provision of low margin loans for the installation of green tech infrastructure; in addition, they should:
- Expand the share of green financing public and private financial institutions;
- Establish new international sources for climate funding; this should be encouraged as a global imperative agenda;
- Initiate an incentive for green tech consumers to procure green bonds that would guarantee yields and coupon payments tax-free;
- Encourage innovative international cooperation on green technologies;
- Institute a framework that would harmonise green technology standards, codes, and contractual principles towards flawless transmission and sharing of eco-innovations and clean technologies;
- Create best-practices and benchmarks on green technologies that would derive expert opinions and advice for global relevance;
- See the need to legitimise forms of public green grant and reduce aberrant subsidies; and

- Create a business platform to nurture and sustain markets for green technologies via optimal trade policy.

Some of these recommendations may not apply to some countries with particular reference to sub-Saharan Africa; however, green technology holds the key to sustainable development respectful of social equity and environmental health equilibrium (Shafiei & Abadi, 2017). This nascent global imperative would not only take cognisance of the harmful impact on dire consequences of climate change and its attendant implications but it also provides a leeway for a sustainable development, where leaders and policymakers would leverage on both domestic and global green technological narratives to drive a formidable and sustainable development. A sustainable development that would deploy green tech to inform a policy framework as a bulwark for future generations within and outside the confines of global spheres (Guo et al., 2020). In essence, green holds the future for sub-Saharan Africa and beyond.

Summary

The chapter outlines the discourse on technology and green tech in Africa. It entails the concept of technology, the meaning and nature of technology deployment, antecedents, trends, and implications for Africa, focussing on some sub-Saharan African countries. The discussions in the chapter encompass the drivers and barriers impacting the adaptation, adoption, and diffusion of green technology in sub-Africa; some of these drivers and barriers animate peculiarities from Africa, while others resonate with environmental and energy challenges within the confines of the global framework. The adaptation, adoption, and diffusion of green tech in Africa are fraught with challenges unique to sub-Saharan Africa; some of these challenges emanate from the global community. Other aspects of the discourse in the chapter attempt to situate the importance of green tech as emergent energy; a source that would help leadership and policy markers in sub-Saharan Africa to appreciate and embrace the strategic significance of green tech as a remedy for environmental degradation, and also, as a viable source of energy for the future if it is properly harnessed. The chapter ends with conclusive genres of advice and recommendations for all stakeholders in sub-Saharan Africa on the emergent need to explore green technology as a future imperative for the wellbeing and relevance of some countries in sub-Saharan Africa.

Points to Ponder

- Owing to the tremendous potential in Africa's population and endowed natural resource, does Africa's leadership possesses the inherent capability to tap into its latent reservoir as an alternative source of renewable energy in the future?
- How can emerging global technologies be harnessed to solve the myriad of technological challenges in sub-Saharan Africa vis-à-vis global concerns for climate change and ESG.
- What options can organisations in sub-Saharan Africa explore in overcoming the barriers inhibiting technology adaptation and implications for green tech for the African continent?

Actionable Recommendations

Private leadership	*Public leadership*
Expand the share of green financing for private institutional frameworks within sub-Saharan countries.	Stimulate green tech awareness and cascade at appropriate strategic levels of leadership.
Provide financial support or financing schemes to adopt green tech in business value chains.	Provide incentives to drive and implement Environment, Social, and Governance (ESG) initiatives using Technological frameworks.
Adopt conventional business practices that incorporate a green tech policy framework.	Create an enabling environment towards fostering ESG within the green tech ecosystem.

References

Adams, S., & Asante, W. (2020). *Politics of renewable energy in Africa: Nature, prospects, and challenges*. Innovation in global green technologies. https://doi.org/10.5772/intechopen.89019.

Akinbami, J. F. K. (2001). Renewable energy resources and technologies in Nigeria: Present situation, prospects and policy framework. *Mitigation and Adaptation Strategies for Global Change, 6*(2), 155–182.

Bhardwaj, M., Neelam, K. (2015). The advantages and disadvantages of green technology. *Journal of Basic and Applied Engineering Research, 2* (22), 1957–1960.

Bozeman, B. (2000). Technology transfer and public policy: A review of research and theory. *Research Policy, 29*, 627–655. https://doi.org/10.1016/S0048-7333(99)00093-1.

Chen, J., Shi, Q., Shen, L., Huang, Y., & Wu, Y. (2019). What makes the difference in construction carbon emissions between China and USA? *Sustain Cities Soc, 44*, 604–613.

Chioma, U. (2020). *Commentaries. The need for adaptation of green technology in Nigeria and the contribution of intellectual property*. https://thenigerialawyer.com/the-need-for-the-adaptation-of-green-technology-in-Nigeria-and-thecontribution-of-Intellectual-property/. Retrieved on August 4, 2021.

Compton, V. (2004). *Technological Knowledge: A developing framework for technology education in New Zealand*. Retrieved July 21, 2021, from http://www.tki.org.nz/r/nzcurriculum/docs/technological-kn.doc.

Dicken, P. (2015). *Global shift: Mapping the changing contours of the world economy*. Sage Publications.

Dunning, J. H. (1994). Multinational enterprises and the global of innovatory capacity. *Research Policy, 23*, 67–88. https://doi.org/10.1016/0048-7333(94)90027-2

Gibson, D. V., & Smilor, W. (1991). Critical variables in technology transfer: A field—Study based on empirical analysis. *Journal of Engineering and Technology Management, 8*, 287–312. https://doi.org/10.1016/0923-4748(91)90015-J.

Gottesfeld, P., & Cherry C. R. (2011). Lead emission from solar photoVoltaic energy systems in China and India. *Journal of Energy Policy, 39*(9), 4939–4946.

Guo, M., Nowakow-Grunt, J., Gorbanyov, V., & Egorova, M. (2020). Green technology and sustainable development: Assessment and green growth Frameworks. *Sustainability, 12*, 6571. https://doi.org/10.3390/su12166571.

Handfield, R., Sroufe, R., & Walton, S. (2005). Integrating environmental management and supply chain strategies. *Business Strategy and the Environment, 14*(1), 1–19. https://doi.org/10.1002/bse.422.

Heal, G. (2012). Reflections—Defining and measuring sustainability. *Review of Environmental Economics and Policy 6*(1), 147–163. https://doi.org/10.1093/reep/rer023

Ho, Y. & Lin, C. (2008)An empirical study on logistics service providers' intention to adopt green innovations. *Journal of Technology Management and Innovation, 3*(1), 17–26. REN21, Renewables Global Status Report, 2011.

International Energy Agency. (2010). *Creating markets for energy technologies"*. OECD/IEA.

Iravani, A., Hasan abkari, M., & Zohoori, M. (2017). *Advantages and disadvantages of green technology; Goals, challenges and strengths*. *International Journal of Science and Engineering Applications, 6*(9), 2319–7560. https://doi.org/10.7753/IJSEA0609.1005

IRENA. (2019). Renewable Energy Statistics, Abu Dhabi: The International Renewable Energy Agency. *Politics of renewable rnergy in Africa: Nature, prospects, and challenges*. https://doi.org/10.5772/intechopen.89019

Karekezi, S., Kithyoma, W., & Initiative, E. (2003). *Renewable energy development*. In *Workshop on African energy experts on operationalising the NEPAD energy initiative* (pp. 2–4).

Kumar, V., Kumar, U., & Persaud, A. (1999). Building technological capability through importing technology: The case of Indonesian manufacturing industry. *Journal of Technology Transfer, 24*, 81–96. https://doi.org/10.1023/A:1007728921126.

Lim, S. (2011). *Green growth: global cooperation—The need for green growth in developing countries*. National Research Council for Economics, Humanities and Social Sciences.

Lan, P., & Young, S. (1996). International technology transfer examined at technology component level: A case study in China. *Technovation, 16*(6), 277–286.https://doi.org/10.1016/0166-4972(96)00005-3.

Lovell, S. A. (1998). *Technology transfer: Testing a theoretical model of the human, machine, mission, management and medium components*. Unpublished MSc. thesis. College of Aeronautics, Cranfield University.

MacKenzie, D., & Wajcman, J. (1985). *The social shaping of technology: How the refrigerator got its Hum, Milton Keynes*. Open University Press.

Malerba, F., & Nelson, R. R. (2012). *Economic development as a learning process: Variation across sectoral systems*. Edward Elgar.

Niehaus, G., Feiboth, H. W., & Goedhals-Gerber, L. L. (2018). Investigating supply chain sustainability in South African organisations. *Journal of Transport and Supply Chain Management, 12*, a335. https://doi.org/10.4102/jetsam.v12i0.335

Oyebanji, I., Adeniyi, B., Khobai, H., & Le Roux, P. (2017). Green growth and environmental sustainability in Nigeria. *International Journal of Energy Economics and Policy, 7*(4), 216–223. http://www.econjournals.com

Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). The Free Press.

Sabban, A. (2020). *Introduction to global green technologies*. Innovation in Global Green Technologies 2020. https://doi.org/10.5772/intechopen.92263.

Sahal, D. (1981). Alternative conceptions of technology. *Research Policy, 10*, 2–24.

Sambo, A. S. (2008). Electricity demand from customers of INGA hydropower projects: The case of Nigeria. In *WEC workshop on financing INGA hydropower projects* (pp. 21–22).

Sambo, A. S. (2009). Strategic developments in renewable energy in Nigeria. *International Association for Energy Economics, 16*(3), 15–19.

Schwab, K. (2016). *The fourth industrial revolution*. World economic forum, Crown publishing group.

Shafiei, M. W. M., & Abadi, H. (2017). The importance of green technologies and energy efficiency for environmental protection. *International Journal of Applied Environmental Sciences, 12*(5), 937–951.

Smith, K. (2000). Innovation as a systemic phenomenon: Rethinking the role of policy. *Enterprise & Innovation Management Studies, 1*(1), 73–102.

UNCTAD. (2020). *Calibrating technology to tackle sustainable development challenges in Africa*. https://unctad.org/news/calibrating-technology-tackle-sustainable-developmentchallenges-africa

UNCTAD. (2021). *Technology and Innovation report*. Catching technological waves innovation with equity. Retrieved July 29, 2021, from https://unctad.org/system/files/official-document/tir2020_en.pdf

UNIDO/UNU-MERIT. (2014). *Diffusion strategy of green technology and green industry in Africa*. A Study of Renewable Energy Technology Market and Energy Efficiency Adoption in Maise and Cassava Processing Industries in Kenya and Nigeria.

Usmani, M. S., Wang, J., Ahmad, N., Iqbal, M., & Ahmed, R. I. (2021). *Mapping green technologies literature published between 1995 and 2019: A scientometric review from the perspective of the manufacturing industry* (pp. 28848–28864) Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-021-13473-w