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ORIGINAL RESEARCH

Bioeconomy for sustainable development in Nigeria: lessons from international experiences.

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Abstract:

Introduction: Bioeconomy has gained significant attention in recent years, with countries adopting it to drive their developmental efforts. However, the concept has not been adequately examined and integrated into policy making in Nigeria.

Aims: This paper provides an overview of the bioeconomy in terms of motivation, policy framework, and application as a concept for achieving sustainable development. It drew from international experiences in implementing bioeconomy to provide lessons that Nigerian stakeholders can use to develop and implement a comprehensive bioeconomy policy framework to solve environmental and societal challenges.

Materials and Methods: The study was essentially based on a desk review of relevant academic papers with reference to publicly accessible documents from governments and their agencies..

Results: The review showed that there is no clear cut definition for bioeconomy, the definitions are evolving and vary depending on the actors, motivation and objectives. However, bioeconomy has become the center of sustainable economic strategies in numerous countries but Nigeria lacks a cohesive bioeconomy policy.

The chief motivation for bioeconomy adoption in these countries is to address societal challenges while achieving sustainable economic development. The policies focused on research and innovation, education and training, stakeholders' engagement, technology transfer, commercialization, and market development support.

Conclusion: In order to achieve sustainable development, Nigeria must develop and implement a holistic bioeconomy policy cutting across all relevant economic sectors.

Keywords: bioeconomy, bio-based economy, biotechnology, Nigeria, sustainable development

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1. INTRODUCTION

Countries and regions around the world are facing a number of economic, environmental and social challenges. Increased demand for energy, primary resources, industrial products and services are putting significant pressure on the sustainability of the ecosystems that support our society. Bioeconomy promises solutions to these major societal challenges.
The emergence of the bioeconomy agenda started with the publication of the Brundtland Report which defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The foreword of the 1987 report called for "a new era of economic growth – growth that is forceful and at the same time socially and environmentally sustainable". This call still rings true three decades later (1).

Advances in biotechnology have transformed the industrial and environmental process and management landscape (2), leading to embedment of bioeconomy in better health care, enhanced food security, improved supplies of potable water, more efficient industrial development processes for transforming raw materials, support for sustainable methods of afforestation and reforestation, and detoxification of hazardous wastes to achieve the sustainable systems of production and consumption (3). This articulation of capitalism and biotechnology has helped in addressing global challenges, such as climate change, natural resource scarcity, environmental pollution and unsustainable consumption patterns (4). A transformative change is needed that involves long-term approaches and interactions at all levels of society (3).

This paper provides an overview of the bioeconomy in terms of motivation, policy framework, and application as a concept for achieving sustainable development.
The primary aim of the study is to examine more in depth the manner in which bioeconomy is defined and implemented in other countries in order to facilitate the development of bioeconomy in Nigeria.

The study is directed at policy makers, industry, research communities, and representatives of civil society for the future development of bioeconomy in developing countries in the quest to overcome their developmental challenges.

2. LITERATURE REVIEW

While conceptions of a bioeconomy emerged in the 20th century, it was not until the 21st century that the concept started attracting great interest from scientists and politicians; shaping development strategies. Today, utilization of living organisms of plants, animals and microorganisms and their integration into one large segment (complex) of real economy, which is the essence of bio-economy, has been adopted by several countries to drive their developmental efforts (5,6).

At the initial stage, bioeconomy was associated with the dynamic development and achievements in the fields of biology and biotechnology before being linked with environment, ecological development, and sustainability but there is little consensus on what it is or what it does or does not include (7).

The way bioeconomy is defined is however important due to the fact that methods and components of its definition are directly reflected in the policies, programmes, and strategies of economic development (8). Different definitions emphasize various technological, economic and social aspects and priorities, and relate to various conditions and developmental concepts such as sustainable development and innovative development, both at national and regional levels (6).

The European Commission defined bioeconomy as "the sustainable production of renewable biological resources and their processing into food products, feed and industrial goods and into bioenergy, which is based on agronomy, ecology, food sciences, social sciences, biotechnology, nanotechnology, ICT and engineering and includes agriculture, forestry sectors, fishing industry, food, pulp and paper production as well as elements of the chemical, biotechnology, energy and transport sector" (9). This definition, a result of the development of strategy in using renewable biological resources in various sectors of the economy, is comprehensive but not final because conditions are constantly changing, new products and solutions are appearing, and concepts of development are modified (6,10).

A presidential administration's definition of bioeconomy in the United States shared several similarities with the EU's definition. A White House document states that "bioeconomy is an economy based on the use of research and innovation in biological sciences in order to power the economic activity and to generate public profits (11).

Generally, bioeconomy can be defined as an economy, in which the main production components – manufacturing of materials, chemical products, and energy, are based on biological and renewable resources (3). It is commonly understood to be a complex of issues related to the safety and security of food and energy, climate change and environment protection, as well as many social and cultural changes. It also includes the traditional sectors of the economy which produce bio-products and services by using biotechnologies (12).

Leveraging on innovations in the life (sciences) and bio-industries, bioeconomy is based on the sustainable production and conversion of renewable biomass into a range of bio-based products, chemicals, and energy to achieve ecological and social sustainable growth and employment based on the wealth of biological resources (13).

In order to unlock the value hidden in bio-resources and bio-processes to address complex problems in a sustainable manner, bioeconomy involves three elements: (i) the use of advanced knowledge of genes and complex cell processes to develop new processes and products, (ii) the use of renewable biomass and efficient bioprocesses to support sustainable production, and (iii) the integration of biotechnology knowledge and applications across sectors (14).

For an initial understanding of the taxonomy of the bioeconomy, one can distinguish between the 'old' and the 'new' bioeconomy. The two 'generations' of bioeconomy differ mainly in terms of resource efficiency and sustainability. The 'new' bioeconomy is often defined as a 'knowledge-based bioeconomy' (KBBE). This term describes the new uses and processes of biomaterial, which are feasible because of new technologies and knowledge, where the objective is to achieve greater resource efficiency and sustainability (15, 16, 17).

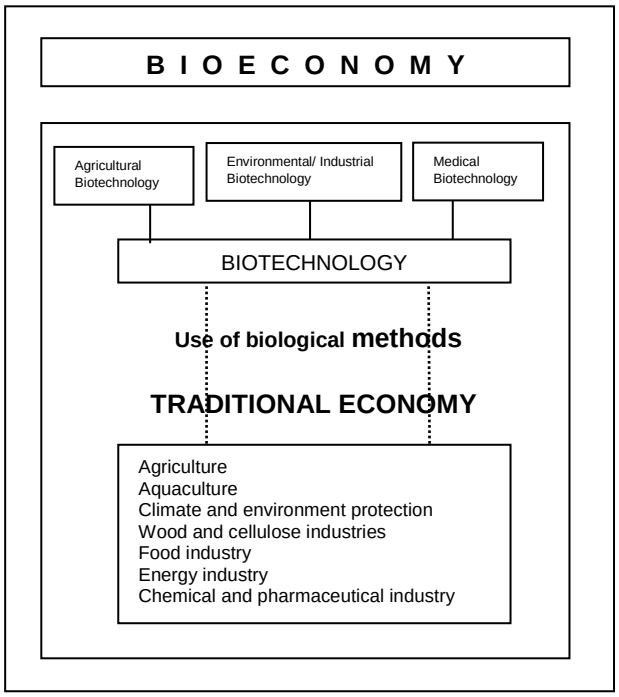

Fig. 1. Areas of bioeconomy
Source: Wozniak & Twardowski, 2017

The boundary between bioeconomy (BE) and bio-based-economy (BBE), two terms often used interchangeably, differs between countries. The distinction is made in relation to the production and use of biomass, often with the exclusion of food and feed production, but in general the distinction is made in relation to the production and use of biomass, often with the exclusion of food and feed production. Bioeconomy encompasses the production of biomass, either through primary production (from agriculture, forestry, fishing, aquaculture and industry) or through the collection of waste streams; and the use of biomass for food, energy and material uses while bio-based economy is part of the overall bioeconomy and addresses only the use of biomass for materials, energy, chemicals and other bio-based processes, with the explicit exclusion of food. However, the two terms are used interchangeably (14, 18).

Put another way, the BE concept is technology-driven focusing on the methods of conversion of raw material into value added products", and in particular on biotechnology as a conversion technology while the resource-driven BBE-concept "focuses on the raw material rather than the conversion process" in that it foregrounds the task of a transition from a fossil-based to a bio-based economic system (19, 20).

2.1 Bioeconomy and Sustainable Development

The worsening environmental, geopolitical, and socioeconomic situation necessitated the principle of sustainable development which reconciles economic, environmental and social objectives while bioeconomy – the sustainable production and use of biological resources, processes and principles to produce products and services in all economic sectors – is a core element for the future economic model allowing a sustainable development, along with dealing with the major issues being faced by humanity nowadays (21).

The bioeconomy is a new economic and social order which promotes systemic change from using non-renewable resources to renewables (22). As an economic system, the bioeconomy combines in a synergic way both natural resources and technologies, together with markets, people and policies to provide a solid and realistic foundation for achieving the sustainability need worldwide (23). It is justified to refer to the transition from a fossil economy to a bioeconomy as the new wave of economic development (24).

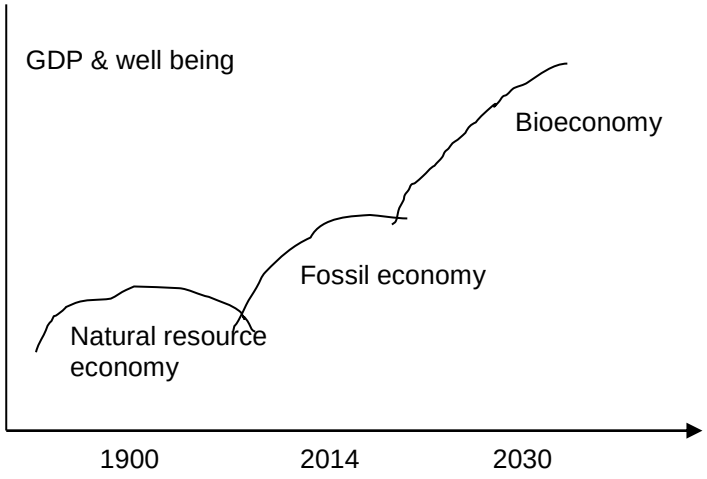

Fig. 2. Bioeconomy: The next economic wave
Source: Finnish Ministry of Employment and the Economy

Acccording to Ramcilovik-Suominen and Helga, the way bioeconomy polices perceive sustainability and sustainable development as concepts will have profound implication not only on a practical level for policy implementation, but also on a conceptual level and for theoretical discourse surrounding sustainability and sustainable development(25). The future of sustainable development is the implementation of bioeconomy strategies to prevent urgent problems, such as increasing competition for natural resources, climate change, and rural sustainable development (22).

There is considerable attention to sustainability in scientific bioeconomy debate, with sustainability seen as an inherent characteristic of the bioeconomy however bioeconomy cannot be considered as self-evidently sustainable. Sustainability may serve as a basis for a more interdisciplinary or trans-disciplinary way of approaching bioeconomy (26).

All together the bioeconomy is complex. From efficient management of raw materials and recycling in a closed circuit – from production through use in order to dispose and process of waste, i.e. the so-called "from cradle to grave" concept; forming a hierarchy and applying the principle of cascading in the biomass chain; creating and strengthening the concept of "product life cycle" and "value chains", all these are within the scope of bio-economy. Most importantly bioeconomy has drawn attention to the need to strengthen the meaning of the term sustainable development (6).

2.2 International Experiences

The European Commission in the document entitled "Bio-economy for Europe" presented production models based on biological processes and natural ecosystems using natural materials, which consume minimal amounts of energy without generating waste, as all waste resulting from one process is the material for the next and as a result it is reused in the ecosystem (27).

The European Commission combined a strategy and action plan document called "Innovating for Sustainable Growth: A Bioeconomy for Europe" which offers direction for research and innovation agendas in the bioeconomy sectors, contributes to a more enabling policy environment and paves the way for a more innovative, resource efficient and competitive European society (28,29).

The policy model brings together several stand-alone policy areas (e.g. climate change, agricultural and industrial policy, R&D and innovation, environmental policy, etc.), as an attempt to provide an integrated response to several broad challenges—i.e. climate change; food and energy insecurity; resource constraints with emphasis on the sustainable use of natural resources, competitiveness, socioeconomic and environmental issues (30).

The actions are based on three key pillars: investments in research, innovation and skills; reinforcement of policy interaction and stakeholder engagement; and enhancement of markets and competitiveness in the bioeconomy sectors. Within these pillars, twelve main actions are established, which include increasing multi-disciplinary research and innovation; creating markets for bio-based products and initiatives through standards and labels; and establishing a bioeconomy panel to increase cross-sectoral collaboration and policy coherence (13,31).

Some selected areas for funding are identified: R&D subsidy to raise commercialization; Standards, norms and certification give confidence to consumers and industry as they provide credibility to claims of performance and sustainability; skills and education; capacity building in industrial biotechnology for competitive advantage (32).

The European Commission's efforts have made bioeconomy the central component in shaping sustainable development in Europe. Countries such as Germany, Finland, Sweden, Russia, Austria, Netherlands, Belgium and West Nordic countries are developing strategies and declare their intentions and visions for the development of a bioeconomy. Denmark has adopted the EU bioeconomy strategy via The Copenhagen Declaration for a Bioeconomy Action 2012. Turkey, Estonia, Italy, Poland and Spain are other countries where dedicated bioeconomy strategies are is under development (19).

The "National Bioeconomy Blueprint" for the United States describes the actions of the government in the area of bioeconomy based on the use of research and innovation in the biological sciences to create economic activity. The driving forces are economic growth, societal benefits, health and environment, as well as the USA being a leading nation in the field. The strategic objectives encompass: supporting R&D investments, facilitating transition from laboratory or market; forming and reforming regulations, adapting training and aligning institutional incentives, and supporting public-private partnerships (11, 19).

There is no official strategic document for bioeconomy in Canada, rather, the "Canadian Blueprint: Beyond Moose and Mountains" was published by BiotecCanada, an association representing the biotechnology sector in Canada. The document defines bioeconomy as biotechnology and used these terms interchangeably throughout the document. The importance of the bioeconomy and biotechnology is said to be its potential to increase quality of life, being an economic pillar for Canada and a means to regain and then stay at a top international position in the field. Success will be measured in at least three ways: the bioeconomy as percentage of GDP; growth in Canada's percentage of the world bio-based sector; and the world's adoption of Canadian biotechnology (19, 33).

An interesting development in bioeconomy development in Canada is the formation of

Bioeconomy Committee the British Columbia (BC) in 2011. The role of the committee under the direction of the Minister of Jobs, Tourism and Innovation was to investigate the opportunities for the province in the emerging bioeconomy. The outcome of the committee's work was published as a bioeconomy strategy for British Columbia (34).

Alberta, another province, also published a bioeconomy policy document in 2013. The report listed the driving forces for building the province's bioeconomy to include securing its economic future, advancing world-leading resource stewardship and investing in families and communities. Alberta's document presents a broad approach to bioeconomy and resembled the strategy of BC more than it resembles the document of BiotecCanada in the sense that it does not focus on biotechnology (35).

Sasson and Malpica reviewed how Latin American - has embraced bioeconomy in the last two decades. The study showed that the transition towards knowledge-based bioeconomy in representative countries in the region, including Argentina, Brazil, Costa Rica, Colombia, Chile, Mexico and Peru is highly dependent on the level of applicability of new technology developments in specific sectors of their economies as shown by high socio-economic impact is the implementation of GMO technology in agriculture . However, as in other regions of the world, Latin America faces significant challenges in its transition towards implementing new bioeconomy value chains, where technological readiness is at lower level and where the economy sector for its application is still building (36).

Countries with small gross national product are also adopting the principles of knowledge based bioeconomy. An interesting case is that of Cuba, which has reached high level achievements in implementation of biotechnology. The development of several enzymes, 150 therapeutic agents and several vaccines, demonstrates that developing countries can exploit technology just as efficiently as developed nations. Brazil also churned out more than 10 biotechnology incubator projects as companies, while India has emerged as a centre for enzyme production and drug development (2, 36).

Other countries relevant to the global bioeconomy but not included in this study are: Russia which launched an innovation strategy in 2010 entitled "Innovative Russia 2020" ; China which is pursuing a strong position in the bioeconomy with a special focus on biochemistry and life sciences ; Malaysia which has a vision for the creation of a bioeconomy , the BioEconomy Initiative Malaysia (BIM) was launched at BioMalaysia in 2011 in addition to the "National Biomass Strategy to 2020" ; and Brazil which issued in 2007 a decree including an annex detailing the development of its bioeconomy . Russia, China, Malaysia and Brazil are still developing their official national documents (19).

Only South Africa has published an official bioeconomy strategy in Africa. The "South Africa Bioeconomy Strategy" (2013) defines bioeconomy as "activities that make use of bioinnovations, based on biological sources, materials and processes to generate sustainable economic, social and environmental development". The majority of African countries have yet to develop any form of integrated bioeconomy development strategy. Countries such as Nigeria, Ghana, Namibia, Uganda, Ethiopia, South Africa, Kenya, Mozambique, Democratic Republic of Congo, Mali, Congo, Tanzania and Zimbabwe do have some bioeconomy development activities based on various crops and oil plants, but there is no evidence of any significant positive impact on the economy (37).

Within the South African context these may include, but are not limited to, technological and non-technological exploitation of natural resources such as animals, plant biodiversity, micro-organisms and minerals to improve human health, address food security and subsequently contribute to economic growth and improved quality of life. The key goal of the strategy is for bioeconomy to be a significant contributor to the country's economy by 2030 in terms of the gross domestic product (GDP). Other goals include food security, job creation and competitiveness. This is to be achieved through policy interventions like promotion of innovation, infrastructure and commercialization that will led to creation and growth of novel industries that generate and develop bio-based services, products and innovations (38).

2.3 The Nigerian Experience

In the quest for effective catch up strategy, Nigeria's government has declared biotechnology development as one of the two major concerns of the science and technology development initiatives (39). The National Office for Technology Acquisition and Promotion (NOTAP), was established by Decree No. 70 of 1979, amended by Decree No. 82 of 1992 now referred to as NOTAP Act cap 268 LFN 1994 in response to Nigeria's need to facilitate the emergence of a strong Science, Technology and Innovation (STI) system reflective of the desire to evolve a strong economy based on Science and Technology. NOTAP's activities include Evaluation/Registration of Technology Transfer Agreements; Promotion of Intellectual Property; Technology Advisory and Support Services; Commercialization of R& D Results; Research Industry Linkage; Maintenance of a Compendium on R&D activities in the country; Production and Publication of Industrial Project Profiles on SMEs, etc

The Federal Executive Council adopted a biotechnology policy and approved the establishment of the National Biotechnology Development Agency (NABDA) on the 23rd of April, 2001 to promote, coordinate and deploy cutting-edge biotechnology research and development, processes and products for the socio–economic well-being of the nation. In the year 2013, the Nigerian government created the

National Science Research Technology and Innovation Fund (NSRTIF) for the development of science and technology in the country (40).

The National Biosafety Management Agency (NBMA) was established by the National Biosafety Management Agency Act 2015. An act to establish the National Biosafety Management Agency charged with the responsibility for providing regulatory framework, institutional and administrative mechanism for safety measures in the application of modern biotechnology in Nigeria with the view to preventing any adverse effects on human health, animals, plants and environment.

Low levels of investment in research have been the major roadblocks for Nigerian scientists towards the development of biotechnology. Other problems include lack of infrastructure and skilled manpower, poor technological entrepreneurial culture, ineffective enforcement of intellectual property rights, and insufficient backing by the national government. The country also lacks the teaching and learning frameworks to generate the necessary domestic labor force for growing needs in the biotechnology sector (41).

The only available bioeconomy related policy is the National Biofuel Policy and Incentives 2007. The Policy Document developed by the Nigerian National Petroleum Corporation, NNPC was approved by the Federal Executive Council on June 20th, 2007 with a view to diversify fuel feedstock and to encourage agro-industrial development in Nigeria. The bio-fuel programme constitutes a major and unique attempt to integrate the agricultural sector of the economy with the downstream petroleum sector, while fostering the use of other renewable energy sources (42).

3. METHODOLOGY

This paper is primarily descriptive in its nature. This is because it attempts to draw lessons from how the bioeconomy is being envisioned and applied at different levels of governance around the world.

The approach of this paper is to systematically review academic papers, and publicly accessible documents from governments and their agencies supplemented by inclusion of opinion papers of civil society organizations about the bioeconomy.

Following Pfau *et al.* (26) and Fink (43), there was selection of key search terms, followed by application of screening criteria to identify relevant literature, followed by the review itself and finally, collation of findings. The conclusions drawn are presented in concise manner.

4. RESULTS AND DISCUSSION

The concept of bioeconomy has gained scientific and political attention during the recent years, with a number of countries, regions and industries creating strategies or declaring their intentions for the development of a bioeconomy. The list of countries with defined comprehensive, dedicated bioeconomy strategies are shown in appendix I. Only South Africa has a defined bioeconomy strategy in Africa. The bioeconomy-related policy strategies in African countries are shown in appendix II.

The study showed that due to the novel nature of the concept, the definition of the bioeconomy is not clear cut. The understanding and definitions are evolving and vary depending on the actors, motivation and objectives but display similarities such as emphasis on economic output and a broad, cross-sectorial focus.

The term bioeconomy (BE) is being used predominantly by the Organization for Economic Cooperation and Development, OECD. The European Union, EU uses the term bio-based economy (BBE) but without consensus among the member countries: it is called bioeconomy in Finland, but bio-based economy in Netherlands.

Analysis of bioeconomy strategies showed they are, as a rule, an integral part of the respective overall research and innovation policy of the governments and share important objectives with them. The concepts of sustainability and sustainable development are used as selling points for bioeconomy agenda and goals to allow various actors to make related commitments without necessarily undertaken any significant changes to their policies, strategies and actions. The common direction at regional level, as demonstrated by EU has led to bioeconomy to become the central component in shaping sustainable development in Europe.

Across the different national and regional strategies a range of vision and motivations for development of the bioeconomy are put forward. These include to address societal challenges; drive economic growth; climate change mitigation; reduce dependence on fossil fuel; transition to a more resource-efficient economy; and to achieve national pride of becoming a leader in sustainable economy. The policy interventions driving bioeconomies across the world are research, development and innovation; stakeholders engagement; and markets and competiveness.

The specific strategies to achieve the bioeconomy visions include support to R&D activities; education and training; knowledge enhancement and technology transfer; policy interactions and stakeholders engagement; commercialization; market development support; removal of regulatory barriers; public procurement mandates; and private-public partnership for business innovation.

Increasing population, demand for energy and goods, environmental pollution, mounting waste generation, etc., are some of the key drivers which can be considered favourable towards the development of Nigerian bioeconomy.

In my research, I identified several sectors which have an important potential in developing the bioeconomy sector in Nigeria. With significant availability of biomass resources and experience in refining, Nigeria is placed in a good position to become a leader in bioenergy (biogas, biofuel). This will reduce our dependence on fossil natural resources, prevent biodiversity loss and create new economic growth and jobs in line with the principles of sustainable development.

Pollution and huge generation of waste/wastewater is having enormous negative environmental impact and bioeconomy provides solutions for effective environmental management. Bioremediation, reusing the waste/wastewater after advanced methods, proper sanitary systems and solid waste management practices could address the environmental problems as well as feedstock issues in the framework of bioeconomy.

There are other potential contributors to bioeconomy development in Nigeria. Nigeria must embrace bioeconomy in the agrifood sector to deliver safe, accessible and optimized nutritional food to increasing population. Animal husbandry, veterinary medicine, aquaculture and fisheries should be adapted to the challenges of the 21 century.
Also Nigeria has potentially extremely valuable natural bio-resources that is not well exploited. Given the economic difficulties of the Nigerian medical system, medical and pharmaceutical biotechnologies should be harnessed to meet medical and pharmaceutical needs of the populace.

5. CONCLUSION

The next wave of economy is bioeconomy, which produces economic growth and wellbeing. Already many developed and developing countries are placing emphasis on the development of a bioeconomy, Nigeria and other African countries must not be left behind.
To advance a sustainable bioeconomy in Nigeria, this paper calls for the development of a holistic bioeconomy policy which must be an integral part of the national developmental agenda.
A responsible bioeconomy sector for Nigeria calls for effective governance and coordination to make it cut across all the relevant economic sectors.
Enhancing a competitive and productive bioeconomy requires target investment in research, innovation and skills; education and training; policy interaction and stakeholders engagement; market development support to enhance competitiveness; and demand side instruments while taking into account legitimate societal concerns and needs.
With appropriate political commitment across all arms of the federation, Nigeria could embrace bioeconomy to overcome a number of her environmental, social and economic challenges.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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Appendix I: Overview of selected specific bioeconomy strategy and policies documents.

Country or region	Publication Year	Document Title	Source	Perspectives	Priority areas
Australia	2008	Biotechnology and Australian Agriculture	ACIL Tasman	High-tech research and innovation. Blue economy. Regional bioeconomy development.	Biotechnology, agriculture, energy, marine sector and healthcare
International organization	2009	The Bioeconomy to 2030: Designing a Policy Agenda	Organization for Economic Cooperation and Development (OECD)		Biotechnology, agriculture, health and industry
Canada	2009	The Canadian Blueprint: Beyond Moose and Mountains	BioteCanada	High-tech research and innovation. Blue economy. Regional bioeconomy development.	Biotechnology
Germany	2009 2010 2011 2013 2013 2013	Combine Disciplines, Improve Parameters, Seek out International Partnerships. First Recommendations for Research into Bio-economy in Germay. Bio-economy Innovation National Research Strategy: Our Route Towards a Biobased Economy National Policy Strategy on Bioeconomy Bioeconomy: Baden-Wuerttemberg Path to a Sustainable Future Basic Points of a Bioeconomy Strategy for North Rhine-Westphalia	Bioeconomy Council Bioeconomy Council Federal Ministry of Education and Research Federal Ministry of food and Agriculture, BMEL Federal State Government Baden-Wuerttemberg Federal State Government North Rhine-Westphalia	Holistic bioeconomy development. Research and innovation. Regional bioeconomy development.	Agriculture, health, food and energy
Finland	2011	Distributed Bio-Based Economy: Driving Sustainable Growth	Finnish Innovation Fund (SITRA)		Efficient resource use and biomass refining
Malaysia	2011	Bioeconomy Initiative	Ministry of	Holistic	Biotechnology, agriculture,

		and National Biomass Strategy 2020	Science, Technology and Innovation	bioeconomy development.	forestry, fisheries, energy and chemicals
EU	2012	Innovating for Sustainable Growth: A Bioeconomy for Europe	European Commission (EU)		Food, resources, innovation and skills
USA	2012	National Bioeconomy Blueprint	White House Administration	Holistic bioeconomy development.	Biotechnology
Sweden	2012	Swedish Research and Innovation Strategy for a Bio-based Economy	Swedish Research Council for the Environment, Agricultural Sciences and Spatial Planning (FORMAS)	Holistic bioeconomy development.	Efficient resource use and research gaps
Russia	2012	Bioindustry and Bioresources – BioTech 2030	National Technology Platform	High-tech	Biotechnology, energy, forestry, marine sector, agro-industry and healthcare.
Austria	2013	*Austria Bioeconomy* Background Paper	*BIOS Science Austria and Austrian* Association for Agricultural Research (*AAER*)	Research and innovation.	Efficient resource, agro-industry, chemicals, timber industry and healthcare.
Netherland	2013	Framework Memorandum on the Bio-based Economy	The Dutch Cabinet	Green economy. Biobased economy.	Biotechnology, energy and chemicals
Belgium	2013	Bioeconomy in Flanders - The vision and strategy of the Government of Flanders for a sustainable and competitive bioeconomy in 2030.	The Flemish Interdepartmental Working Group (IWG) for the Bioeconomy	Regional bioeconomy development	Agriculture, forestry, fisheries, energy, agro-industry, chemicals, cosmestics and healthcare.
South Africa	2013	The Bioeconomy Strategy	Department of Science and Technology	Holistic bioeconomy development.	Bio-based products, services and innovations, agriculture, chemicals, industry and health
Finland	2014	The Finnish Bioeconomy Strategy	Ministry of Employment and the Economy in co-operation with the Ministry of Agriculture and Forestry and the Ministry of the Environment.	Holistic bioeconomy development.	Forestry, wood processing, chemistry, energy, construction, technology, food and health.
West Nordic Countries (Iceland, Greenland, Faroe)	2014	Artic Bioeconomy: Future Opportunities for Bioeconomy in the West Nordic Countries	The Nordic Council of Ministers Arctic Co-operation Programme	Holistic bioeconomy development.	Fisheries, agriculture, energy, aquaculture
France	2016	A Bioeconomy for France	French Ministry of Agriculture, Agri-Food, and Forestry.	Holistic bioeconomy development.	Agriculture, forestry, agrifood, energy, chemical, industry

Appendix II: Overview of selected bioeconomy-related policy strategies in Africa

Country	Document Title	Perspective
Ghana	National Bioenergy Strategy in Ghana (2014).	Bioenergy
Kenya	Strategy for developing the Bio-Diesel Industry in Kenya (2008). National Biprospecting Strategy (2011).	Bioenergy High-tech
Mali	Renewable Energy Strategy (Strategie Nationale de Développement des Energies Renouvelables en Mali) (2006). Biofuel Strategy (Strategie Nationale de Développement des Biocarburants en Mali) (2009)	High-tech Bioenergy
Mauritius	Ocean Economy 2013.	Blue economy
Mozambique	National Biofuel Policy and Starategy (Politica e Estrategia de Biocombustiveis (2009).	Bioenergy
Namibia	National Programme on Research Science, Technology and Innovation (2015).	Research and innovation
Nigeria	National Biotechnology Policy (2001) Biofuel Policy and Incentives (2007)	Research and innovation Bioenergy
Senegal	National Biofuels Strategy (2006). *Letter of Development Policy of the Energy Sector* (Lettre de politique de développement du secteur de l'énergie) (2008,2012)	Bioenergy Bioenergy
South Africa	The Bio-Economy Strategy (2013).	Holistic bioeconomy development.
Tanzania	National Biotechnology Policy (2010).	High-tech
Uganda	The Renewable Energy Policy for Uganda (2007). National Biotechnology and Biosafety Policy (2008). Biomass Energy Strategy Uganda (2014).	Bioenergy High-tech