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Transformative climate potentials: Role of chemistry and positioning Nigeria's leadership in space regulations for agricultural development and food security

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Abstract:
Transformative Climate Approach (TCA) is an adoptable and sustainable broad and systemic approach addressing climate change. TCA requires the knowledge of Chemistry to cause fundamental changes to environmental systems to reduce greenhouse gas emissions. In Nigeria, TCA is essential to enhance agricultural development and food security through climate transformational actions. TCA involves climate resilient practices of which Climate-Smart Agriculture (SCA) is a key strategy that integrates land management practices to tackle the challenges of climate change and food security. This tends to offer improved agricultural productivity, increase agroforestry, reduce deforestation, ensure food security, provide strong resilience and support small-holder farmers. Government plays a vital role in building the nations agricultural base. Thus, positioning Nigeria's leadership in climate and space regulations is necessary to: make policies that are climate-resilient, invest in agricultural research, build and improve climate information services and technologies and foster partnerships to drive progress in Nigeria's agricultural transformation. By leveraging these strategies, Nigeria's leadership can harness several transformative climate potentials including renewable energy, green infrastructure and low carbonisation to achieve sustainable agricultural development, improve food security and enhance the livelihood of its citizens.

Keywords: *Agriculture, Chemistry, Climate, Food Security, Leadership, Potentials, Regulations*

1. Introduction

Climate is the average weather condition that determines the general temperature of a place over a long time. Atmospheric condition of a place is determined by temperature, humidity, wind, air pressure, cloud cover, sunshine and precipitation (FME, 2025). Climate change refers to shifts in weather conditions and patterns over a long period of time. The shifts may be natural or anthropogenic in nature, with human activities contributing more largely to the climate change (Badru, 2020; FME, 2025).

At the moment, climate change is a serious multifaceted threat the world is facing (Dzahan *et al*, 2024). The phenomenon may be limited to a specific region or may occur across the whole earth. Climate change poses environmental, social and economic challenges on a global scale (Mendelsohn *et al*., 2006). The impacts of climate change are being felt by both developed and developing countries. Climate change impacts are felt on agricultural production, health, biodiversity, social and economic conditions and affect people and the environment in general (Dzahan *et al*, 2024). Effects of climate change are as summarised in Figure 1.

Transformation is a change in the fundamental attributes of natural and human systems (IPCC, 2019; FAO, 2022). Transformative Climate Potential (TCP), a code red moment and a wake-up call, is a comprehensive systemic approach to addressing climate change (Day, 2021). It is a transformative climate action (TCA) and strategies involving fundamental changes to societal and environmental perspectives to reduce greenhouse gas emissions, enhance resilience, and promote sustainable development.

Key aspects of transformative climate action include decarbonisation, resilience and adaptation to climate-related impacts, promotion of sustainable development pathways that balance economic, social and environmental considerations, and encouragement of societal, economic and environmental systemic changes to address the root causes of climate change (Fedelea *et al.,* 2019; Day, 2021; FME, 2025). TCA promises to mitigate and reduce greenhouse gas emissions in order to limit global warming to well below 2 °C and pursue efforts to limit it to 1.5 °C (Day, 2021; FAO, 2022).

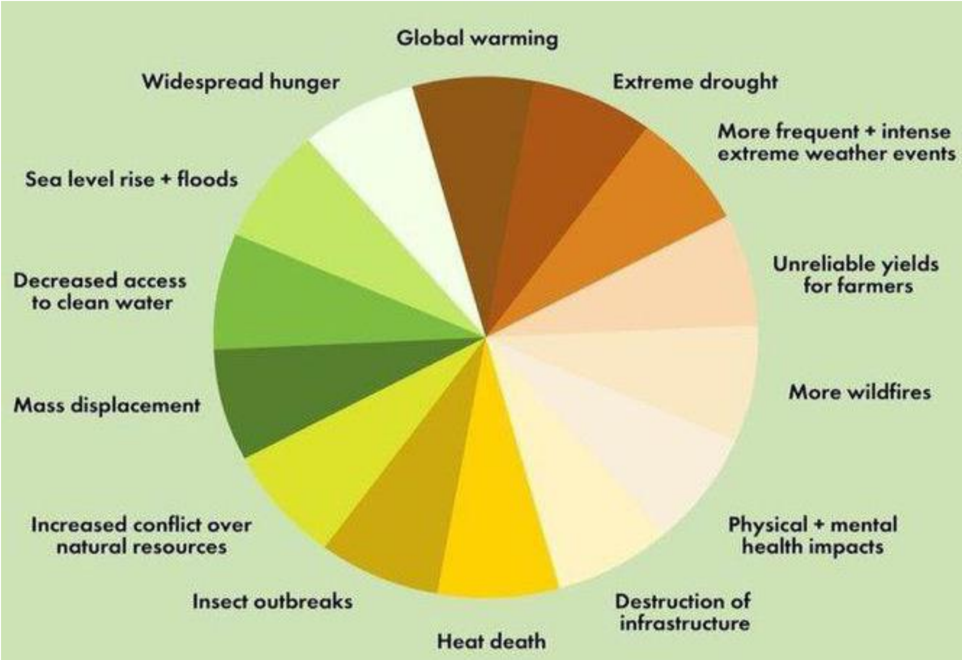

Figure 1: Climate Change Impacts (FME, 2025)

Examples of TCPs include:

a. Transitioning from fossil fuels to natural renewable energy sources like the sun, hydro and wind which can help keep the atmosphere clean.
b. Promoting circular economy where old things/wastes are reused/recycled.
c. Promoting climate smart agriculture: using high tech farming facilities to boost food production and general agricultural practices.
d. Urban and infrastructural redesign such as building energy-saving edifices and well- structured town planning systems.
e. Educating the workforce to learn new skills that can help protect the environment.
f. Employing and implementing carbon capture and storage (CCS) technologies that capture greenhouse CO_2 emissions and store them underground.

It is evident that addressing climate change and achieving the Sustainable Development Goals (SDGs) such as eradicating poverty and hunger by 2030, requires the transformation of food and agriculture systems (FAO, 2022; HLPE, 2020). To do these therefore, the knowledge of Chemistry is key in understanding natural phenomena like greenhouse effect, global warming, carbon footprint and Carbon Capture and Storage (CCS) as they affect/mitigate climate change (Muhammad *et al*., 2024; Okonkwo *et al*., 2024).

1.1 Role of chemistry in transformative climate potential

Chemistry plays a vital role in addressing climate change by providing innovative solutions to reduce greenhouse gas emissions and promote sustainability. Key areas where Chemistry makes a transformative impact include climate change mitigation strategies, greenhouse gas reduction, and chemical innovations for a sustainable future (Rapson and Dacres, 2014; Haider, 2019; FMAFS, 2024; Muhammad *et al*., 2024; Mustapha *et al*., 2024; Shi *et al*., 2024; Teila, 2024; USEPA, 2025).

1.2 Climate change mitigation strategies

1.2.1 Carbon capture and storage (CCS)

Chemistry enables the development of CCS technologies that capture CO_2 emissions from industrial sources and store them underground, preventing atmospheric release. This technology is crucial for industries like cement, steel, and energy production.

1.2.2 Renewable energy

Chemists are working on more efficient solar cells, wind energy technologies and biofuels to reduce dependence on fossil fuels. For instance, advancements in photovoltaic technology have led to the development of solar panels that convert sunlight into electricity through chemical reactions.

1.2.3 Sustainable materials

Chemistry contributes to the development of sustainable materials like bioplastics, which can break down more quickly and safely than conventional plastics. These materials reduce waste.

1.3 Greenhouse gas reduction

1.3.1 CO_2 Utilization

Chemists can explore ways to convert CO_2 into valuable products, such as stable carbonates through mineralization processes. This approach not only reduces atmospheric CO_2 but also creates valuable materials.

1.3.2 Methane Reduction

Understanding methane's chemical properties helps scientists to develop strategies to reduce its emissions from sources like livestock and landfills. Methane has a global warming potential of about 25 times greater than CO_2 over a 100 year period.

1.3.3 Nitrous oxide reduction

Chemistry plays a role in minimizing nitrous oxide emissions from agricultural practices, particularly through the use of synthetic fertilizers. N_2O has a global warming potential nearly 298 times that of CO_2.

1.4 Chemical innovations for a sustainable future

1.4.1 Green chemistry

Green Chemistry is a discipline that prioritizes reduced environmental impact and enhances material efficiency throughout product lifecycles. Green chemistry promotes the development of products that are less harmful to ecosystems and human health. Biofuels innovations have seen the light of the day through the knowledge of green chemistry. Chemists are developing methods to convert biomass into biofuels through processes like fermentation and transesterification. This approach provides a renewable alternative to gasoline and diesel, which can pollute the environment.

1.4.2 Energy-efficient processes

With the knowledge of Chemistry, exploration of alternative reaction pathways and catalysts that can operate under milder conditions, reducing energy consumption and emissions is made possible.

2. Impacts of climate change in Nigeria

Nigeria's climate has been changing. This is evident in increases in temperature, decline in precipitation leading to drought and desertification in the northern Nigeria, variable rainfall, rise in sea level and flooding in the southern Nigeria, land degradation; more frequent extreme weather events, losses of fresh water resources and biodiversity. Lake Chad and other lakes in the country are drying up and at risk of disappearing (Badru, 2020; Butu *et al.*, 2022).

The impacts of climate change in Nigeria vary across geographic locations. There are low and high precipitation regimes in the North and South respectively. Thus aridity, drought and desertification in the north and flooding and erosion in the South are eminent (Butu *et al.*, 2022; Kolawole, 2024).

In terms of vulnerability to climate change, northern states are more vulnerable than the southern states, with the Northeast and the Northwest being the most vulnerable. These regions experience rising heat and less rain, desert encroachment, loss of wetlands, reduced amount of surface water, and dying flora and fauna resources (FME, 2014). Within Southern Nigeria, the Niger Delta in the South-South region is the most vulnerable. This is due to increased precipitation resulting into rising sea level, coastal erosion and flooding with consequent displacement of many settlements (Haida, 2019; Matemilola, 2019).

Over 70 % of Nigeria's population engage in agricultural practices ranging from fisheries, animal husbandry to forestry. Farmers find it difficult to plan their operations due to unpredictable rainfall variations. Climatic variations have reduced agricultural productivities and productions (Anabaraonye *et al.*, 2019; Haida, 2019).

The effect of climate change on human health is inestimable. Human health is affected directly/indirectly by high temperatures, causing diseases such as meningitis and high fever. Indirect impacts of climate change are malnutrition caused by food shortages, outbreak of air and water-borne diseases such as typhoid and cholera, stemmed from polluted air, water and food contamination (Abdulkadir *et al.*, 2017; Haida, 2019).

Nigeria's economy and energy are adversely affected by climate change due to the undermining effects on the agricultural sector. Gross Domestic Product of the nation is reduced, productivity and infrastructures are lost to flooding. Low precipitation output in the North results into reduced availability of trees and loss of biomass for fuelling hydropower generators. On the other hand, excessive rainfalls in the South have resulted into damage of transmission lines and substation equipment. All of these bring about excessive spending in terms of recovering, and goes to tell on the economy of the nation (Ebele and Emodi, 2016; Anabaraonye *et al.*, 2019; Haida, 2019).

Climate change has impacted negatively on the security outlook of the country. Increased emigration of people from areas faced with encroached desertification into areas less threatened by desertification in search of food and water resources and for resettlement has constantly prompted communal and inter-ethnic clashes in different regions (Elisha, *et al.*, 2017; Haida, 2019). Example is the herders-farmer's clashes experienced in the country over the years till date, which affect food availability (Okonkwo, *et al.*, 2024).

2.1 Nigeria's transformative climate potentials

Nigeria's transformative climate agenda can offer several potentials. These may include: renewable energy, green infrastructure, low-carbon development, improved public health, increased energy access, enhanced climate resilience, climate-resilient infrastructure, sustainable agriculture and job creation (Obada, *et al.*, 2024; Ibrahim and Ibrahim, 2024).

Nigeria is capable of mitigating climate change by investing heavily on renewable energy sources such as solar, wind and hydropower and reduces dependence on fossil fuels. Investment in green infrastructure, such as green roofs, urban forests, and green spaces will mitigate the urban heat and improve air quality. Low-carbon development will reduce greenhouse gas emissions and promote sustainable economic growth. Adoption of clean energy and sustainable practices will reduce air and water pollution, and public health will be improved. Particularly in rural areas, increasing access to clean energy will promote economic development and improved living standards. Climate resilience can be enhanced through the adoption of climate-resilient practices, such as climate-smart agriculture and climate-resilient infrastructure.

Development of climate-resilient infrastructure such as sea walls and flood-resistant buildings are to protect communities from climate-related disasters. Implementing climate-resilient agricultural practices will enhance food security, improve livelihoods, and promote sustainable development (HLPE, 2020). Creation of jobs in the renewable energy, sustainable agriculture, and green infrastructure sectors will promote economic development and reduce poverty.

3. Nigeria's agricultural development and food security

Transformative climate potentials in agricultural sector involve adopting climate-resilient practices to enhance food security and sustainable development. Climate-Smart Agriculture (CSA) is a key strategy that integrates land management practices to address food security and climate change challenges (FMAFS, 2024). By leveraging CSA, Nigeria can:

a. Improve agricultural productivity, enhance crop yields and improve farmers' incomes.
b. Develop climate-resilient crop varieties, drought-resistant seeds, and innovative agricultural technologies to mitigate climate-related impacts.
c. Ensure food security by increasing food production and availability, particularly for Nigeria's growing population projected to reach 400 million people by 2050 (FMAFS, 2024; Kolawole, 2024).

3.1 Transformative climate potentials

There are roles for Nigeria's leadership in agricultural development and food security. Nigeria faced a significant climate finance gap, with an estimated annual need of $17.7 billion to meet its Nationally Determined Contribution (NDC) targets. The country received only $1.9 billion in climate finance in 2019/2020, highlighting the need for increased investment (Stout and Meattle, 2022).

To tap the transformative climate potentials for agricultural development and food security, Nigeria's leadership has a key role to play. The government is recommended to:

a. Formulate and implement comprehensive agricultural policies that support climate-smart agriculture, sustainable land use and climate-resilient infrastructure.
b. Invest in agricultural research by supporting research institutions and organizations to develop innovative agricultural technologies and climate-resilient crop varieties.
c. Enhance climate information services by providing advanced weather tracking technologies and climate simulation software to provide accurate climate information to farmers and stakeholders.
d. Foster Partnerships and collaboration with international development financiers, private sector stakeholders and state governments to drive progress in Nigeria's agricultural transformation and improved food security.
e. Encourage private sector investment in agriculture, especially in farm mechanization, storage, and processing to reduce post-harvest losses and increase food availability.
f. Offer financial support and market access to farmers, particularly smallholder farmers, to increase their productivity and income.
g. Improve and strengthen extension services to provide farmers with technical support, training, and advice on best practices.
h. Improve and enhance food distribution systems and increase access to nutritious food, particularly for vulnerable populations.

By adopting these strategies, Nigeria can harness transformative climate potentials to achieve sustainable agricultural development, improve food security, enhance the livelihoods of its citizens and promote economic growth.

4. Conclusion

To address the pressing challenges of climate change, transformative climate potentials hold significant promise, particularly in the context of agricultural development and food security. Chemistry plays a vital role in unlocking these potentials, from developing sustainable materials and technologies to enhancing the understanding of climate-resilient agricultural practices. The intersection of transformative climate potentials, chemistry, and space technology holds immense promise for Nigeria's agricultural development and food security. By leveraging chemistry-driven innovations and space-based solutions, Nigeria can enhance climate resilience, improve crop yields and ensure sustainable agricultural practices. Moreover, Nigeria's leadership positioning in space regulations is crucial to drive momentum innovations and economic growth, with improved food security and agricultural sustainability.

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