Driving Climate Smart Technologies for Food Security and Poverty Reduction in Nigeria Through the Ward Based Technology Cluster Programme: A case study of the Federal Ministry of Innovation, Science and Technology (FMIST), Abuja, Nigeria, illustrating national STI policy to address SDGs implementation challenges

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Abstract

The Ward Based Technology Cluster Programme (WBTCP) is a policy initiative of the Federal Ministry of Innovation, Science and Technology in Nigeria to tackle infrastructure poverty and poor service delivery in the agricultural sector at the 9,995 Wards (grassroots) of the 774 Local Government Areas in Nigeria. The Wards are lowest political authorities of government. The aim of this paper examines the importance of the Climate Smart Technologies that can help Nigerian farmers through the WBTCP to increase their productivity while adapting climate change and at the same time helping in the international effort to mitigate climate change.

Nigeria is richly endowed with natural resources that are inclusive of solid minerals, water resources, land resources, agriculture and agro-allied resources, etc. These resources remain untapped due to lack of appropriate technologies.

The Federal Ministry of Innovation, Science and Technology (FMIST) through some of its agencies has developed, acquired and piloted various technologies that have added value to local raw materials with substantial capacity to fast track development of rural communities in Nigeria. The expected output is climate mitigation and improved socio-economic indices through employment generation and wealth creation, in addition, to improving the social status of our people.

The WBTCP provides the platforms for the demonstration and further application of proven indigenously-developed technologies which will specifically transform identified natural resources, as well as provide housing, roads, create micro industries, foster critical development mass, and engage community development through effective partnership structures with improved marketing for achieving increased human capital and economic indices (Uket J., 2019).

It is a Ward based innovation clusters. These clusters at the various 9,995 wards (grassroots) in the country will captures the six geopolitical zones and the Federal Capital Territory (FCT), with the aim to empower people at the ward level with relevant technology for development and promote innovation.

Therefore, this grassroots oriented technological strategy which is enunciated on the principles of technology transfer and Technology Needs Assessment is better driven by the use of Climate Smart Technologies (CSTs) in order to tackle issues of climate change while enhancing agricultural production.

The proven success of Climate Smart Technologies in Agriculture, in some northern States in Nigeria has informed the need to deliver the WBTCP with CSTs (Dwary D., Wakawa R., 2022). Climate Smart Technologies are a host of clean low greenhouse gas emission technologies to facilitate adaptation and mitigation to achieve resilience directly and indirectly against climate change impacts globally in short, medium and long term in across all sectors.

The WBTCP is therefore designed to entrench a technological driven culture on the rural populace. It has a life-line component and potentials to leap-frog the expected quantum change in socio-economic lives of the people. Its core objective is to promote livelihood of the rural and community dwellers.

Problem Statement

According to a report of the National Bureau of Statistics (NBS), 2022), "In Nigeria, 40.1% of people are poor according to the 2018/19 national monetary poverty line, and 63% are multidimensionally poor according to the National MPI 2022. Multidimensional poverty is higher in rural areas, where 72% of people are poor, compared to 42% of people in urban areas".

Nigeria has not been able to derive appreciable benefits from her natural resources - solid minerals, water, land, agriculture and agro-allied products in terms of revenue, employment generation and exports. This situation is partly due to minimal value addition resulting from very limited use of indigenous and

acquired technologies; lack of synergies between government research institutions and funding organizations.

Furthermore, the potential of developing small scale manufacturing enterprises as the real prime mover of economic development in Nigeria has not been fully exploited in spite of all the natural resources that are bestowed upon the country. The underdevelopment of this sector is greatly responsible for the high rate of poverty and hunger.

The problem of achieving a sustainable growth of micro enterprises is multifaceted – technical, financial, management, marketing.

Justification

Technological Innovation is central to economic development, therefore; the technology portfolio of the FMIST must be connected to the grassroots level to end poverty and hunger. Notably, WBTCP relies on natural resources available at the ward level which require value addition that will lead to the development of micro industries in rural communities (Uket J., 2019). It is therefore critical to the actualization of the country's development agenda as it will catalyse National Industrial Revolution Plan (NIRP) through its multiplier effects. It is replicable and sustainable.

Specifically, the WBTCP is a Sustainable Development Goals (SDGs) enabled and tailored initiative of the Department of Technology Acquisition and Adaptation (TAA), FMIST, Nigeria.

The setbacks in the implementation of the WBTCP in the past years, has been largely due to lack of an appropriate Climate-Smart Technologies (CSTs) that will create an enabler for the WBTCP. This is why the use of CSTs has become an imperative.

Objectives

Primary Goal

To deploy indigenous technologies developed by FMIST to harness endowed natural resources and raw material in the country.

Main Objective

The main objective of the WBTCP is to fast track natural resources development through the deployment of developed indigenous technology.

Specific Objective

These objectives include:

i. Use CSTs to end poverty and hunger through proven technologies for value addition to raw materials or natural resources in rural communities thereby tackling the rising issues of poverty, hunger and food security. CSTs in Agriculture is acclaimed to potentially reverse the situation by eliminating poverty and food insecurity (A. Akpan, & D., Zikos, 2023);
ii. Create wealth and jobs, through spin off enterprises. This accelerates technology transfer through spin off. By launching a spin-off, the technology remains closer to its origin, creating job opportunities and tax revenues (Spin-off partners, 2024). Establishing spin-offs nurtures an entrepreneurial spirit within the community, encouraging young people to explore the possibility to establish their own business instead of looking for a job (Spin-off partners, 2024);
iii. Increase development of new products. This is to bring about rapid entrepreneurship development. The entails new products, improving on existing ones. Local businesses can use new technologies to produce new (NOUN, 2003);
iv. Build human and infrastructure capital. Technology is an enabler of human capital development (Nerdzfactory Company, 2023). Technology is undoubtedly a game-changer in the realm of human capital development. It breaks down barriers, provides access to resources, etc;
v. Enhance product competitiveness. "Competitiveness" is used interchangeably with "comparative advantage," "favorable business environment," and "productivity," for example. Furthermore, underlying structural factors that influence productivity may not show up directly in measures of competitiveness but may account for improved terms of trade (Raj N., & Brenda G., 2013); and
vi. Encourage Gender re-orientation - gender reorientation (approximation of the status of the opposite biological sex) on the other (Ray B., et al, 1983). As children move through childhood and into adolescence, they are exposed to many factors which influence their attitudes and behaviors regarding gender roles in the grassroots communities. These attitudes and behaviors are generally learned first in the home and are then reinforced by the child's peers, school experience, television viewing and social media.

Expected Outcomes of the WBTCP

- Tackle climate change and its effect on the agricultural sector;

- Increased revenue and growth in the national GDP;
- Employment creation;
- Improvement living standards;
- Stimulation and enhancement of competitiveness;
- Increased local productivity;
- Increased income;
- Value addition and resultant transformation of the natural endowments of every ward into value-added and marketable products and services;
- Wealth generation; and
- Gender re-orientation.

Policy Context

The key policies in place is the National on Science, Technology and Innovation Policy (NSTIP, 2022) which advocates for ensuring R & D activities are directed towards the development of appropriate technologies for the production of industrial goods and services in small, medium and large scale firms; as well as foster the National Industrial Revolution Plan (National Science, Technology and Innovation Policy (NSTIP), 2022).

The first National Science and Technology Policy in the country was produced in 1986. The policy was designed to create harmony in the pursuit of knowledge about the environment through Research and Development (R&D). The aim of this policy is to use STI knowledge to ensure a better quality of life for the people (Uket J., 2019).

The NSTIP prioritises building adequate skills and competence in the Science, Technology and Innovation ecosystem for comprehensive implementation, monitoring and evaluation, among Nigerians.

The National Science, Technology and Innovation Policy (NSTIP) is in tandem with the objectives and pillars of the NDP 2021-2025 (in line with the Nigeria Agenda 2050). The 2022 revised STI policy is articulated to develop and utilise STI to build a large, strong, diversified, sustainable and competitive economy that guarantees a high standard of living and quality of life for the citizens (NSTIP, 2022).

The cardinal objectives of these successive plans of lifting 100 million Nigerians out of poverty by the year 2030, is specifically by expanding business growth; entrepreneurship and industrialisation; enhanced social inclusion and reduced poverty.

Beneficiaries of the WBTCP

- Cooperative Societies in the rural communities;
- Community Development Committees;
- Local Government areas;
- Investors and entrepreneurs;
- Women and youth; and
- Climate justice advocates.

Collaborators of the WBTCP

- NASENI –National Agency for Science Engineering and Infrastructure
- NBRRI –Nigerian Building and road Research Institute
- NACETEM –National center for Technology Management
- ECN –Energy Commission of Nigeria
- RMRDC –Raw Materials Research and Development Council
- PRODA –Project Development Agency
- FIIRO –Food and Industrial Research Oshodi
- NABDA –National Biotechnology Development Agency
- SHESTCO –Shade Science and technology Complex
- LGAs –Local Governments Areas
- Cooperative Societies
- FMIST – Federal Ministry of Innovation, Science and Technology

Implementation Plan

The WBTCP implementation plan is critical to achieving all its components. The plan is streamlined with respect to stakeholders, location and funding.

WBTCP Workplan/Activities

- Ward Population Analysis;
- Technologies Chosen to Leverage Existing Ward Natural Resources;
- Review of existing ward housing structure & needs assessment;
- Market Analysis to explore what is feasible in each ward;
- Assessment of the availability of potable water;
- Inventory of existing road structure and feeder road requirements;
- Estimation of energy demand for project & household utilization;
- Pilots in 9 locations;
- Construction of Model Feeder roads;
- Construction of Model Houses using local resources;
- Improvement of Production Capacity for local bio-resources;
- Establishment of Micro and Cottage industries to promote value addition to the local resources; and
- Provision of power for rural electrification;

Implementing Agencies/Key Partners – Roles

Figure 1. Showing implementing agencies/key partners and their roles

Agencies/partners	Role(s)
FMIST	Coordination, Monitoring and Evaluation
FMIST's Participating Agencies	Deployment of indigenous technologies
Pilot Communities	Provision of land
SMEs	Facilitate awareness/commerce
L.G.As	Provision of land and support
*Private Sector	Support, funding, investment
*Federal Ministry of Finance, Budget and National Planning	Funding
*DONORS/Development partners	Funding, investment
* National Information Technology Development Agency (NITDA)	Technical Support
*Nigeria Meteorological Agency (NIMET)	Technical Support
*Civil Societies Organizations (CSOs)	Technical support
*Media	Publicity/technical society

Note: (*) proposed partners. Source: FMIST/TAAD.

Monitoring and Evaluation/Key Performance Indicators (KPIs)

- 18 proven technologies deployed in the 6 Geo-Political zones in the year 2027
- 7200 jobs (direct and indirect) created by the technologies by the year 2027.
- 72 new products in the market by the year 2027
- Achieving SDGs

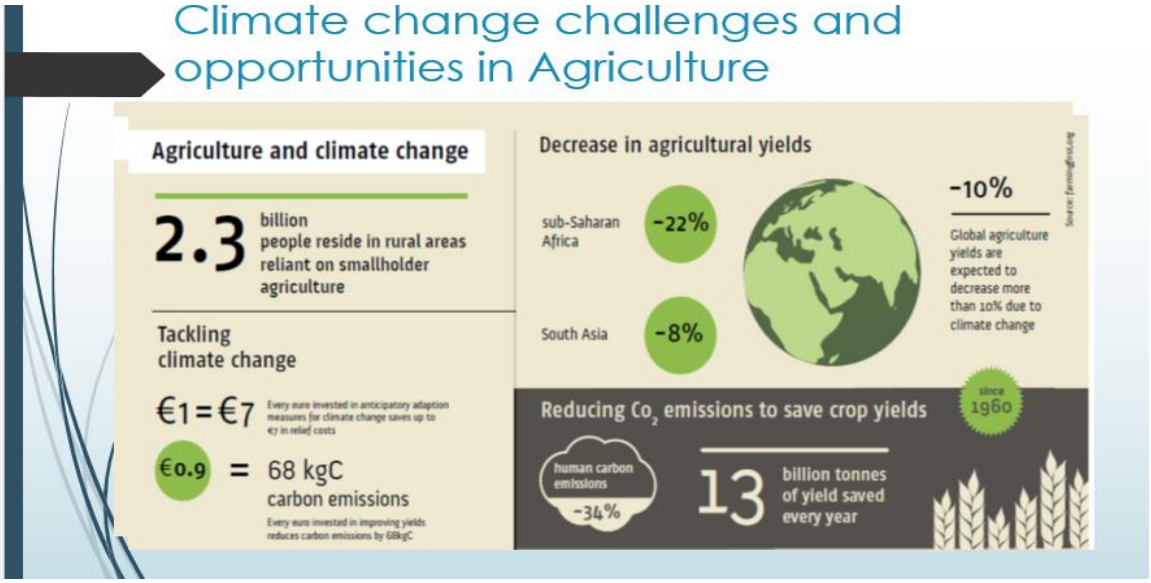
Programme Description in relation to Climate-Smart Technologies (CSTs)

Climate change is a global threat to the food and nutritional security of the world (Gurdeep M., Manpreet K., et al, 2021). Similarly, agriculture is the most vulnerable sector to climate change, owing to its huge size and sensitivity to weather parameters, thereby causing huge economic impacts.

There are a lot of climate change challenges and opportunities in agriculture. There are about 2.3 billion people in rural areas reliant on smallholder agriculture. The high CO2 emissions has decreased agricultural yields. Reducing CO2 emissions will help to save crop yields, and this could amount to approximately 13 billion tonnes of yield saved every year.

The Figure 1 below show climate change challenges and opportunities in Agriculture.

Figure 1. Climate change challenges and opportunities in Agriculture



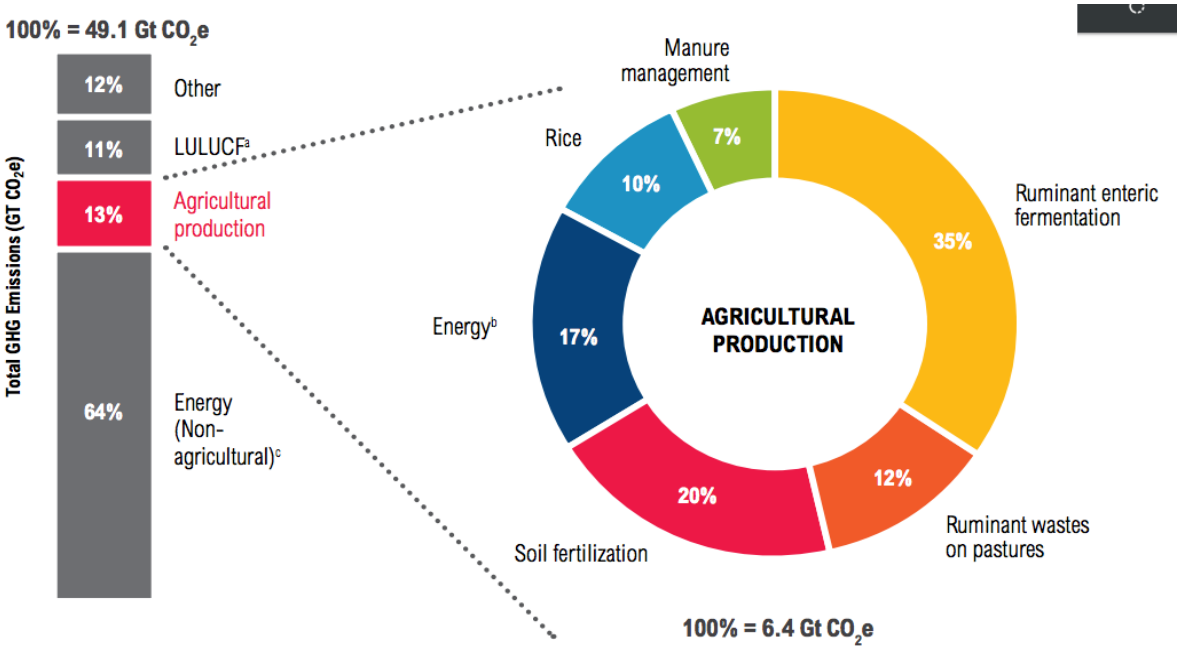
Source: Gwary D., 2020

Agricultural Greenhouse Gases Emission

- Agriculture, forestry and other land use activities emit more than 10 billion tonnes of greenhouse gases; and
- Farms emitted 6 billion tonnes of GHGs in 2011, or about 13 percent of total global emissions. That makes the agricultural sector the world's second-largest emitter, after the energy sector.

The Figure 2 below shows the agricultural sector as the world's second-largest CO2 emitter.

Figure 2. Agricultural sector as the world's second-largest CO2 emitter



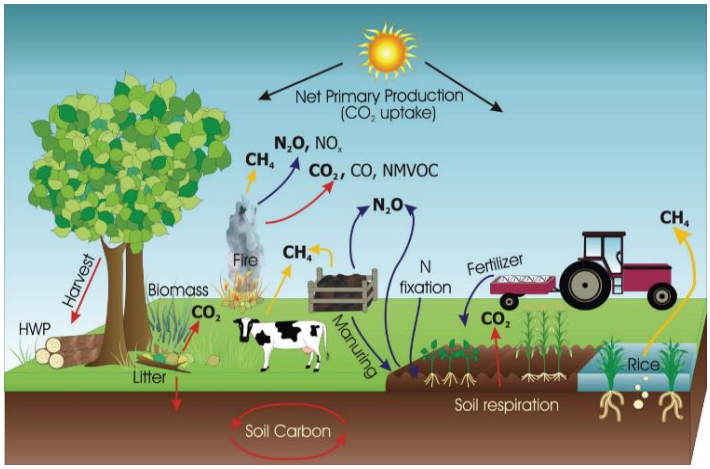
Source: Quora.

Agriculture is a Source and Sink of Greenhouse Gases

- Farming emissions come from a variety of sources that differ depending on the type of farm.
- Trees & vegetation generally as well as undisturbed soils are good sinks of carbon

The greenhouse gases which constitute climate change comes from different sources, but the net primary production is CO2 uptake as shown in the Figure 3 below:

Figure 3. Impact of Greenhouse gases on Agriculture and food production

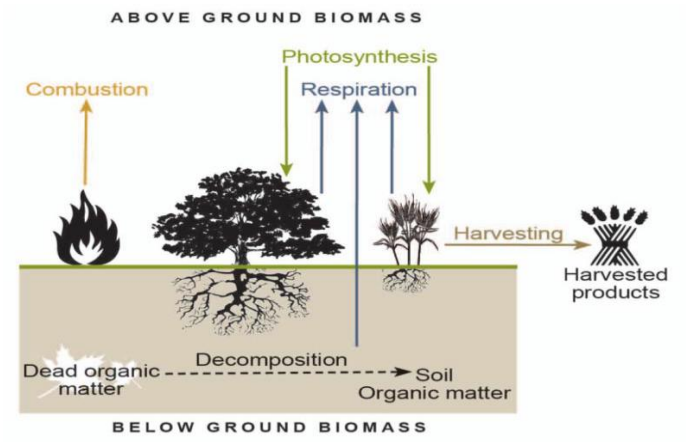


Source: ResearchGate

Furthermore, Semi-natural habitats are considered as the main source of biodiversity in agricultural landscapes (Rémi D., Stéphanie A., 2014). Above–ground biomass (AGB) and below–ground biomass (BGB) for forests, grasslands and shrublands are key factors for harvest of agricultural produce in rural areas in Nigeria.

The above ground biomass and below ground biomass are important components in achieving results (harvests). The products (new and improved) will be determined by the state of the biomass or biomass activities. The following Figure 4 shows these biomass activities.

Figure 4. Biomass activities



Source: Wine Institute

Is Climate-Smart Technology (CST) proposed as an innovative solution?

Climate-Smart Technology (CST) also known as Climate-Smart Agriculture (CSA) Technologies, is proposed as a solution to transform and reorient WBTCP agricultural systems to support food security under the new realities of climate change. This can be achieved by the following proposed innovative practices that enhance productivity, adaptation and mitigation.

i. Productivity Practices: Example, expansion of agricultural land, increased use of mechanization, fertilizers and other inputs;
ii. Adaptation Practices: Example, diversification of crop, livestock, and fisheries; improved on-farm and off-farm storage;
iii. Mitigation Practices: Example, reforestation, decreased livestock production, agroforestry options that have low food benefits;
iv. Productivity – Adaptation Practices: Examples, improved irrigation infrastructure and weather forecasting;
v. Productivity – Mitigation Practices: Examples, use of high-yielding varieties
vi. Adaptation – Mitigation Practices: Examples, on-farm production and use of biofuels;
vii. Productivity – Adaptation – Mitigation Practices: Practices that benefit food productivity, adaptation and mitigation. Examples, restoration of degraded land, improvement of macro- and micro- nutrients in soils.

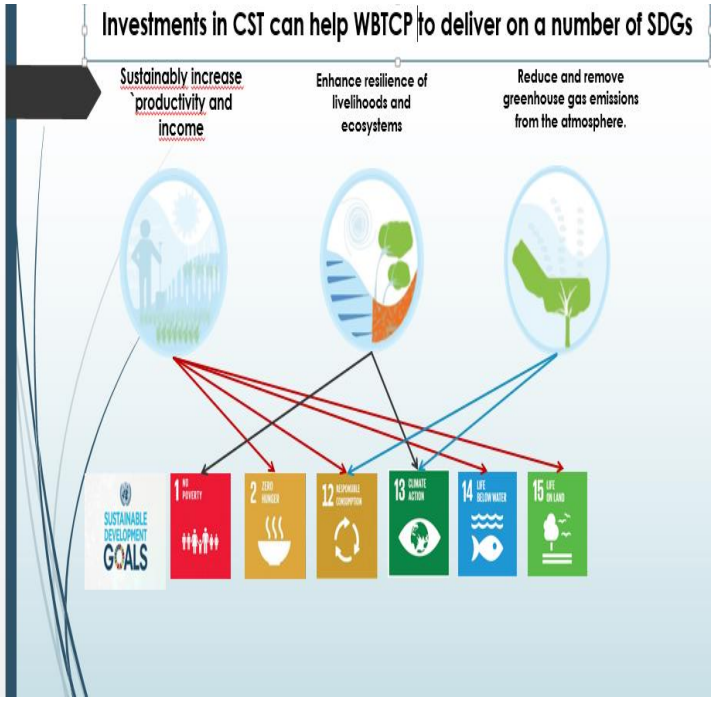
Can Investments in CSTs help WBTCP to deliver innovative solution on a number of SDGs?

Corresponding investments in CSTs can help WBTCP to deliver on a number of SDGs in Nigeria in the following ways:

i. Investment to sustainably increase productivity and income – would deliver SDGs 2, 12, 14 and 15;
ii. Investment to enhance resilience of livelihoods and ecosystems – would deliver SGDs 1 and 13; and
iii. Investment to reduce and remove greenhouse gas emissions from the atmosphere – would deliver SDGs 12 and 13.

The Figure 5 below illustrates how WBTCP can deliver the proposed innovative solution on a number of SDGs.

Figure 5. How CST delivers SDGs through WBTCP



Source: Gwary D., 2022

What are the viable innovative Climate-Smart options for WBTCP?

The types of climate-smart options for WBTCP in Nigeria are:

i. Weather-smart activities: Examples, weather forecasts, climate-informed, agro-advisories, weather insurance, climate, analogues, etc;
ii. Water-smart practices: Examples, rainwater harvesting, community, management of water, laser-land levelling, micro irrigation, raised-bed planting, solar pumps;
iii. Seed/breed smart: Examples, adapted varieties and breeds;
iv. Carbon/nutrient-smart practices: Examples, agroforestry, minimum tillage, etc; and
v. Institutional/market smart activities: Examples, cross sectoral, linkages, local institutions including learning platforms or farmer-to-farmer learning and capacity development.

What are the types of Crops for which Climate-Smart techniques are being promoted?

- CSTs in Agriculture have been profiled in Borno, Adamawa and Yobe States of Nigeria, where so many farmers face many challenges of food production due to impacts of climate change and insurgency leading to large number of internally displaced persons (IDPs);
- CSTs in Agriculture are available for all cereals i.e. Rice, Maize Sorghum, Millet and grain legumes such as soybeans, groundnuts and cowpea across 11 northern Nigeria;
- The benefits of the use and promotion of the profiled CSTs in Agriculture are:
  - Increased crop productivity and increase income for farmers;
  - Adapting to climate variability and climate change and increased resilience; and
  - Assist in the national and International efforts to mitigate climate change by reducing GHG emissions (Gwary D., Wakawa R., 2022)

Can Climate Information Services be used for early warning and decision making in Agricultural Systems of the WBTCP?

Using climate information Service (CIS) for early warning and decision making in agriculture systems of the WBTCP can be applied in the following ways:

i. Before: This include seasonal forecast (crop variety, varieties);
ii. During cropping season: This include nowcasting (flooding saving life [thunder]), daily forecast (use of fertilizer/pesticide), ten-day forecast (weeding, field work), and updating seasonal forecast (second cropping);
iii. Maturity/end season: This include ten-day forecast (optimum harvesting period, rain during dry season).

Therefore, the dissemination of CIS workshops, Participatory Integrated Climate Services for Agriculture (PICSA) approach, rural radio, mobile phones and social media is imperative to prepare

beneficiaries of the WBTCP through the stages (sowing, vegetative stage, reproductive stage and harvest).

Strategic Implementation Plan of the CSTs in the WBTCP

- **Phase 1(Two Farming Seasons):** Introduction and testing of CSTs practices on four cereals and three grain legumes across farming communities in North-East geopolitical Zone (Borno, Adamawa and Yobe States) of Nigeria including IDPs returnees communities for two seasons;
- **Phase 2 (Two Farming Seasons):** Introduction and testing of CSTs practices on four cereals and three grain legumes in selected pilot farming communities in the remaining nine drought frontline states of Nigeria (Jigawa Gombe, Bauchi, Kano, Kaduna, Katsina, Zamfara, Sokoto and Kebbi) for two seasons (Gwary D., 2020); and
- **Phase 3 (Two Farming Seasons):** Introduction and testing of CSTs practices on maize and rice cereals and cassava and yam in the middle belt and southern States for two seasons and across all other geopolitical zones including the Federal Capital Territory.

Proposed Cost of Implementation of CSTs in the WBTCP

Estimated Cost of Implementation

- Phase 1(Two Farming Seasons): USD550,000.00
- Phase 2 (Two Farming Seasons): USD750,000.00
- Phase 3 (Two Farming Seasons): USD1,000,000.00

Expected Outcome/Targets/Beneficiaries of CSTs in the WBTCP

- In phase 1, over two million farmers will be contacted and impacted including IDPs returning to their communities;
- In phase 2, over five million farmers will be reached with CSA Technologies;
- In phase 3, over twenty million farmers will be reached with CSA Technologies.
- These would deliver the overall objective of the WBTCP efficiently, productively and effectively in the rural communities.

Policy recommendations

Climate change disrupts food markets, posing population-wide risks to food supply. Threats can be reduced by increasing adaptive capacity of farmers to combat the challenge (Food and Agricultural Organization of the United Nations, 2014).

Climate-Smart Technologies (CSTs) play a crucial role in the Ward-Based Technology Cluster Programme (WBTC) innovation equation. These technologies aim to address climate change challenges while simultaneously enhancing agricultural productivity, building resilience, and reducing emissions. When WBTCP typically integrate CSTs into the innovation strategies, it would help to achieve sustainable development goals in Nigeria; and further, empower farmers and communities to adapt to climate change, improve food security, and contribute to a more sustainable future.

Therefore, there is a need to undertake national CSTs profiling in the agricultural sector using the WBTCP as a model in order to effectively tackle the issues of climate change and achieve the SDGs in Nigeria. In view of this, the following policy recommendations are hereby made:

i. Enhancing funding opportunities: Funding opportunities are critical towards the success of the WBTCP and this must be diversified to reflect multi-funding by stakeholders nationally and internationally. This will move the WBTCP from the limitations of annual budgetary provisions;
ii. Enhancing access to information and resources: Climate-smart technologies like mobile apps, sensors, and online platforms can provide farmers in rural areas with access to real-time weather data, market information, and best practices for climate-smart agriculture. This empowers them to make informed decisions and improve their productivity;
iii. Facilitating collaboration and knowledge sharing: Technology can connect farmers, researchers, and extension officers within and across wards, fostering knowledge exchange and collaboration on climate-smart practices. This can lead to the development of locally-adapted solutions and accelerate the adoption of climate-smart technologies;
iv. Improving efficiency and resource management: Climate-smart technologies can optimize water use, reduce fertilizer application, and promote soil health. This leads to increased efficiency, reduced environmental impact, and improved resource management within the cluster;
v. Promoting market access and value addition: Technology can connect farmers to markets and buyers, enabling them to sell their produce at better prices. Additionally, it can

facilitate value addition activities like processing and packaging, further increasing income and economic opportunities;

vi. Strengthening monitoring and evaluation: Technology can be used to monitor the impact of climate-smart technologies and practices, allowing for adjustments and improvements to the programme. This ensures that the programme remains effective and adaptable to changing circumstances;

vii. Enhanced Productivity and Sustainability: Implementing CSTs in rural Nigerian communities can enhance the productivity and sustainability of smallholder farmers. These technologies allow farmers to optimize production while minimizing negative impacts on the environment;

viii. Climate Change Resilience: Smallholder farmers face climate change-induced challenges such as erratic rainfall patterns and extreme weather events. CSTs can help farmers adapt to these changes by providing real-time weather data, precision irrigation, and crop management techniques;

ix. Market Access and Information: Integration of digital platforms with CSTs enables smallholder farmers to access critical market information. Farmers can make informed decisions about crop selection, pricing, and market timing, leading to better prices for their products;

x. Creating an Enabling Environment: Policymakers and stakeholders should create an enabling environment that incentivizes farmers to adopt CSTs. This includes providing training, subsidies, and infrastructure support for technology adoption; and

xi. Establishing Climate Smart villages/models: This would help policymakers and stakeholders to develop variety of models using CSTs. For example, Systems of Rice intensification (SRI) is a climate smart farming method that helps to lower greenhouse gas emission from rice production, while simultaneously improving farmers yields by up to 100% and increasing incomes for farming communities. The existence of the WBTCP as a climate smart village or model will product agricultural produce diversification within same rural communities.

Conclusion

There are a lot of climate change challenges and opportunities in agriculture in Nigeria. However, this is better harnessed by WBTCP, which relies on natural resources that requires value addition; and; these natural resources are available at the ward level, and its processing is certain will lead to the development of micro industries in rural communities in Nigeria.

Accordingly, with the successful implementation of CSTs in Agriculture in some Northern States in Nigeria, which has improved the agricultural produce of rural farmers, the potentials of the WBTCP lies in the proper utilization of Climate-Smart Technologies (CSTs). The CSTs have emerged as innovative solutions that seek to revolutionize traditional agricultural practices by leveraging enabled sensors and automation and using data analytics to boost yields, reduce costs, and increase profitability.

With Nigeria's largely agrarian rural population, the adoption of CSTs has the ability to transform the country's agricultural sector significantly. The implementation of WBTCP with CSTs in rural Nigerian communities can enhance the productivity and sustainability of smallholder farmers, particularly in the face of climate change-induced challenges (Otitoju M., Fidelis E., et al, (2023)). By utilizing advanced Climate-Smart techniques and technologies through the WBTCP, rural farmers can optimize production while minimizing negative impacts on the environment in Nigeria.

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