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IMPACT OF CLIMATE CHANGE ON FOOD SECURITY, ITS CONSEQUENCES AND MITIGATION

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Abstract
Food insecurity is a global public health concern and is being aggravated by climate-change. This paper discussed the impact of climate-change on food-security, its consequences and mitigation. Keywords such as "climate-change", "food-security", "food insecurity", "causes", "consequences" and "mitigation strategies" were searched for on Google and other climate-change-related journals. Climate-change is caused by methane and carbon dioxide emissions from the use of coal for heating, deforestation, landfills for garbage, energy, industry, transport, buildings, agriculture and land use, gas flaring, vehicle and generator fumes. Climate-change has both positive and negative effects on food-security. It increased the suitability of some countries for growing cereal crops but reduced crop productivity in some. It reduced cereal yields, production and nutrient content of fruits and vegetables, low food crop quality, quantity and safety, reduced shellfish productivity, crop and livestock losses, food animals and overall milk production, induced food shortage, nutrient scarcity and low food diversity, high cost of food leading to poor food availability, accessibility and utilisation causing global and national hunger thus precipitating malnutrition. Mitigation includes the use of irrigation, flood protection of farmlands and crops, modifying/improving farming practices, breeding crops more resilient to biotic and abiotic stresses, diversification, reduction of food losses and wastage, consumption of planet-healthy diets, efficient use of climate data and forecasts and control of pests. Climate-change is one of the key factors in food insecurity. Establishment of climate-change policies, a sustainable food system, and resilient strategies to discourage environmental pollution, production of carbon dioxide and other greenhouse emissions is crucial.

Key Words: *Causes, Climate-Change, Consequences, Food Insecurity, Mitigation.*

Introduction
Climate change occurs as a result of long-term shifts or changes in the usual climate of the planet that lasts for a few decades or millions of years in terms of temperature and weather patterns such as precipitation and wind (United Nations, 2022; YouMatter, 2022). Climate change is caused by the release of carbon dioxide (CO_2) and other heat-trapping gases known as Green House Gases (GHG) into the atmosphere thereby depleting the ozone layer and this leads to an increase in the earth's surface temperature due to direct heating of earth's surface by the sun (Okoli and Ifeakor, 2014). Global warming is not uniform but it shows that many regions of the earth are getting warmer

than cooling. The future level of global warming will depend on the amount of greenhouse gases emitted into the earth. It refers to the rise in global temperatures due mainly to the increasing concentrations of greenhouse gases in the atmosphere such as carbon dioxide, methane, nitrous oxide and fluorinated gases such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6), and nitrogen trifluoride (NF3) (U.S. Environmental Protection Agency, 2021). The main causes of climate change have been variations in the solar cycle and human activities (United Nations, 2022). These human activities include the use of gasoline for driving a car, the use of coal for heating a building, clearing land and forests can also release carbon dioxide, and landfills for garbage are a major source of methane emissions, energy, industry, transport, buildings, agriculture and land use, gas flaring, fumes from vehicles and generators, deforestation and agriculture. Burning fossil fuels and clearing forests add about eleven (11) billion metric tons of carbon (about 40 billion metric tons of carbon dioxide) to the atmosphere each year. Because this amount of carbon is more than that the natural processes can remove, atmospheric carbon dioxide increases each year (Lindsey and Dahlman, 2022). It has been reported that agriculture contributes very significantly to climate change. Globally, agri-food systems account for about 30 % of greenhouse gas emissions (GHGs), especially from livestock. About 14.5 % of global greenhouse gas (GHG) is produced by the livestock industry (Ajilogba and Walker, 2021). If the current trends continues, food production alone will exceed global targets for total greenhouse gas emissions (Fears, 2020). Effects of climate change include extreme weather events, droughts, floods, new rain patterns and heat waves.

Sustainable Development Goals (SDGs) also support the achievement of food security. SDG 1: states "No poverty - end hunger in all its forms everywhere" while SDG 2 says "Zero hunger - End hunger, achieve food security and improved nutrition and promote sustainable agriculture". It is obvious that climate change if not reduced, will be a limiting factor to the realisation of SDG2 by 2030. The indicators of food security are food availability, accessibility, utilisation and stability.
The aim of this paper is to review the impact of climate change on food security, its consequences and mitigation.

Conceptual Review

Effect of climate change on food production (Agriculture)

Climate change results in increased demand for soil nutrients, moisture, water availability and consequently affects food production and food animals' welfare. Agriculture produces the food eaten by humans and animals and it is the primary source of livelihood for 36 % of the world's total workforce (ILO, 2007). Climate change affects agriculture as agriculture affects climate change. The two are seriously interconnected. Agriculture, forestry, and fisheries have all been affected by climate change and they have contributed to the increase in greenhouse gas emissions (Ajiliogba and Walker, 2021). Climate change has a positive effect on agriculture as it increases the suitability of Northern Europe for growing cereal crops, but will reduce crop productivity in large parts of Southern Europe although the growing season there might shift into winter in partial compensation. In some countries such as Australia, increase in temperature, has led to the reduction in fungal growth and mycotoxin production and this might result in low

food production, food contamination and low yield (Lake et al. 2012). Climate change also negatively affects the yield of vegetables and fruits thus resulting in future nutritional health consequences (Fear, 2020). The negative effect of climate change on food production increases food insecurity and food nutrition due to its impact on farm lands. This is because pronged food insecurity results in hunger and starvation which precipitates undernutrition. Globally, climate change is affecting agriculture in all regions and countries. In European Union for example, there is climatic changes in temperature, precipitation, extreme weather events, wild fire and variation in patterns of pests and diseases. Some of the climatic impacts include reduced cereal yields in Southern Europe, reduced yield and nutrient content of fruits and vegetables, changing fisheries and expanding distribution of livestock infections (Fear, 2020). Modelling future impacts, subject to the severity of climate change, indicates potentially large reductions in yields in central and southern Europe. Increasing atmospheric concentrations of CO_2 may have additional effects on crop quality and quantity.

Climate change affects the production of fishes and livestock. Warmer temperatures affect the habitats of species of fishes and shellfish. It causes fish stocks to migrate from tropical to temperate latitudes, thereby causing the disappearance of local variations. Climate change causes ocean acidification which reduces shellfish productivity. It decreases production of livestock. It has been reported that consumption of water by livestock is expected to increase by a factor of three thereby leading to about 70 % increase in demand for agricultural products (Ajilogba and Walker, 2021). Globally, cattle are the number one agricultural source of greenhouse gases. Methane from cattle is shorter lived than carbon dioxide but 28 times more potent in warming the atmosphere. Cows and other ruminants account for 4 % of all greenhouse gases produced in USA and beef cattle 2 % of direct emissions (Quinton, 2019).

Food safety issues is also important because about one-third of the world's cereal harvest is used for animal feed (Rojas-Downing et al. 2017). Increasing temperatures might lead to the death of some food animals and reduction in the overall milk production. Temperature affects most of the critical factors for livestock production, such as water availability, weight gain (feed conversion ratio), reproduction (semen quality, cow calf efficiency), and general health. A combination of increases in temperature, CO2, and variability influences the quantity, quality, and availability of forage and grain feed crops. Recent assessment indicates an increasing probability of weather hazards occurring at the same time in the world's major food-producing regions (Europe, North America and Asia) with the potential for world food system collapse (Fears, 2020). Climate change will affect everybody directly or indirectly, even though some populations and settings are more vulnerable than others. Vulnerable groups to climate change include children, the elderly, migrants and the sick.

Climate change-related increases in pests, weeds and diseases: Temperature increases have led to an increase in the distribution of weeds, pests and diseases some of which are threats to marine life, plants, animals and humans (Ajiogba and Walker, 2021). Climate change influences the trends in seasons and the prevalence of disease-causing organisms and vectors thus increasing the use of herbicides and fungicides (Zinyemba et al. 2020).

Higher temperatures create imbalances in natural systems, causing more outbreaks and damage from unwanted pests and weeds (Peterson, 2021). The reactions will vary according to crops and geographical locations. It also results in decrease and extinction of some animals and flies such as dragon flies and damselfly in USA (Beyond Pesticides, 2022). Climate warming also leads to global change in the distribution of crop pests and their resistance to pesticides (Chun-Sen et al. 2021). Warmer weather conditions encourage wheat stem rust infections thereby hindering wheat production in some countries such as Germany (Olivera et al. 2017; Saunders et al. 2019). The recent increase in termites' colonies due to climate change threatened yam yield in Southern Nigeria (Nwaogu, 2020). All these affect crop yield, quality, quantity and human health. Climate change also influences the adaptation of disease pathogenes to the environment leading to new disease outcomes (Lindsey and Dahlman, 2022). Plant diseases affect crop yield and the quality of the grain or products as a result of toxins released into these crops by disease pathogens and this reduces the quality of the crop and can also cause infection in both animals and humans (Gururani et al. 2012).

Some other consequences of climate change are soil erosion and flooding. Increase in extreme weather events have also led to soil erosion and loss of arable land for forestry and agriculture. Flooding and droughts have ruined crops and pastures already being cultivated on the fields. Climate change hinders the quality of essential crops by plant diseases thus affecting food quality and safety. For example, increase in temperature result in increase in the production of mycotoxins (such as aflatoxins) and pesticide residues in USA (Lake et al. 2012). Nigeria is also affected by aflatoxins. Higher temperatures favour the growth and replication of bacteria such as Salmonella species leading to food poisoning in the transportation of food crops from the farm before consumption (Lake et al. 2012).

In Nigeria, there has been decrease in agricultural produces due to heat wave, flooding, drought, wild fire. Climate change causes new patterns of crops, stops the growth of some crops and causes low yield in staple crops. It has also affected subsistence and commercial farming in Nigeria with excessive flooding in the South-east and North-central regions and decline in rainfall in the North-eastern and Southern regions with increased temperature in all the regions. This has greatly affected food production and availability. Challenges being faced by farmers in Nigeria occasioned by climate change include excessive heat on the crops especially vegetables and melon, flooding which affected rice farming and increased cost of farming due to droughts or lack of water. There is a decline in crop yields. Low yields in arable crops have been reported over the years in the South-South Zone of Nigeria especially rice (27 % decline) except yam and maize. There is also a very low yield in vegetables. For example, in 2017, vegetable yields in Nigeria were 3.8 tons per hectare, compared to 5.7 and 19 tons per hectare in West Africa and globally respectively. The effects of climate change in the vegetative zones include reduced rainfall, drought and increasing desertification, delayed rainfall and longer dry seasons, severe flooding during the rainy season, heat waves and persistent rise in sea level. Climate change is negatively affecting oceans, seas, lakes, rivers, animals and plants. In Nigeria, thousands of people and their families whose livelihoods depend on fishing and aquaculture are affected by climate change as fish

become less abundant because many migrate to other areas due to extreme weather events, droughts and the warming of waters (Okoli and Ifeakor, 2014).

Effect of Climate Change on Food Availability, Accessibility, Utilisation and Stability

Globally, food security has been affected by climate and weather conditions (Ajiloba and Walker, 2021). Consequently, it has become important that food and Nutrition has to be addressed. Food security has been defined as "when all people, at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2016). Food security is based on four (4) key pillars (availability, access, utilization and stability): food availability (production, distribution and exchange), food accessibility (affordability, allocation and preference), food utilisation (food safety, nutrition and social value) and food stability (food distribution in the supply chain) (Ziervogel and Frayne, 2011; Menhas et al. 2016). Climate change induced hunger crisis causes food shortage, food scarcity, high cost of food. Consequently, it affects food availability and access resulting in global and national hunger. About 9.8 % of world population are hungry while 14.6 % Nigerians are hungry (Macrotrends, 2022). Nigeria is designated as one of the 6 countries whose level of hunger is considered serious (28.3) (Global Hunger Index, 2021). Climate change therefore precipitates food unavailability, inaccessibility, utilisation and stability thereby resulting in food insecurity. Table 1 shows the hunger statistics in selected West African Countries according to the Global Hunger Index ranking from 2018-2023. Until 2023, the African countries captured in this table are still experiencing either alarming or serious levels of hunger. Only Cameroon achieved moderate hunger in 2023. Some of the factors aggravating hunger in these countries, especially Nigeria are corruption, climate change, insecurity, banditry, war, communal/armed conflicts, kidnapping, and farmers' clashes. Nigeria has vast arable farms but farmers can no longer go to their farms because of kidnappers and insecurity. Initially, it was open gracing, where cows are moved into farmers' farms to graze on their crops and consequently destroy the farm crops. Many farmers lost a lot of crops. Open grazing was condemned and cattle ranching was recommended. The implication is that a serious or alarming GHI severity scale shows that the population is food insecure. Food insecurity will affect a lot of things including life expectancy. Conflict is the main driver of hunger in most of the world's food crises (WFP, 2022). It has also been reported that hunger influenced life expectancy in war-torn Sub-Saharan African countries. (Uchendu, 2018). Also, corrupt practices negatively influence food security and life expectancy in developing countries (Uchendu and Abolarin, 2015). The United Nations Security Council acknowledged the link between conflict and hunger, and condemned the use of starvation as a weapon of war when it adopted its landmark Resolution 2417 in 2018 (WFP, 2022).

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Table 1: Hunger Statistics in selected West African Countries, 2018 - 2023

	Nigeria		Niger		Togo		Benin Rep.		Cameroon		GHI Severity Scale
Yr	Ranking	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking	Score	
2018	103	31.1	99	30.4	80	24.3	80	24.3	71	21.1	serious
2019	93	27.9	101	30.2	81	23.9	82	24	76	22.6	serious
2020	98	29.2	-	-	86	24.1	79	22.4	70	19.1	alarmin
2021	103	28.3	-	20 -34.9	89	23.7	82	22.2	74	18.6	alarming
2022	103	27.3	115	32.6	92	22.8	91	21.7	80	18.9	serious
2023	109	28.3	120	35.1	88	21.1	91	22.6	79	18.6	Nigeria: serious Niger: alarming Togo: serious Cameroon:moderate

*The higher the ranking/score, the higher the hunger
- No data
Scale: **low** (≤ 9.9); **moderate** (10.0–19.9); **serious** (20.0–34.9); **alarming** (35.0–49.9); **extremely alarming** (≥ 50.0)

Climate change affects the quality and safety of food crops. It has been reported that exposition of crops to high CO^2 concentration reduced the protein concentration in crops (Taub et al. 2018). This implies that continuous increase in atmospheric carbon dioxide results in decreased food crop quality. High rainfall, flooding and drought affect the mineral composition of soil, loss of soil fertility, increase in soil acidity and toxicity (Berhanu and Wolde, 2019). Rising water temperature brought about by climate change results in low volume of oxygen in water which destabilizes the fish habitat and may cause death in fish, low productivity or contamination of fish with harmful bacteria (Ani et al., 2021). Persistent flooding has been linked to high solution of harmful element such as arsenic in the soil which if absorbed by crops can lead to heart failure when consumed by man in high quantity. Flooding and drought also lead to food contamination (Ughaelu, 2017; Ikem, 2018). Table 2 shows the challenges of climate change and its nutritional effects on food security.

Table 2: Challenges of Climate Change and its Nutritional effects on Food Security

Climate change	Challenges	Nutritional effects
Increase in average temperature	Reduced quantity and reliability of agricultural yield.	Food scarcity and unavailability, hunger
	Increased heat stress on livestock.	Death of food animals, food & nutrient scarcity
	Destruction of crops or lowering crop productivity	Food & nutrient scarcity
	Decline in certain fish stocks due to increased sea temperature.	Food & nutrient scarcity

Change in amount of rainfall	Reduced water availability for crops and livestock e.g rice, wheat	Food & nutrient scarcity
	Heavy reliance on irrigation	High cost of production and food prices
	Poor quality of crops due to deteriorating water quality	Food & nutrient scarcity
Increased severity of drought	Decreased crop yield	Food & nutrient scarcity
	Increased probability of wild fire e.g Algeria, California, Portugal –extreme heat conditions, high temperatures 45^{o}C+	Food & nutrient scarcity; failure of small and marginal farms with resultant economic, political, and social disruptions.
Increased intensity of extreme events e.g flooding, storms, hurricanes, and tornadoes	Soil erosion, flooding e.g India - flooding	Food & nutrient scarcity
	Increased land degradation and desertification	Food & nutrient scarcity
	Inability to cultivate land	Food & nutrient scarcity, unavailability, hunger
	Damage to crops, livestock, food stores and other infrastructure	Food & nutrient scarcity; food instability

Adapted from Masipa (2017).

Food Spoilage, Losses and Wastes

Climate change also causes changes in patterns of food-borne pathogens resulting in increased losses of cereals, fruit crop yield, food spoilage and toxins (Fear, 2020). For example, the outbreaks of a vector-borne disease for sheep called Bluetongue which is spreading in the Northern Europe and this is associated with climate change (Fears, 2020). Flooding and erosion causes a lot of destruction of farmlands. For example, there was flooding in Obubra in Cross-River (August, 2022) and a lot of farm lands were destroyed. Food waste contribute significantly to greenhouse gas emissions. About 40% (76.9 metric tonnes of food/year) of total foods produced in Nigeria every year is wasted (UN, 2022). This is equal to 31% of its total land use and produces 5% of the country's greenhouse gas emissions. UN ranks food wastage per citizen in Nigeria as the highest in Africa. This is due to a lack of cooled storage/packing facilities. The report cited that a Nigerian generates at least 189 kg of food waste every year and this amounts to a total of 37.9 million (37,914,470) tonnes of food every year (UN, 2022). Climate change-related pests and diseases affect over 80% of cotton yield and 50% of other crops. These also result in postharvest and storage losses. An average of 13% of global harvest is lost to pests and diseases and 9% to post-harvest losses, especially in developing countries. Climate change due to storms, hurricanes, and flooding has led to losses of crops and livestock. Food loss and waste worsen the climate change crisis because it generates a significant greenhouse gas footprint. Production, transportation, and food handling

generate significant carbon dioxide emissions. Foods dumped in landfills while decaying, generate methane a more potent greenhouse emission (Buzby, 2022).

Mitigation of climate change on Food Security

Climate change adaptation is a way of responding to global climate change. According to The Intergovernmental Panel on Climate Change (IPCC), adaptation is the sequence of modifications to actual or expected climate and the impacts of the modification. Adaptation is aimed at mitigating or preventing harm or manipulating beneficial possibilities of the consequences of climate change within human systems (Noble et al., 2014). This requires intentional efforts in the human-environmental system to adapt behavioural patterns, lifestyles, and perceptions that can lower the risk to human lives and livelihoods, while mitigation involves coordinated actions to reduce long-term emissions of greenhouse gases. Climate change mitigation also means reducing greenhouse gas emissions and short-term sequestration and processing of coal and even more significantly by making infrastructural decisions that will reduce risk by reducing long-term emissions. While the entire food system is a producer of greenhouse gas emissions, still the most important component is primary production. Incentives are required to encourage producers, agribusinesses, and managers of biodiversity to follow good practices to mitigate climate change (Ajilogba and Walker, 2021). Climate change mitigation on human nutrition could be at regional, national, local (Community), and individual levels. These adaptation processes can be applied from region to region. There is no "one size fits all" adaption process. These levels will require getting the stakeholder and policy-maker awareness and buy-in. In the USA, communities' strategies that have been employed to mitigate climate change include focusing on internal operations, beginning with a sector that is particularly vulnerable to climate change, integrating climate change concerns into existing planning approaches, and conducting a community-wide assessment.

The agricultural sector in Nigeria is currently facing two challenges which are to increase food supply and adapt to the climate variations and extreme weather events across the six geographical zones. To ensure food production, and availability and reduce food scarcity as a result of climate change in the agricultural sector, there should be provision of new infrastructure for irrigation and flood protection of farmlands and crops. Farmers should be assisted with farming equipment. Use of better and wider drainage channels to check floods and erosions be encouraged. Modification of farming practices and breeding crops more resilient to biotic (e.g. pests and diseases) and abiotic (e.g. drought, water-logging) stresses (Fear, 2020). There should be initiatives to reduce pests and diseases. Conservation of soil and other natural resources is very important. Changes in farming practices including diversification. For example, farmers in Nigeria are now using traditional rainmakers to control rain, and reduce food loss and waste. Options need to be explored throughout the food system to ensure climate resilience. For example, in food storage and transport, market transparency, sighting of food processing facilities and other infrastructure (Fear, 2020). The decline in climate resilience of European wheat must receive more attention from plant breeders, wheat traders and farmers. Measures to decrease the risks of extreme weather events should be explored. Modifying food intake patterns to planet-healthy diets such as fruits, vegetables and fewer animal food sources

to reduce cardiovascular diseases and hidden hunger. Diet patterns should move away from excessive consumption of carbohydrates and large amounts of animal-source foods e.g. beef. This will result in health benefits as a well as reduction in greenhouse gas emissions and alleviate pressures on other natural resources. The livestock sector is a key player in reducing greenhouse emissions and enhancing global food security. Fewer livestock should be used to feed the world population. Better breeding, genetics and nutrition practices have produced efficient result in the USA. For example, the use of cattle has drastically reduced in the USA. Consumption has reduced from 140 million head of cattle to 90 million head and those 90 million cattle are producing more meat (Quinton, 2019). Adaptation of sustainable agricultural practices known as smart agriculture has also worked in Nigeria by using organic fertilizers which are mostly extracts from plants to control pests and diseases by Abuja farmers. There is also the use of more efficient crop varieties, irrigation (with rain-fed systems), and watershed management. A variety of crops with different sensitivity to climate variations can also be grown. For example, growing drought-resistant crop varieties such as cassava and maize. The use of efficient irrigation infrastructures will reduce crop failure due to drought and extend the farming season into the dry season instead of depending on rain-fed agriculture. For example, in Lagos State, Nigeria this strategy has been successfully used thus making it possible for the State to have vegetables all through the year as a result of irrigation. Other mitigation strategies include efficient use of climate data and forecasts, through early warning systems and use of accurate and timely weather forecasting to improve crop performance and yield. There is a need to develop human capacity and infrastructure for accurate weather forecasts and dissemination of information on weather conditions. Farmers could react to changing precipitation patterns by changing crops, using different planting/sowing dates and different harvesting dates. By maintaining flexibility in decisions about when crops are to be planted, farmers could ensure their harvest against failure and achievement of quality crops. Farmers growing rain-fed crops in a drought-prone environment may diversify the locations of their farm plots to the high spatial variability of rainfall areas. Regional farmer groups can be established to facilitate collaboration. There could also be the use of agricultural extension services to acquire scientific methods of improving farming operations to improve crop yield.

Food losses and wastage can be reduced by investment on provision of good road networks and efficient transportation systems, power and railways, increase in technology and infrastructure such as the provision of cold-chain technology and energy sources for efficient use, provision of storage facilities in market places. Importation of food processing and storage facilities should be tax-free. Farmers should be linked in clusters to food manufacturing industries for supplies. Efforts should be made to preserve excess food produced during their seasons. According to the World Food Preservation Centre, 95 % of agricultural resources are allocated to food production and there is only 5 % to food perseveration. As long as this poor allocation happens, African farmers will continue to lose about half of their produce before it gets to the market (Tomson, 2022). Other mitigation strategies to reduce food waste include selling assets such as livestock to use the money to start all over again, replanting fast-maturing varieties after the growing season has started if early season planting fails, planting trees in rows to serve

as windbreakers and checking erosion, growing more cover crops to protect the soil from erosion and leaching of soil nutrients examples groundnuts, melon, potatoes. Early maturing crop varieties such as maize and cassava can be planted. Increasing and upgrading storage facilities to preserve crops for longer periods and prevent the destruction of crops by insect pests and excessive heat from the sun to ensure food availability all through the year can be practiced. Control of pests, insects, and birds to ensure increased crop yields, low food losses, and wastage will increase food production and availability and ultimately food security.

Conclusion and Recommendation

Nigeria with a population of over 200 million is threatened by the negative effects of climate change on food security such as poverty, hunger, starvation, and malnourishment with various forms of health diseases especially malnutrition (stunting (37%), wasting (7%), underweight (22%)), micronutrient deficiencies (vitamin A deficiency, iron deficiency, iodine deficiency, zinc deficiency, and folate deficiency), especially among the Under-5 and cardiovascular diseases such as high blood pressure, diabetes, cancer and obesity. There is a need to establish climate change policies, sustainable food systems, and resilient strategies to discourage environmental pollution, production of carbon dioxide and other greenhouse emissions at Global, National, State, and Local Government Areas to reduce global warming and other extreme weather events associated with climate change. It is important to implement policies and actions to create healthy, safe and sustainable food environments. This will increase and improve the quantity and quality of food crops produced, reduce food losses, spoilage, wastage and ultimately improve food security and the achievement of sustainable development Goals (SDGs 1 and 2) in 2050 especially in Nigeria.

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