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Trends in climate, socioeconomic indices and food security in Nigeria: Current realities and challenges ahead

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Food security in Nigeria is presently in dire strait owing to several factors, such as skyrocketing energy prices, climate change, and terrorism. This study is aimed at revealing the role of the aforementioned factors in shaping food affordability and availability in the country. The study used descriptive statistics and coefficients of variation and determination to ascertain the change in the trend in these factors and their correlates to food security over time. From the results of our research team, we inferred that temperature increases, political instability, rising food prices and erratic energy supply have had distressing consequences in the areas of affordability, availability and stability of food supplies. We conclude that a rapidly growing population such as Nigeria's would need crucial interventions in increasing food production, mitigating the impacts of climate change, and buffering energy supplies. Ultimately, Nigeria needs to overhaul the important components of her food systems and the respective linkages between these components in order to ensure food security for the entire population.

KEYWORDS

climate variability, energy use, environmental sustainability, food sovereignty, food security

Introduction

Food security is crucial to the achievement of the United Nations Sustainable Development Goals (SDGs) (Mollier et al., 2017; FAO et al., 2021). This is because well-nourished and healthy people are the primary focus of sustainable development. Food security is attained when all people at all times have physical, social, and economic access to sufficient, safe, and nutritious food, that meets their dietary needs and food preferences for an active and healthy life (FAO, 1996). The major dimensions to food security include the physical availability of food, economic and physical access to food, and adequate food utilization, the latter depending on the ability of the body to process and use nutritious materials. As an important global issue,

food security has a close relationship with human health, nutrition, climate, and other factors (Murthy, 2016; Matemilola and Elegbede, 2017; Meybeck et al., 2017; Mc Carthy et al., 2018; Ben Abdallah et al., 2021). These "other" factors include insufficient food production, gender inequality, the implementation of poor policies, and corruption. Amongst others, factors such as conflict and civil insecurity, natural disasters, and inferior technological methods for the processing and storage of food are also significant. Food insecurity, usually associated with low incomes, denotes a lack of regular access to enough food and the consumption of diets poor in nutrients which could contribute to the development of diseases such as obesity, heart disease, hypertension, diabetes, and other chronic diseases (Murthy, 2016; FAO et al., 2021).

The different dimensions of food security are mostly affected by climate change (FAOWFP and IFAD, 2012; Mbow et al., 2019). Climate change is already affecting food availability through its impact on crop yields, and the negative impacts have generally been greater than the positive impacts (Pachauri et al., 2014; Harvey et al., 2018). Reduced food supplies lead to increased food prices which would then reduce the purchasing power of many households (FEWS NET, 2022). Globally, between 720 and 811 million people face hunger, while 3 billion people are unable to access a healthy diet as a result of rising prices, burgeoning poverty, and income inequalities. Furthermore, malnutrition in children is a serious challenge in both Africa and Asia (FAO et al., 2021).

Middle and low-income countries, particularly in sub-Saharan Africa, are the most vulnerable to the impacts of climate change owing to the climate-sensitive (agriculture and food) sectors of their economies, poor levels of economic development, weak institutional capacity, poor governance, and a rapidly growing population (IPCC, 2007; UnmuBig and Cramer, 2008; FAO and ECA, 2018). Climate change has impacted food production in Africa and is widening the food security crisis (Ketiem et al., 2017; FAO et al., 2021). Climate change is also changing the range and dynamics of pest infestations and diseases. For example, *Spodoptera frugiperda* (the army worm), which first invaded Africa in 2016, are now established in many parts of the continent and are posing a serious threat to food security on the continent (Ashagidigbi et al., 2022; Timilsena et al., 2022). As opposed to other regions, the prevalence of undernourishment on the African continent was the highest between 2019 and 2020 when it increased by three percent (3%) (FAOSTAT, 2022).

Climate change has also impacted the livelihoods of arable crop farmers in Nigeria (Abiona et al., 2016; Ifeanyi-obi et al., 2016; Onyeneke et al., 2018). Eze (2017) reported that high temperature stress, variability in humidity and frequent floods have been major risk factors in the production of cassava in Ebonyi State, Nigeria. Furthermore, conflicts and insurgencies are negatively affecting agriculture, especially in the North East and North Central parts of the country.

The Boko Haram insurgency that started in 2009 in the north-east of the country has led to the displacement of several households in the area, thereby impairing their access to their farmlands. This has resulted in a reduction in food production and ultimately in food insecurity (Ojo, 2020; Ladan and Badaru, 2021). There has been a long-standing conflict over land and water resources in the North Central geopolitical zone between farmers and herdsmen. This has led to the destruction of crops on farmlands by the cattle of the herdsmen, the death of farmers and herdsmen, the displacement of communities, unemployment, and food insecurity (Kah, 2017; Udosen, 2021; FEWS NET, 2022). The appalling security situation in these areas limits the opportunities for households to earn an income, while the shortage of supplies results in increased food prices, thereby reducing the population's access to food (Shittu et al., 2017).

The erratic supply of electricity and the incessant scarcity of fuel have also impacted food security in Nigeria. Fuel price increases have affected the cost of transportation, which ultimately affects food prices. Over the last 20 years, fuel (petrol) prices have been on the upward trend in the country, increasing from N22 ($0.05) in 2000 to N165 ($0.60) in 2022. Persistent increases in the price of food items in the country have had negative consequences for food security (Ajibade et al., 2020; Amolegbe et al., 2021).

Hunger and poverty are widespread and a large proportion of the population faces food-security challenges. Furthermore, several diet-related and communicable diseases are on the increase in the country. Owoo (2021) reported that access to food in Nigeria has been on the decline between 2011 and 2016, such that many urban households have been adopting strategies to cope with the situation.

Conceptual framework to guide the study

In a quest to comprehensively investigate the factors behind food insecurity in Nigeria, this study is guided by the interdependencies between climate variability, energy use, political instability, and governance indicators, and their effects on food security in Nigeria (Figure 1). The framework in Figure 1 establishes the linkages between these variables and their relevance in respect of the achievement of the highlighted SDG goals, namely no hunger, no poverty, promoting healthy lives and wellbeing, and climate action. In fact, this framework narrates the relationship between food availability/affordability and its direct determinants, amongst others, climate change and food costs. It also explores the relationship between the food security components and the perceived latent variables, such as energy and political instability.

Given the foregoing, the study seeks to achieve three objectives. The first is to assess the role of climate in the areas

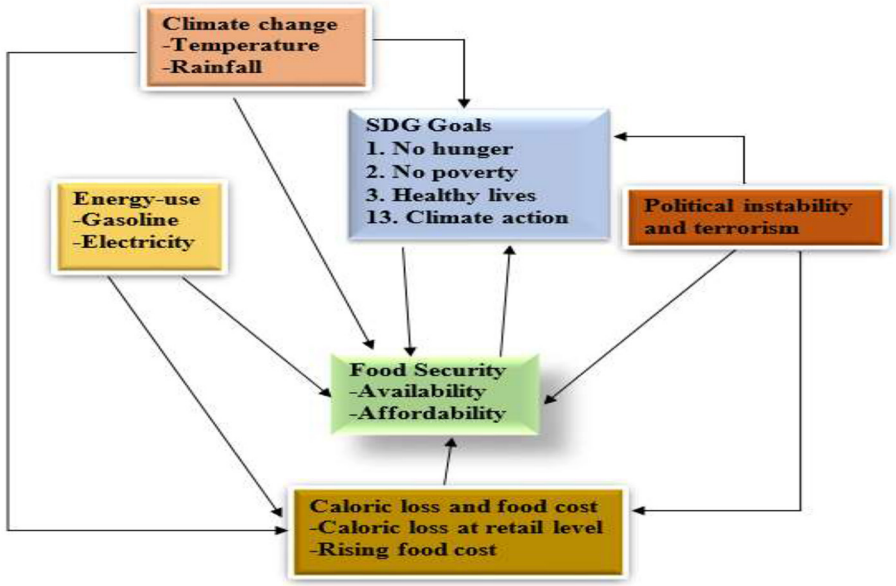

FIGURE 1
Conceptual framework depicting interdependencies between the study components. It relates the interconnectivity between the components of food security and several determinants, including climate change, energy use, food costs, and political instability, *vis à vis* the attainment of SDGs. Source: Author's framework.

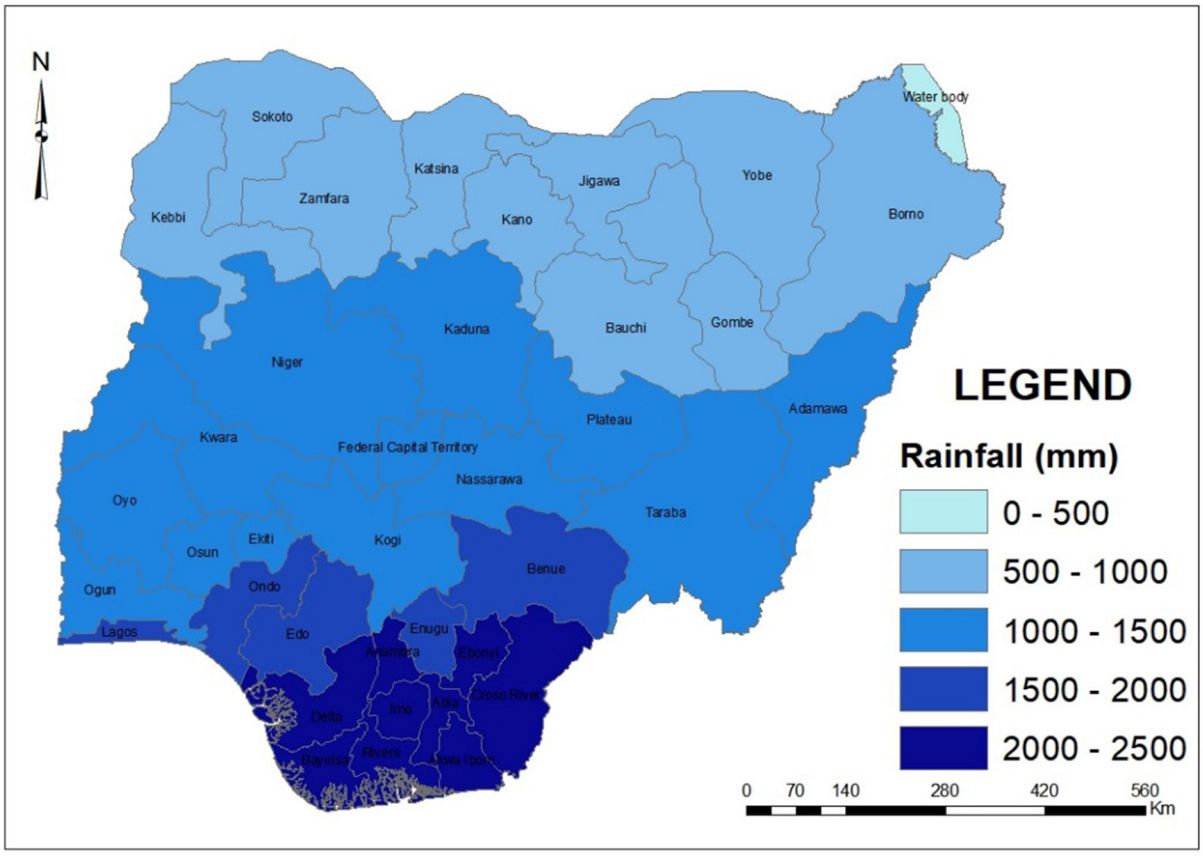

FIGURE 2
Rainfall distribution in Nigeria (1901–2020). Source: Generated from CRU dataset *via* Climate-change Knowledge Portal-World Bank.

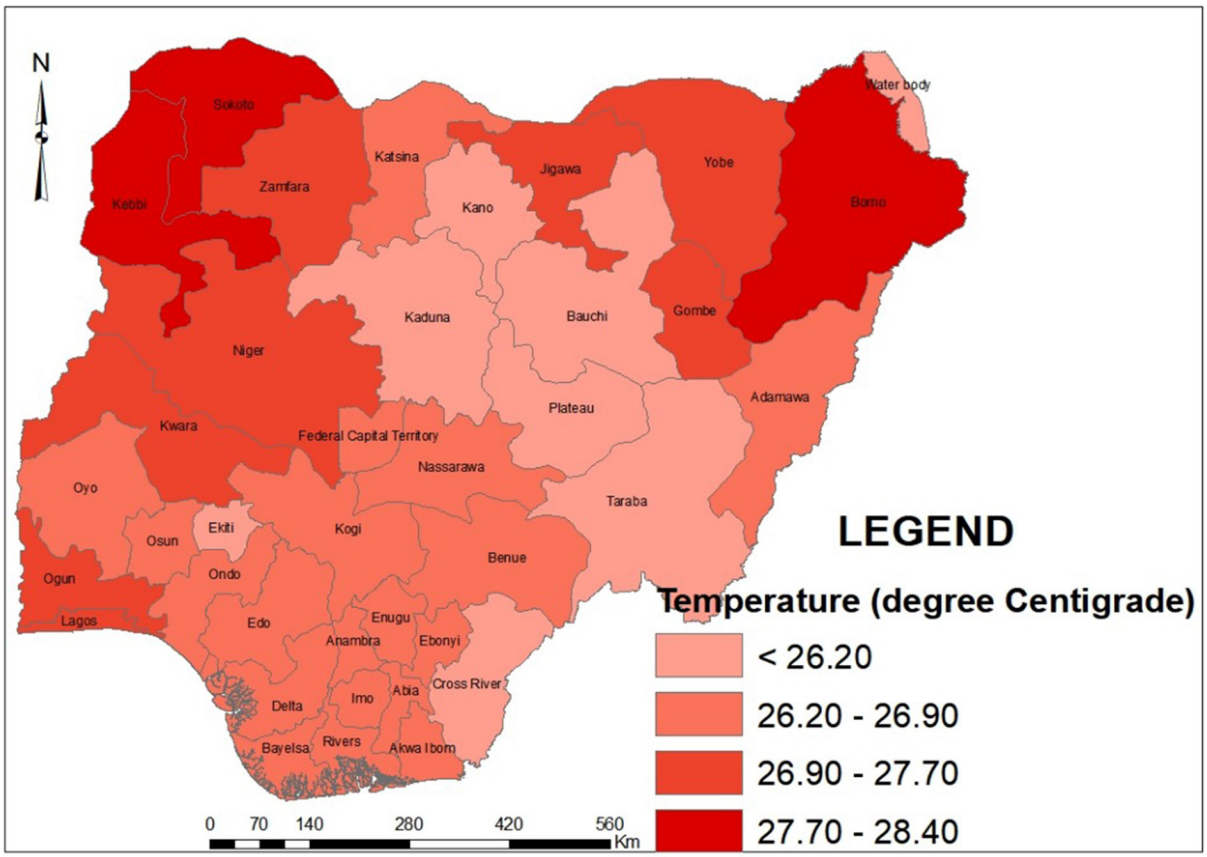

FIGURE 3
Mean temperature over Nigeria. (1901–2020). Source: Derived from CRU dataset *via* Climate-change Knowledge Portal-World Bank.

of food availability and affordability. Secondly, it seeks to assess the effect of rising fuel prices and an erratic electricity supply on food availability. Thirdly, it examines the roles of political instability, and fluctuating food prices, and caloric losses at the retail level, on food availability in Nigeria.

Methods

Study area

The study area is in Nigeria, located between latitudes 4^0 and 14^0 North and longitudes 3^0 and 15^0 East, and covers an area of 923,768 km^2. It is bounded by Niger Republic in the north, Benin Republic in the west, and Chad in the north-east, Cameroon in the east and the Atlantic Ocean in the south. The topography of the country varies, with a gradual rise from the coastal plain to the northern savanna region, the latter rising to a height of about 600 to 700 meters (Federal Ministry of Environment, 2020). There are areas around the Jos Plateau and along the Cameroon border in the Eastern Highlands which exceed 1,200 m. The drainage systems include the Niger-Benue, the Chad, and the coastal river systems.

The climate of the country is influenced by the Tropical Maritime (Mt) air mass and the Tropical Continental (cT) air mass (Ojo, 1977). The climate of Nigeria is characterized by two rainfall regimes. These are a single maximum rainfall regime, with rain falling once a year, and a double maxima rainfall regime, with rain falling twice a year. The length of the rainy season decreases from south to north. The mean annual rainfall varies from about 1,800 mm to over 2,500 mm along the south-west and south-east coastal areas, respectively, to as low as 450 mm in the far hinterland of the north (Figure 2).

The temperature difference between the coastal areas (26–27°C) and the interior (>27°C), as well as between the plateaux (<26°C) and the lowlands (>27°C), is remarkable (Figure 3). The southern portion of the country is covered by tropical forest vegetation, while the northern region is made up of savanna. The distribution of vegetation follows that of climate. However, human impact on the vegetation is increasing as a result of the prevailing increase in population numbers and the exploitation of resources. The soils in the country can be grouped into respective belts running parallel to one another and from the coast inland, namely the hydromorphic, ferralitic, ferruginous and the semi-arid and arid tropical soils. Agriculture

is an important sector in the country's economy being the largest and a significant employer of labor (Federal Ministry of Environment, 2020).

Data sources and description

The data used in the study were sourced from Food and Agricultural Organization Statistics (FAOSTAT, 2022), the Global Food Security Index (GFSI) of the Economist Intelligence Unit (EIU, 2021), and the Climate-change Knowledge Portal (World Bank Climate Change Knowledge Portal, 2022), at the national level (Table 1). Studies have utilized data from these sources at international (FAO et al., 2021) and national levels (Ayinde et al., 2020). In this study, descriptive statistics were used to report trends in the distribution of data. Inferences were made from the available data to present the effect of socioeconomic and climate influences on food security in Nigeria. However, the time series for the various data used in the study were not homogeneous; hence, stochastic and time-series models requiring that the data be in panel form were not considered.

This team of researchers disaggregated the national data on rainfall and temperature using points along the relevant geographical zones (Borno-Northeast, Abuja-North Central, Sokoto-Northwest, Enugu-Southeast, Rivers-South South and Lagos-Southwest) to graphically depict the spatial variations in Nigeria. We selected states that were representative of each geographical zone for emphasis. Furthermore, we did not correct the climate data generated from CCKP for bias (World Bank Climate Change Knowledge Portal, 2022) because the data had already been downscaled and were already presented at low resolution levels (CRU dataset is at 0.5×0.5^{O} and CMIP6 at 1.0×1.0^{O}). The climate data were analyzed only for trends and variations and did not fit into any modeling procedures. Hence, we ensured that coarse data were not reported in this study. We generated future climate projections using model ensembles at SSP 2 (a shared socioeconomic pathway representing intermediate challenges to climate adaptation and mitigation), RCP 4.5 (a relative concentration pathway characterized by greenhouse gas (GHG) emission peaking by 2040), and the 50th percentile to exclude overgeneralization of the model. This process absolves the future representation of climate data from being speculative. The future climate projections are presented in the Appendix section.

Statistical analyses

Descriptive statistics (mean, standard deviation, minimum and maximum), the coefficient of variation (CV), and the coefficient of determination (R^2) were used to draw statistical inferences from the data-sets.

TABLE 1 Description and sources of data used in the study.

Data	Unit	Year	Source
Rainfall and mean temperature CRU (Historical), Future projections (multi-model ensemble) CMIP6 (SSP 2, RCP 4.5, 50th percentile)	mm, ^{O}C	1991–2020 (historical), 2031–2070 (middle distant), 2071–2100 (distant)	World Bank (Climate-change Knowledge Portal)
Energy use in Agriculture [diesel, liquefied petroleum gas (LPG), liquefied natural gas (LNG), electricity, gasoline]	Terajoule	2000–2019	FAOSTAT
Change in food cost	%	2000–2020	FAOSTAT
Incidence of caloric losses at retail distribution level	%	2000–2020	FAOSTAT
Political stability and absence of terrorism	Index	2000–2020	FAOSTAT
Food security environment, food availability, food affordability, food quality and safety	Value (better is closer to 100) Change (value)	2012–2021	Economist Intelligence Unit (EIU)

Coefficient of variation (CV)

The coefficient of variation quantifies the variation of a distribution in a set of variables and depends on the arithmetic mean values. It is given as:

$$V = \frac{S}{X} * 100 \quad (1)$$

Where, S = standard deviation, X = arithmetic mean of variables.

A CV value of <20 shows low variability in rainfall (Hare, 2003), while a value of <2 shows low variability in temperature.

Coefficient of determination (R^2)

The coefficient of determination (R^2) is the proportion of variance in the dependent variable that is predictable from the independent variables (Wright, 1921; Chicco et al., 2021). It is expressed as:

$$R^2 = 1 - \frac{\sum_{i=1}^{m} (Xi - Yi)^2}{\sum_{i=1}^{m} (Y - Yi)^2} \quad (2)$$

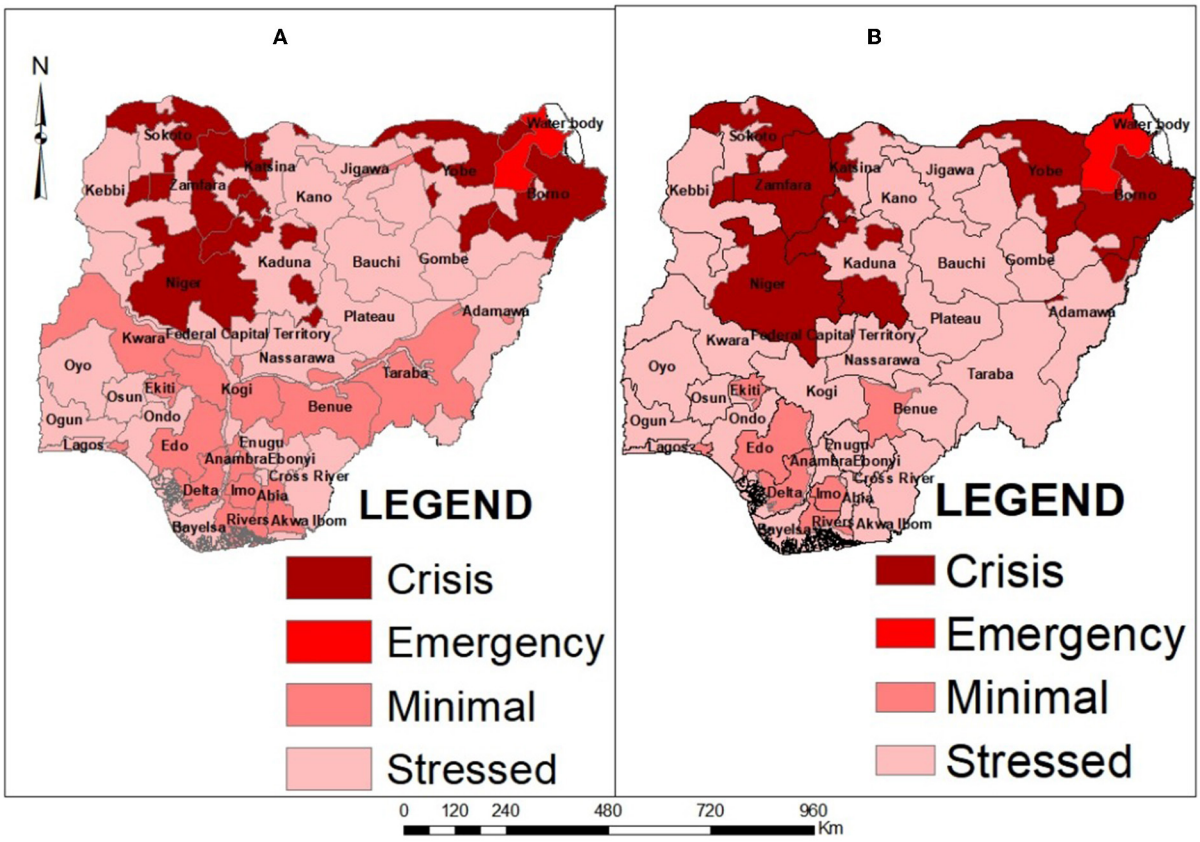

FIGURE 4
Projected food insecurity prevalence in Nigeria. **(A)** March to May 2022. **(B)** June to September 2022. Source: Derived from FEWS NET, 2022.

Simplified as;

$$R^2 = 1 - \frac{MSE}{MST} \quad (3)$$

Where MSE = mean squared error.

MST = mean total sum of squares.

N.B. Worst value = -∞; best value = + 1 (Chicco et al., 2021).

Geospatial method

Using ArcGIS 10.5 version, the spatial analysis of centennial climate data on rainfall and mean temperature (1901–2020), and the projected food security situation in Nigeria (March to September, 2022) (Figure 4) were presented to add background and context to the issue of climate change and food insecurity. The maps on centennial climate data were presented by spatially interpolating the respective CRU datasets on mean temperature and rainfall across 36 states and the federal capital from 1901 to 2020 (World Bank Climate Change Knowledge Portal, 2022). Those maps for projected food security were presented using shape files obtained from FEWS NET (2022).

Results and discussion

Trends in temperature and rainfall

The results show that climate change poses a distressing challenge to the socioeconomic lives of the people in Nigeria and their access to food and nutritional security. Table 2 indicates significant variation (CV = 3.01) in temperature projections over Nigeria, as CVs > 2 indicate negative variations in temperature trends. This research team disaggregated national data on rainfall and temperature using points along geographical zones (Borno-Northeast, Abuja-North Central, Sokoto-Northwest, Enugu-Southeast, Rivers-South South and Lagos-Southwest). There has been significant variation in the historical temperature in the North Central ($R^2 = 0.573$), South South ($R^2 = 0.713$), and South East ($R^2 = 0.716$) geographical zones (Figure 6). Mean temperatures across Nigeria increased from 26.5°C, they being the lowest observed in the 1990s, to 29.6°C in the 2000s (Table 2). There was significant variation in rainfall over the North East ($R^2 = 0.085$), South South ($R^2 = 0.038$), and South East ($R^2 = 0.036$) zones (Figure 5). Moreover, over time, the coefficient of determination showed a reduction

TABLE 2 Variations in data used in the study across Nigeria. Source: EIU, FAOSTAT, World Bank Climate Change Knowledge Portal, 2022.

Variables	Mean	SD	CV	Max	Min
Rainfall (Historical)	1162.817	65.15291	5.603023	1269.15	1027.38
Rainfall (Historical+future)	1109.679	51.05159	4.600574	1269.15	1027.38
Temperature (Historical)	27.23967	0.299269	1.098652	27.81	26.53
Temperature (Historical+future)	28.34	0.853428	3.01139	29.61	26.53
Diesel	245.1	95.74522	39.06374	430	172
Gasoline (petrol)	28516.11	12078.28	42.35601	47014.51	14608.86
LPG	262.8934	210.5227	80.07911	821.128	37.84
LNG	453.5417	327.695	72.25246	1191.461	108.3037
Electricity	806.2938	272.3974	33.78389	1237.249	420.9925
Incidence of caloric losses at retail level	3.229524	0.065534	2.029229	3.3	3.11
Change in food costs	3.99	3.412868	85.53553	12.2	−0.5
Political stability and absence of terrorism	−1.91053	0.198592	−10.3946	−1.46	−2.21
Food security environment	41.04	1.152967	2.809374	42.6	39
Food availability	40.53	4.307371	10.62761	45.3	33.3
Food affordability	38.81	3.729894	9.610653	42.8	33.1
Food quality and safety	46.34	2.401018	5.181308	50.6	42.6
Natural resource and resilience	40.48	1.300256	3.212096	42.5	38.9

(R^2 = 0.00006) in historical rainfall (1991–2020), minimal increases (R^2 = 0.034) and R^2 = 0.036 in the near-distant (2031–2070) and far-distant futures (2071–2100), respectively (Figures 5, Appendices A1, B1).

This research showed that the agricultural and food sectors are significantly impacted by climate change (Antle and Capalbo, 2010; Wossen and Berger, 2015). In the future, temperature variations and increased warming will be the most significant climate-change factors to impact the country (Abiodun et al., 2013; Haider, 2019). In fact, the results of this research show excessive variations in mean temperature for the historical (48.5%), near-distant (94.8%) and far-distant future (72.9%) (Figures 5–7). Also, a larger scale of increase in temperature compared to rainfall will have consequential outcomes on future food security in Nigeria. Increases in temperature will promote drought and desertification, crop failures and yield losses, the proliferation of new pest infestations and diseases, and ultimately, food and nutritional insecurity (Bett et al., 2017; Mustafa et al., 2019; Azare et al., 2020; Gomez-Zavaglia et al., 2020; Ristaino et al., 2021; SkendŽić et al., 2021). Owing to a larger proportion of rural dwellers in Nigeria being smallholder farmers (Cervigni et al., 2013), the impacts of climate change are likely to impede the attainment of SDG goals such as no poverty, zero hunger, good health and wellbeing, and climate action.

The results also show the likelihood of more spells of extreme weather events occurring in Nigeria (Shiru et al., 2018; Chukwudum and Nadarajah, 2022) in the near and distant futures. Increasing temperatures, with a corresponding decline in rainfall, will occasion droughts and heat waves, especially in Northern Nigeria (FEWS NET, 2022). Agricultural lands will be lost to drought and desert encroachment. Erratic rainfall will disrupt the growing season, impact pastoral resources, increase food prices and access to food (FEWS NET, 2022). Apart from these impacts, a lack of water for human and agricultural use, competition for scarce food and resources, and mismanagement of natural resources (Lu et al., 2015; Tumushabe, 2018; Stavi et al., 2021) will exacerbate the crisis of food insecurity. Owing to the increasing intensity of climate warming in Nigeria, livelihoods will be lost, poverty will deepen, food will be scarce, and social unrest will escalate.

Energy use in agriculture

Affordable and accessible sources of energy for use in agriculture are strategic for achieving the desired deliverables (Nathwani and Kammen, 2019). The results of the research indicate that gasoline (petrol) and electricity (Figure 7) are the most widely used sources of energy in the agricultural sector. The downward trend in diesel, as observed in Figure 7A, suggests that it is the least used source of energy in Nigerian agriculture, attesting to the preponderance of smallholder farming systems in Nigeria. This is due to the exorbitant price and persistent unavailability of the product for consumer use (Vanguard Nigeria, 2022).

Furthermore, the results indicate large CV values, which connote large-scale variations in the use of energy from several sources in Nigerian agriculture (Table 2). This indicates the possibility of bouts of recurrent but erratic supplies of energy to power farming operations in Nigeria. The recent scarcity in the country's energy resources and the consequent price hikes in electricity tariffs and petroleum products experienced nationwide between February and March, 2022 (Vanguard Nigeria, 2022) further confirm this. The inability to access energy for day-to-day farm operations should be expected to lead to poor yield outcomes at the farm level, reductions in the timeliness of farm operations, poor post-harvest handling and besetting bottlenecks along the agricultural value chain, thus leading to food scarcity.

Erratic electricity supplies and the lack of access to energy resources on account of their high cost (Iwayemi, 2008; Solarin, 2020) are discouraging farmers from adopting modern

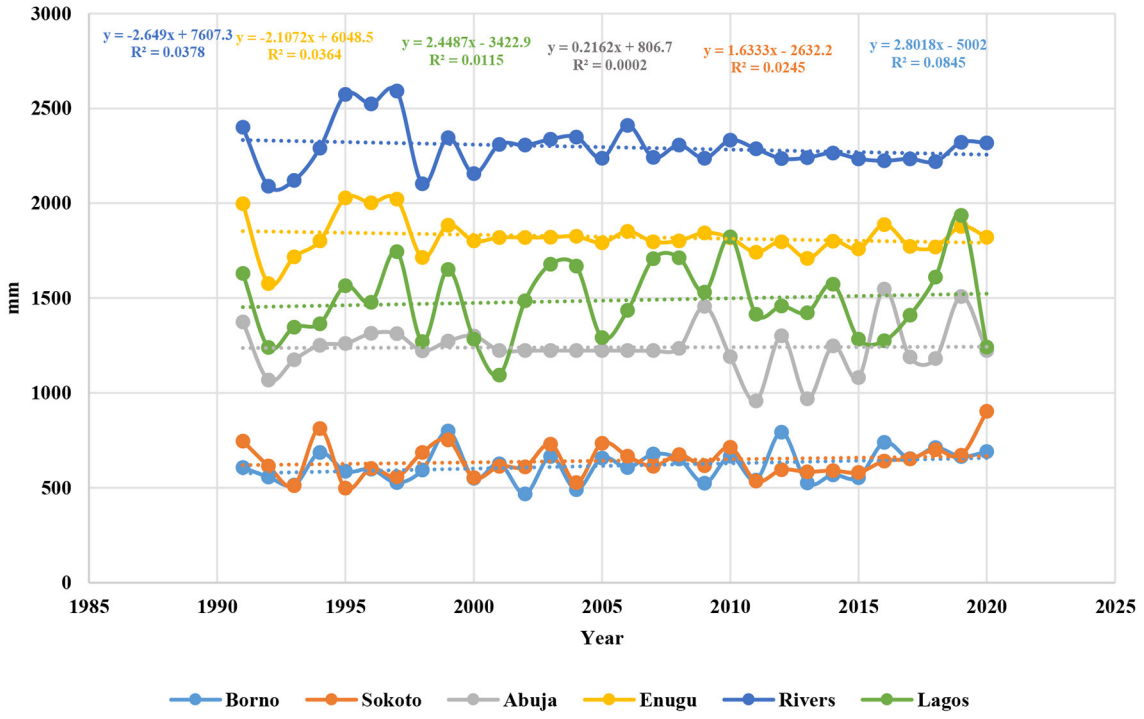

FIGURE 5
Rainfall distribution in Nigeria (1991–2020). Source: World Bank Climate Change Knowledge Portal (2022).

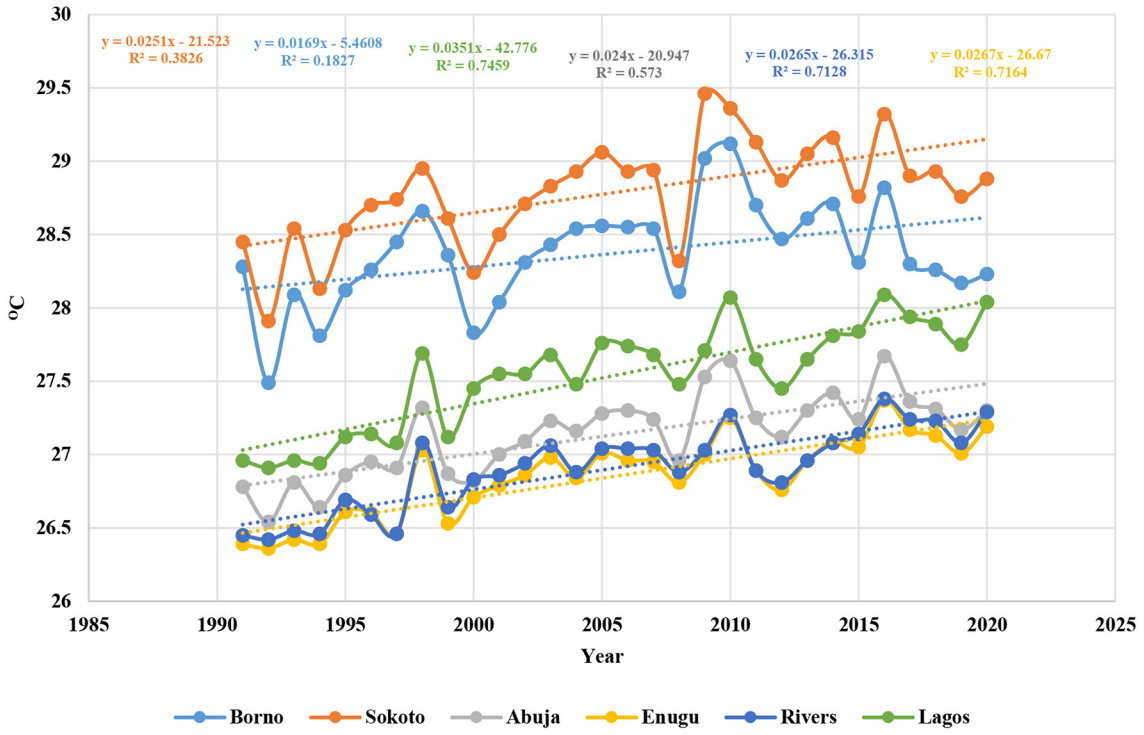

FIGURE 6
Temperature distribution in Nigeria (1991–2020). Source: World Bank Climate Change Knowledge Portal (2022).

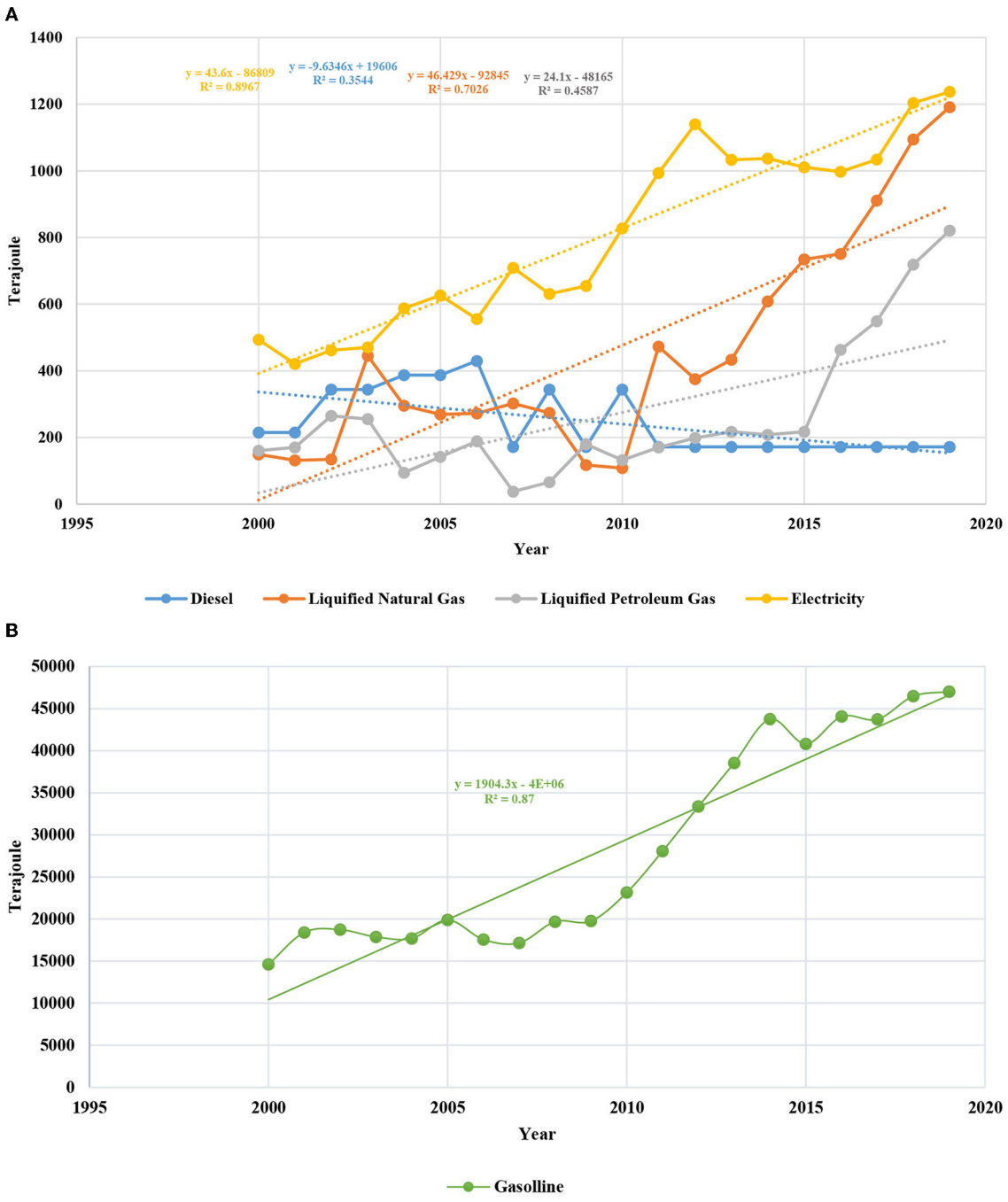

FIGURE 7
(A,B) Energy use in agriculture in Nigeria (2000–2019). Source: FAOSTAT (2022).

practices powered by machines, which would in fact encourage commercialization. Likewise, on account of the high cost of transportation, usually powered by gasoline or diesel, moving agricultural produce from the farm to the farm gate and markets is becoming difficult (FEWS NET, 2022). The results further corroborate one of the causes of the high incidence of caloric losses at retail level (Table 2, Figure 8), which is largely due to the challenges of accessing energy and electricity to extend the shelf life of agro-produce. The continued state of the aforementioned predisposes Nigeria to increasing cases of food

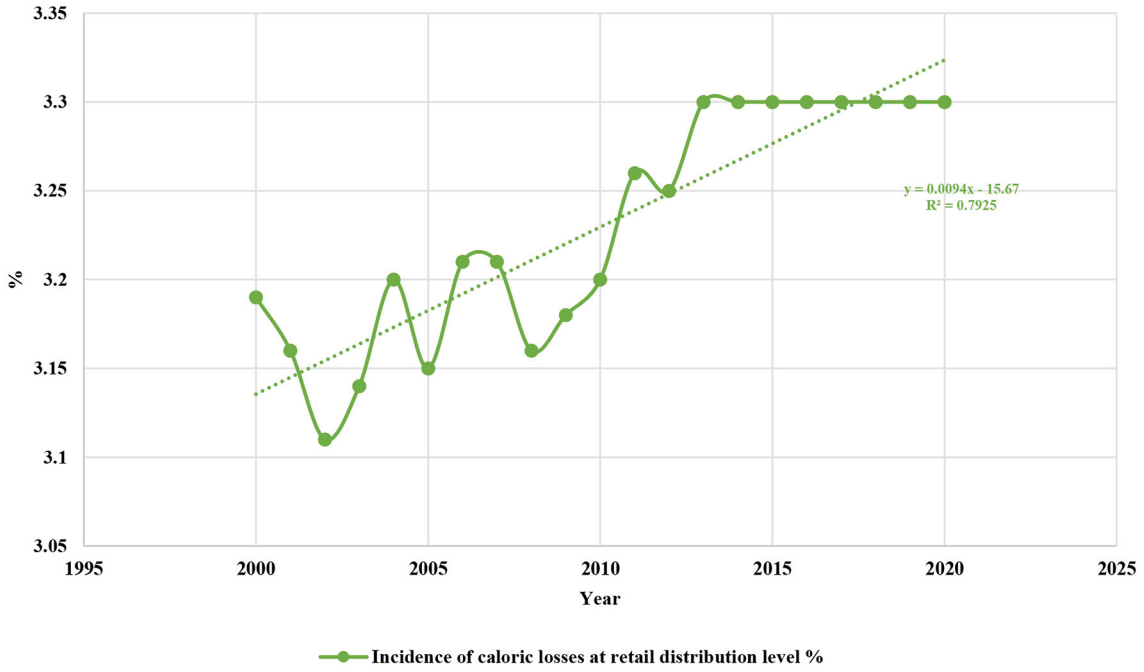

FIGURE 8
Caloric losses at retail distribution level in Nigeria (2000–2020). Source: FAOSTAT (2022).

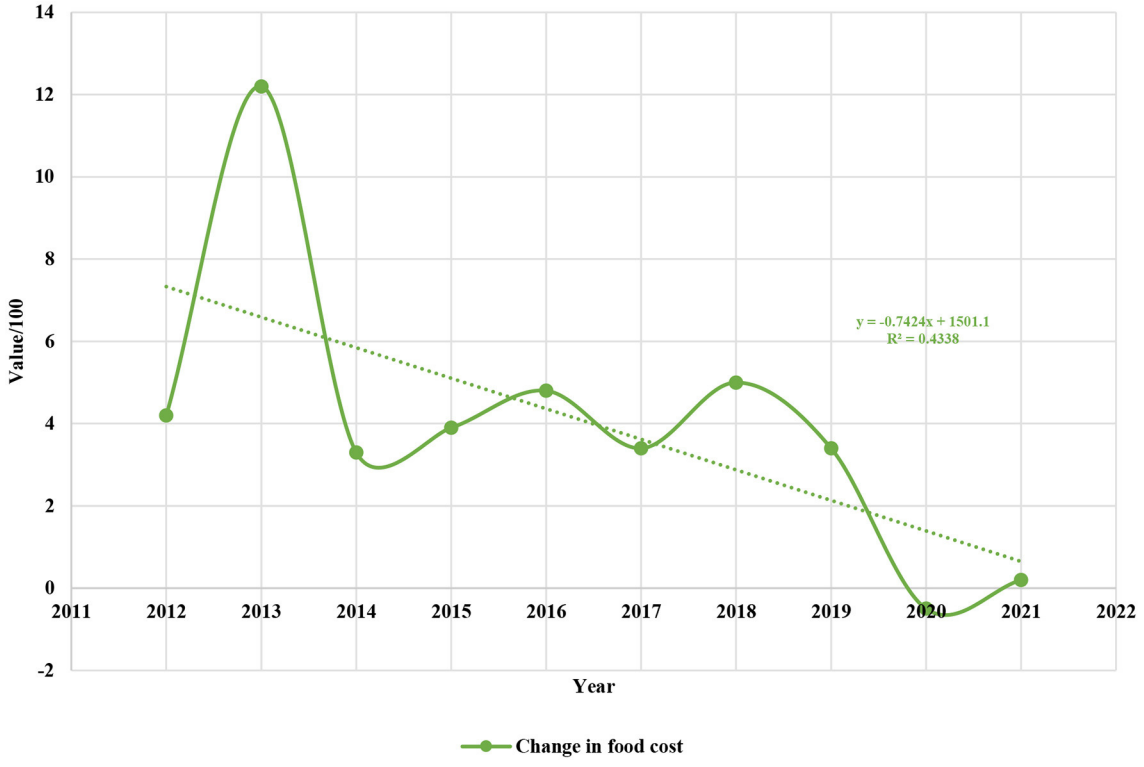

FIGURE 9
Change in food costs in Nigeria (2012–2021). Source: EIU.

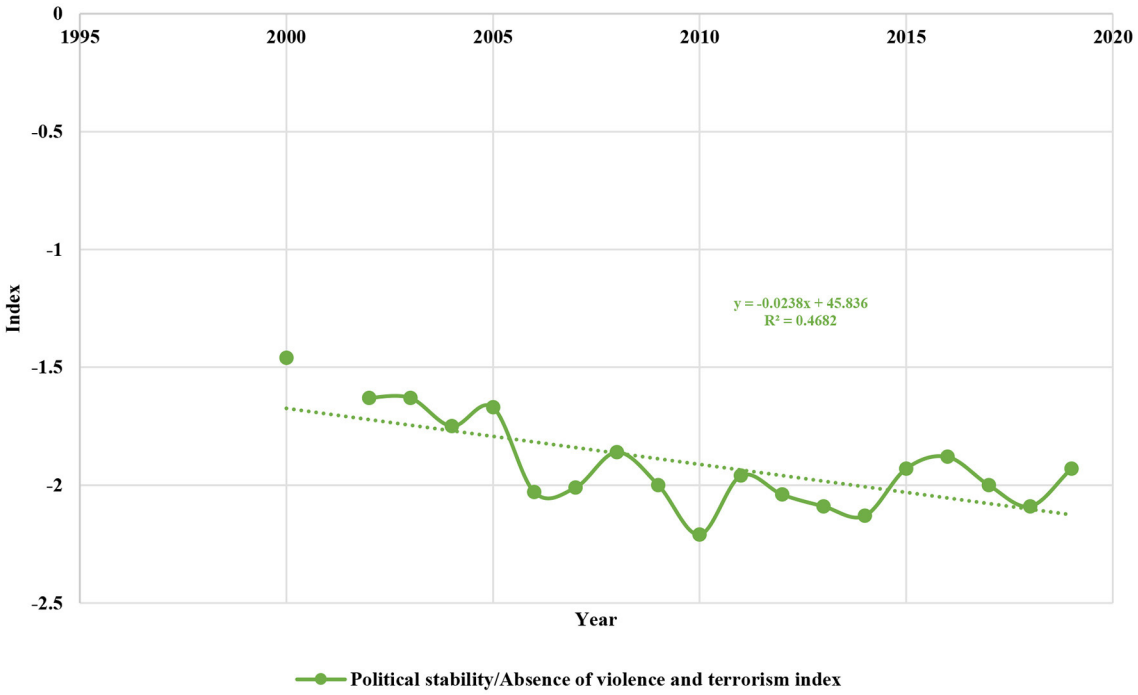

FIGURE 10
Political stability index in Niger ia (2000–2019). Source: FAOSTAT (2022).

insecurity and poverty. To ensure sustainable supply of energy in the agricultural sector, Nigeria will need to adopt alternative cheap and renewable sources of energy.

Caloric losses and change in food cost

Caloric losses at the retail level and variations in food costs are key contributors to food insecurity. An increasing trend was observed for caloric losses at the retail distribution level (Table 2, Figure 8). The scale of variation in food costs (CV = 85.5) is large (Table 2, Figure 9). A food-insecure nation cannot then achieve its full potential in terms of human capital productivity.

Caloric losses at the retail level in Nigeria stem from the generic challenges of erratic electricity supply, fuel scarcities, and rising energy costs (Blimpo and Cosgrove-Davies, 2019) that hamper post-harvest storage and preservation (With opposing conditions prevailing, the positive attributes of these particular variables would normally extend the shelf life of food for retailers). These challenges are also associated with inefficiency in food transport systems and hinder consumer access to food markets, where proximity is an important factor (Aschemann-Witzel et al., 2015). Where temperature and heat levels increase, the efficient storage and preservation of food becomes a distressing issue as most food items are easily subjected to spoilage and snowballing microbial activities (Sharif et al., 2017). Also, rising food costs impose caloric losses at the retail level, as, on account of the constant change in food prices, consumers are in limbo as to what to purchase. Intensified efforts to streamline food processing and preservation are considered to be a most necessary measure to address caloric losses and food insecurity in Nigeria (Adeyeye, 2017; Ayinde et al., 2020).

On the other hand, instability in the cost of food predisposes Nigeria to food security challenges. The results confirm that a change in food costs is exacerbated by the effects of climate change, incessant bandit attacks on farmers, fuel scarcity, and energy price hikes. The COVID-19 pandemic has also negatively affected food prices in Nigeria (Amare et al., 2020; Omotayo et al., 2022). While the economic indices remain stable, food prices are expected to be at near-record levels across the globe (FAO et al., 2021). In Nigeria, however, economic downturns, high transportation costs, inflation and price hikes are limiting the purchasing power of households (FEWS NET, 2022). The incidence of caloric losses and rising food costs in Nigeria will heighten the unavailability, unaffordability and instability of food.

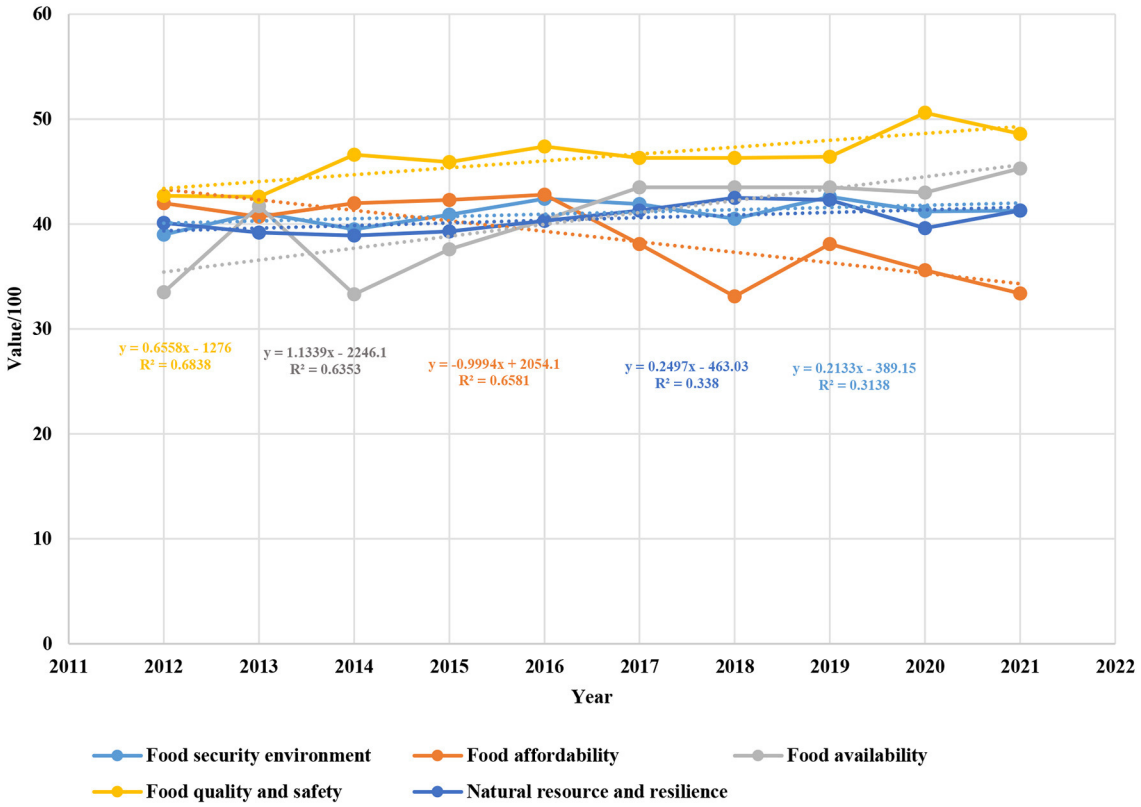

FIGURE 11
Food security environment in Nigeria (2012–2021). Source: EIU (2021).

Political instability, insecurity, and terrorism

Table 2 shows variations in the political stability index for Nigeria and Figure 10 reveals the state of political instability and insecurity prevailing in the country. The country has been victim to incessant terrorist and banditry attacks (Ojo, 2020; Yusuf and Mohd, 2022), which have affected its governance indicators. The near non-existence of political stability (Figure 10) has made it almost impossible for the nation to harness its population and economic growth potential to bolster its agricultural sector for the purpose of food security. Persistent attacks on farmers and the loss of farmland to bandits have negatively affected agricultural production in Nigeria (Ajibo et al., 2018; Awotokun et al., 2020; Ladan and Badaru, 2021).

Also, terrorism, banditry and political instability, as revealed in the results of this research, have continued to prevent farmers, especially in the northern parts and the middle belt of Nigeria from harvesting and processing their food crops. These factors have hampered livestock production and increased cattle rustling (Ajibo et al., 2018; Awotokun et al., 2020; Ladan and Badaru, 2021). Analyses of food security in Nigeria suggest that despite the harvest recorded, the emergency in the area of food security is expected to persist in the North Eastern region (FEWS NET, 2022). This will increase the need for humanitarian interventions in this region as households with homegrown food supplies that have been exhausted now need to access markets for food (FEWS NET, 2022). Hence, Nigeria needs to seek avenues to ensure the following: a sustainable increase in the production of more food for its teeming population, greater access by the population to food supplies, thus making food more readily available, and greater stability in the production, pricing, distribution and marketing of food supplies, thus promoting the affordability of food (Omotayo, 2018, 2020; Omotoso et al., 2022). This it can achieve by addressing the various factors already discussed above, in particular terrorism and banditry, in a confrontational manner.

Food security indices

Table 2 and Figure 11 contain the results obtained from the examination of food security indices. They show that the food security environment (41.04/100), food availability (40.53/100), food affordability (38.1/100), food quality, safety (46.34/100), and natural resource resilience (40.48) are in a

very poor state, with significant negative changes recorded annually. Furthermore, Table 2 shows larger variations in food availability (CV = 10.6) and food affordability (CV = 9.6). The declining trend in food affordability (R^2 = 65.8) has been the most significant indicator of food insecurity in Nigeria (Figure 11). From the foregoing, climate change, rising energy and food costs, and political instability are vital elements that are contributing to the below-par performance of food security indicators in Nigeria.

Globally, hunger and food insecurity are on the increase (FAO et al., 2021). Women and children are mostly affected by food insecurity (FAO et al., 2021). A rapidly warming environment with dwindling rainfall will impart instability in food production and occasion wide-scale agricultural losses from the farm to the retail level. The preponderance of smallholder farmers and systems in Nigeria which positions them as the major food producers (Cervigni et al., 2013; FAO, 2022), with limited capacity to cope with climate vagaries (Harvey et al., 2018), further dents concerted efforts at attaining national food security. This is plausible as being largely rainfed and more impacted by climate change, Nigeria's agricultural production systems are heavily dependent on climate services.

As indicated in the results, the resiliency status of the natural resource base in Nigeria and the country's food security environment to support enhanced and sustainable food stability are poor. This is largely due to the impact of climate change on food systems (Table 2). Food quality will continue to be strongly impacted by climate change (Taub et al., 2008; Tirado et al., 2010), and will result in reduced caloric indices (Havlík et al., 2014; Ray et al., 2019). Strengthening climate services in agriculture to ensure resilience to climate change is imperative if better food security indices are to be achieved. Furthermore, the development of novel methods and systems to assist actors along the agricultural and food-value chains is most necessary. Also the use of efficient climate-change-resistant inputs in the agricultural sector is imperative for improving agricultural yields and enhancing food security in the current phase of climate change.

Conclusion

This study sought to examine the current socioeconomic status of the population, and climate and food security trends in Nigeria. The roles of the socioeconomic, energy and climate indices on food security were discussed. From the results, temperature variations and constantly rising temperatures are expected to damage food systems and intensify food insecurity. In fact, the increasing temperatures will be the most significant challenge to be faced in achieving food security in Nigeria. Championing climate resilience across the food, social and economic sectors has to be immediate. The erratic supply, lack of access to and the fluctuating prices of energy products, especially electricity and gasoline, will heighten the necessity for the effective handling of poor post-harvest produce and instigate a hike in transport prices. This will increase food and caloric losses from the farm to the retail and household levels, and thus result in severe food insecurity in the country. Following these observations, it is a matter of urgency for Nigeria to encourage actors along the food and agricultural value chains to adopt strategies that are climate-change responsive and that would enhance efficiency in this area of study. Conflict resolution, improved quality of life, and maximizing the potential of a fast-growing population should be pressing concerns on the table of policymakers and governance managers in Nigeria in order to curtail the intensifying food insecurity situation in the country. Efforts must be made to bring down the cost of food and improve access to good nutrition in Nigeria. A business-as-usual approach toward achieving resilience against the threats of the effects of climate change, economic wellbeing, an efficient energy supply, affordable and accessible food, political stability and enhanced governance will certainly not produce the expected results.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

FO and OA conceived the study, sourced and analyzed the data, and wrote the draft manuscript. FA and AO validated the results, edited the draft, and improved on the content. All authors approved the final draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2022.940858/full#supplementary-material

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