

Climate Change, COVID-19 Lockdown and Agricultural Input Supply: Implications for Sustainable Food Production in Southeast, Nigeria



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ABSTRACT

This study aimed to assess the effects of climate change and the COVID-19 lockdown on agricultural input supply and their implication on sustainable food production in Southeast Nigeria. In particular, the study focused on the effects of climate change and COVID-19 lockdown on agricultural input supply, the agricultural inputs affected by the lockdown and climate change, the implication of the disruption of agricultural input supply on sustainable food production, and measures for enhancing resilient agricultural input supply. The study adopted a descriptive survey design. The study was carried out in Abia, Anambra, Ebonyi, Enugu, and Imo states. The target population was agricultural input dealers, extension agents, and registered farmers. A multistage sampling procedure was used, and a total of 391 respondents were selected from the sampling framework. The data collected were analyzed using frequency counts, percentage, mean, and standard deviation. The study found that climate change and COVID-19 lockdown had adverse effects on agricultural input supply by causing a deficit of agricultural inputs such as fertilizer, improved seeds, agrochemicals, machinery, and veterinary products, affecting the prices of agricultural inputs, disrupting transportation, and causing delays in agricultural input distribution. Consequently, the disruptions caused by climate change and COVID-19 lockdown resulted in lower crop production, higher production costs, delayed planting schedules, food shortages, lower farm income, and increased food insecurity. The respondents suggested improving rural infrastructure, producing agricultural inputs locally, creating input reserves, implementing climate-smart policies, adopting digital platforms in distributing agricultural inputs, and providing government support for agricultural input production and distribution. The study concluded that there is a need to enhance resilient agricultural input supply in Southeast Nigeria to ensure sustainable food production and security.

Keywords: Climate change, COVID-19 lockdown, agricultural input supply, sustainable food production, food security, Southeast Nigeria.

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Introduction

Agriculture is one of the significant pillars of Nigeria's economy as it contributes immensely to employment, households' income, poverty alleviation, and food security. This sector provides direct employment to about 35% of Nigeria's workforce. In addition, most farmers depend on the availability of agricultural inputs like improved seeds, fertilizers, agrochemicals, irrigation, and mechanization to enhance production [1,2]. In Southeast Nigeria, most people depend on agriculture as their primary livelihood, and therefore, the continuous supply of agricultural inputs is essential in ensuring food production is uninterrupted.

Sustainable food production entails providing food for present and future generations while maintaining natural resources, sustaining agricultural production levels, and conserving the environment [3]. However, disruptions in the supply of agricultural inputs due to the COVID-19 lockdown and climate change challenges have affected sustainable food production and, by extension, food security in Southeast Nigeria [1,4]. Climate change is among the most dangerous environmental challenges affecting agricultural production worldwide. Shifting weather patterns, rising temperatures, and extreme weather events have forced farmers to adopt climate-smart techniques while also altering agricultural input demands.

In Nigeria, climate change factors have influenced farmers' decisions concerning crop varieties, fertilizers, input use, and production functions, ultimately lowering agricultural production and food security [5]. Recent studies also reveal that climate-smart agricultural production has augmented food security and dietary diversity in Nigerian farmers. Thus, climate-resilient agricultural inputs and technologies are critical in achieving sustainable agriculture and enhancing food production and security [6]. Climate change factors such as excessive rainfall, flooding, gully erosion, high dry seasons, and loss of soil nutrients have increased the demand for agricultural inputs in Southeast Nigeria. Farmers are more likely to acquire improved seeds, organic and inorganic fertilizers, irrigation, pest control agents, and extension advice to enhance production and offset the adverse effects of climate change.

The COVID-19 pandemic, which began in 2020, has significantly affected agricultural production worldwide. It is worth noting that COVID-19 is not directly detrimental to agricultural production but rather through the restrictions enforced to control its transmission. The COVID-19 lockdown, imposed to reduce the spread of the disease, caused significant disruptions to agricultural input supply chains, affecting agricultural production [1,4,7]. The lockdown, for instance, hindered the distribution and transportation of agricultural inputs, thereby restricting their availability and accessibility. Apart from disrupting input supply chains, COVID-19 also caused illness and restricted movement of individuals, hindering farm production and the distribution of farm produce. According to the Food and Agriculture Organization (FAO), disruption of agricultural supply chains due to COVID-19 has revealed vulnerabilities and threatened food security, necessitating the need for more robust and reliable supply chains to ensure agricultural sustainability during emergencies [7].

Agricultural input dealers have faced numerous challenges, including restricted movement of people and goods, increased transportation costs, limited access to wholesale agricultural input markets, and lack of labor during the COVID-19 lockdown. These challenges hindered the free flow of agricultural inputs, such as fertilizers, improved seeds, agrochemicals, and other farm equipment. As a result, farmers could either do without farm inputs, plant on a small scale, adopt substitute inputs, or give up cultivation, affecting agricultural production and food security. Although the lockdown restrictions were mainly designed to limit the spread of the disease, they had adverse effects on agricultural production, especially in Southeast Nigeria. Additionally, the combined effects of COVID-19 lockdown and climate change have further hindered agricultural production. Climate change has forced farmers to depend on agricultural inputs to overcome the adverse effects on crop yield, and at the same time, COVID-19 restrictions have hindered the free flow of agricultural inputs, affecting agricultural production. Recent studies demonstrate that resilient supply chains, efficient logistics, climate-smart techniques, and responsive policies can enhance agricultural input availability during emergencies and bolster sustainable food production.

Increased food insecurity cases in Southeast Nigeria could be attributed to the challenges affecting agricultural production, including limited access to agricultural inputs, low agricultural productivity, and disruption of supply chains. Studies reveal that ensuring access to agricultural inputs is one of the most crucial interventions for sustaining food production and, by extension, national food security [1,4,7].

This study examined the impact of climate change and COVID-19 lockdown on agricultural input supply and explored their implications for sustainable food production in Southeast Nigeria. The findings of this study will offer empirical evidence for policymakers and agricultural stakeholders to formulate resilient agricultural input supply systems that can withstand future climate change and COVID-19-like disasters, thereby enhancing sustainable food production.

Agricultural production in Southeast Nigeria depends on the availability, accessibility, and affordability of agricultural inputs such as fertilizers, improved seeds, agrochemicals, and other farm implements. Most farmers rely on agricultural inputs to increase crop yield and income while also countering the adverse effects of climate change [1,6]. In recent times, agricultural production has faced numerous challenges, including disruption of agricultural input supply chains due to the COVID-19 lockdown and climate change challenges such as flooding, erosion, and gully invasion [8,9]. Climate change, for instance, has forced farmers to adopt climate-smart agricultural production techniques to increase agricultural production while also offsetting the adverse effects of climate change on crop yield. Some of the adaptation measures that have been implemented include the use of improved and hybrid seeds, farm mechanization, and the application of climate-resilient agricultural inputs such as fertilizers and agrochemicals [6]. On the other hand, the COVID-19 lockdown has caused significant disruptions to agricultural input supply chains, hindering their free flow to farmers, thereby affecting agricultural production [1,4,7].

These disruptions to agricultural input supply chains caused by climate change and COVID-19 lockdown have resulted in reduced agricultural production, lowered food availability, and increased food prices. Such effects of disrupted supply chains have been felt in Southeast Nigeria, which is among the leading contributors to the country's food production. Farmers in Southeast Nigeria are mostly small-scale and depend on local markets to sell their products and purchase agricultural inputs. Therefore, disruptions to agricultural input supply chains due to climate change and COVID-19 lockdown have significantly affected Southeastern farmers, who are the country's primary food producers. Previous studies have demonstrated the impact of climate change on agricultural production and the effect of COVID-19 lockdown on agricultural production and food security. However, there is a paucity of empirical studies that examined the combined effect of climate change and COVID-19 on agricultural input supply and their implications for sustainable food production in Southeast Nigeria. A better understanding of the effects of these two factors on agricultural input supply will help develop appropriate policies that cushion farmers against future similar occurrences while promoting sustainable food production. Hence, this study sought to establish the effects of climate change and COVID-19 lockdown on agricultural input supply and their implications on sustainable food production in Southeast Nigeria. The general objective of this work is to examine the effects of climate change and the COVID-19 lockdown on agricultural input supply and their implications for sustainable food production in Southeast Nigeria. The specific objectives, among other things include ; a). determine the effects of climate change on the supply of agricultural inputs in Southeast Nigeria; b). examine the effects of the COVID-19 lockdown on agricultural input distribution and supply; c). identify the major agricultural inputs affected by climate change and the COVID-19 lockdown; d).

assess the implications of disruptions in agricultural input supply for sustainable food production; and e). recommend strategies for strengthening resilient agricultural input supply systems during future climate-related and public health emergencies. This study contributes empirical data from Southeast Nigeria on the impact of the COVID-19 lockdown on agricultural input distribution and supply. The findings add to the understanding of agricultural input distribution and will inform policy on input supply and agricultural production and help build capacities of agricultural extension agencies, input suppliers, cooperatives, and other developmental organizations in improvisation and adoption of appropriate strategies that will enhance input distribution and supply to sustain agricultural production during emergencies such as the COVID-19 pandemic. The study will also provide baseline data for future similar studies and contribute to sustainable agricultural production, food security, poverty alleviation, and the attainment of the Sustainable Development Goals (SDGs), especially goals 2 and 12.

Methodology

The research was carried out in Southeast Nigeria, which includes the states of Abia, Anambra, Ebonyi, Enugu, and Imo. This area is located between latitudes 4°30'N and 7°30'N, and longitudes 6°30'E and 8°30'E, covering about 29,000 square kilometres. The region features tropical rainforest and derived savannah vegetation, with annual rainfall averaging between 1,500 and 2,500 mm. Farming is the primary livelihood for most rural residents, who grow key crops like cassava, yam, maize, rice, cocoyam, vegetables, and legumes. Many also raise poultry, pigs, fish, and small ruminants. Success in agriculture here depends heavily on reliable access to critical inputs such as high-quality seeds, fertilizers, agrochemicals, machinery, veterinary supplies, and extension support. A descriptive survey approach was used for this study, chosen for its effectiveness in gathering direct insights from farmers on how climate change and the COVID-19 lockdown affected agricultural input availability and, in turn, sustainable food production. This method allowed for the collection of quantitative data on farmers' experiences, views, and coping strategies without altering any variables. It also supported the examination of current conditions and the connections between climate events, disruptions in input supply chains, and food production results [10]. Survey designs are commonly used in similar research on agricultural resilience, climate adaptation, and food security in developing regions. The area has seen a rise in climate-related issues, including floods, extended dry periods, unpredictable rainfall, soil erosion, and higher temperatures. These environmental pressures, combined with movement and market restrictions during the pandemic, interfered with transportation, labour availability, market operations, and the distribution of farming inputs—ultimately undermining sustainable agricultural output. Given these overlapping challenges, Southeast Nigeria provided a relevant context for analyzing the joint impact of climate change and pandemic-related disruptions on farming systems. The study focused on registered crop and livestock farmers across the five states, including those involved in Agricultural Development Programmes (ADPs), farmer cooperatives, commodity groups, and extension-linked farming networks. Data from the Federal Ministry of Agriculture and Food Security and state-level ADPs indicated approximately 18,600 registered farmers engaged in agriculture in the region, forming the study's target population.

A sample of 391 farmers was selected using Taro Yamane's (1967) sampling formula. Data were gathered through a structured questionnaire, reviewed and validated by specialists in Agricultural Extension, Agricultural Economics, and Measurement and Evaluation. To assess reliability, a pilot test was conducted with 30 farmers outside the study area, using Cronbach's Alpha; a coefficient of 0.70 or above was deemed acceptable [11]. Collected data were coded and analyzed using SPSS Version 29. Descriptive statistics—such as frequencies, percentages, means, and standard deviations—were applied to present and address the research objectives.

Result and Discussions

Perceived effects of climate change on the supply of agricultural inputs in Southeast Nigeria.

The data presented in the table 1 shows that most participants agreed that climate change has had a significant impact on the availability of farming materials in Southeast Nigeria. The statement that received the highest average rating was "The rise in prices of fertilizers, seeds, and agrochemicals is due to climate change" ($\bar{x} = 3.34$, $SD = 0.87$), indicating that the increased costs of inputs are widely recognized as a major consequence of climate change. This was closely followed by "Severe weather conditions have led to higher expenses in transporting agricultural materials" ($\bar{x} = 3.29$, $SD = 0.89$) and "Floods cause disruptions in the movement and delivery of farming supplies" ($\bar{x} = 3.26$, $SD = 0.91$). The overall average of 3.21 ($SD = 0.91$) surpasses the benchmark average of 2.50, showing that respondents believe climate change has a significant adverse impact on the supply, availability, cost, and distribution of farming inputs in Southeast Nigeria. The relatively narrow range of standard deviation values (0.87–0.94) indicates a high level of agreement among respondents. This suggests that climate-related occurrences like floods, unpredictable rainfall, higher temperatures, and deteriorating transport systems are still hindering the efficient provision of farming materials, creating obstacles for sustainable agricultural practices in the area. Climate change has become a significant threat to the agricultural input supply chains in Nigeria, Southeast. Excessive rains, flooding, drought, extreme weather, and rising temperatures have disrupted the availability, transportation, storage, and distribution of agricultural inputs, including improved seeds, fertilizers, agrochemicals, animal feeds, and farm equipment, ultimately impacting agricultural production. This occurrence has resulted in reduced availability of farm inputs in the local market during the planting season, causing insufficient food production and threatening food security in the study area [7,8].

Climate change has caused flooding and damage to roads in Southeast, impeding the distribution of agricultural inputs to farms. The disruption of transportation routes has triggered a surge in agricultural input prices as suppliers incur additional costs while attempting to navigate the affected areas [12,7]. Moreover, the impact of climate change has hindered the effective utilization of alternative means of transportation in rural areas, affecting agricultural production. A combination of high temperature and high humidity has impeded proper storage of farm inputs and significantly reduced their efficacy in agricultural production. Climate change also impacts the supply chains of farm inputs by deterring private investors from engaging in sustainable agricultural practices. Such an occurrence has resulted in limited supply of improved agricultural technologies to farms in Southeast Nigeria [8,13].

Furthermore, the implication of disrupted farm input supply chains, induced by climate change, has resulted in a reduction in production of food crops by individual farmers. Consequently, the reduced agricultural surplus has adversely influenced individual farmers' capacity to purchase farm inputs from local markets, affecting agricultural production in Southeast Nigeria. Increased occurrences of extreme weather such as gully erosion, prolonged droughts, and flooding have prompted individual farmers to utilize cheaper inputs in crop production while reducing the rate of adoption of newer improved inputs. These occurrences have become a constraint to achieving sustainable agricultural production and increasing farm income while alleviating hunger in Southeast Nigeria [7,1,14].

Table 1: Perceived Effects of Climate Change on the Supply of Agricultural Inputs in Southeast Nigeria

S/N	Item Statement	Mean	SD	Decision
1	Climate change has reduced the timely availability of agricultural inputs.	3.19	0.94	Agree
2	Flooding disrupts the transportation and distribution of farm inputs.	3.26	0.91	Agree
3	Increased temperatures have affected the storage quality of agricultural inputs.	3.15	0.92	Agree
4	Climate change has increased the prices of fertilizers, seeds, and agrochemicals.	3.34	0.87	Agree
5	Irregular rainfall patterns have delayed the supply of agricultural inputs.	3.22	0.91	Agree
6	Climate-related road damage has limited access to input markets.	3.16	0.94	Agree
7	Climate change has caused shortages of improved crop seeds.	3.12	0.92	Agree
8	Climate change has reduced the efficiency of agricultural input supply chains.	3.19	0.91	Agree
9	Extreme weather events have increased the cost of transporting farm inputs.	3.29	0.89	Agree
10	Climate change has negatively affected farmers' access to quality agricultural inputs.	3.23	0.91	Agree

Effects of the COVID-19 Lockdown on Agricultural Input Distribution and Supply in Southeast Nigeria.

The results in Table 2 shows that the COVID-19 lockdown had a significant impact on the distribution and availability of agricultural supplies in Southeast Nigeria. The primary reported impact was a delay in distributing agricultural inputs (87.2%), followed by price increases for fertilizers, seeds, and agrochemicals (84.1%) and disruptions in transportation and logistics for farm supplies (80.6%). Respondents also mentioned shortages of quality seeds (77.2%), decreased availability of fertilizers (74.4%), and restricted access to agrochemicals (70.6%). Additionally, more than half of the respondents stated that the lockdown caused agro-input shops to close (67.3%), reduced the importation of agricultural supplies (65.7%), raised transportation expenses for suppliers (63.4%), delayed the delivery of farm equipment (59.8%), decreased extension services (56.5%), and led to hoarding and scarcity of products (54.7%). These outcomes highlight that the COVID-19 lockdown severely disrupted the agricultural supply chains, causing delays, shortages, price hikes, and limited access to essential farm inputs necessary for agricultural activities in Southeast Nigeria.

The covid-19 lockdown created adverse effects on the distribution and supply of agricultural inputs in Nigeria, Southeast. The restrictions, bans, and prohibitions imposed on transportation, inter-state trading, markets, and commercial activities disrupted agricultural production processes and food systems. Consequently, agricultural production inputs such as improved seeds, fertilizers, agrochemicals, animal feeds, and farm equipment were not easily accessible to farmers during the covid-19 lockdown.

The lockdowns, therefore, caused a shortage of agricultural production inputs which hindered optimal yields, posing a threat to food security in many households [15,16].

The covid-19 lockdown also caused inflation in agricultural production inputs due to restricted transportation activities, increased logistical costs, and inadequate production and distribution of agricultural inputs [15, 17]. Further, the ban on imports of fertilizers, improved seeds, pesticides, and farm equipment resulted in shortage of these agricultural inputs in the local market. Farmers suffered the most since they purchased these materials with their personal money and used them for commercial purposes. Additionally, the covid-19 lockdown resulted in disruption of agricultural extension and advisory services to farmers in the Southeast geo-political region of Nigeria. The lockdown hindered direct physical contact between extension agents, farmers, and input dealers regarding agricultural production processes and new developments in the sector. The lockdowns impact on restricted agricultural input distribution and soaring prices disrupted agricultural production processes and food systems, affecting many farmers and communities [15]. The Nigerian government and other stakeholders have proposed several interventions in the agricultural sector to build more resilient agricultural production input distribution systems, promote local production of agricultural inputs, develop digital marketing platforms, invest in strategic reserves of agricultural production inputs, and respond to production shocks during the covid-19 pandemic [17,15].

Table 2: Multiple Responses on the Effects of the COVID-19 Lockdown on Agricultural Input Distribution and Supply

S/N	Perceived Effect	Frequency (n)	Percentage (%)
1	Delay in the distribution of agricultural inputs	341	87.2
2	Increased prices of fertilizers, seeds, and agrochemicals	329	84.1
3	Disruption of transportation and logistics of farm inputs	315	80.6
4	Shortage of improved seeds and planting materials	302	77.2
5	Reduced availability of fertilizers	291	74.4
6	Limited access to agrochemical products	276	70.6
7	Closure of agro-input shops during the lockdown	263	67.3
8	Reduced importation of agricultural inputs	257	65.7
9	Increased transportation costs for input distributors	248	63.4
10	Delayed delivery of farm machinery and equipment	234	59.8
11	Reduced extension support for input distribution	221	56.5
12	Hoarding and scarcity of agricultural inputs	214	54.7

Major agricultural inputs affected by climate change and the COVID-19 lockdown in Southeast Nigeria.

The outcomes on table 3 indicates that survey participants recognized fertilizers as the agricultural input most impacted by climate change and the COVID-19 lockdown, with 347 respondents (88.7%) acknowledging this impact. Following this, enhanced crop seeds (335; 85.7%) and agrochemicals (82.1%) were also highlighted. A significant number of respondents also noted that farm machinery and equipment (76.2%) and livestock feed (72.6%) suffered negative effects. Moreover, organic manure/soil enhancers (68.8%), irrigation tools (64.2%), veterinary medications and vaccines (61.1%), planting materials/seedlings (58.3%), and farm implements (54.7%) were recognized as inputs impacted by both climate change and the COVID-19 pandemic. These results imply that disturbances caused by climate issues and restrictions due to the pandemic had widespread consequences on the availability,

accessibility, and affordability of essential agricultural inputs necessary for sustainable farming in Southeast Nigeria. The disruptions caused by climate change and COVID-19 lockdown significantly impacted the availability, access, and affordability of key agricultural inputs in Southeast Nigeria. Floods, insufficient rainfall, rising temperatures, and extreme weather events influenced the damage to infrastructure, hindering the distribution of agricultural inputs from manufacturers to farms. The COVID-19 lockdown also triggered restrictions, impeding the free circulation of agricultural inputs within the country and from foreign markets, especially during the planting season [17,18].

Agricultural inputs such as fertilizers, improved seeds, and agrochemicals were among the top three most affected production factors. For example, the distribution of fertilizers was disrupted by floods and bad roads caused by climate change and COVID-19 lockdown. At the same time, fertilizer had become expensive as a result of increased transportation costs and restrictions causing acute shortages in many parts of the country. This led to reduced amounts of fertilizer use, hence poor yields [14,17]. Similarly, the production of improved seeds and planting materials faced challenges with climate change and a lack of farm labor due to COVID-19 lockdown. Moreover, the trade and transportation of improved seeds and planting materials were disrupted, limiting farmers' access to quality and climate-resistant seeds and affecting the overall planting program [19,18].

Herbicides, pesticides, and fungicides were also significantly impacted as agricultural chemical companies rely on the importation of raw materials. Therefore, the COVID-19 lockdown disrupted the supply chain, increasing the prices of these products due to high demand while limiting their availability due to restricted free movement [17, 14]. Additionally, extreme weather such as heavy rains and high humidity caused by climate change increased the prevalence of pests and diseases, hence farmers had to purchase more of these agricultural chemicals while they were unavailable in some regions. Other farm inputs significantly affected by COVID-19 lockdown and climate change are farm equipment and implements, irrigation machines, livestock and feed, livestock drugs and vaccines, and farm tools. For instance, poor maintenance of farm equipment due to the inability to import and purchase spares and high fuel prices reduced the rate of mechanized farming. At the same time, animal husbandry was also affected as animal feed became scarce and costly due to disrupted supply chains and increased fuel prices, limiting the amount of livestock that could be reared in the region [20, 17].

Table 3: Major Agricultural Inputs Affected by Climate Change and the COVID-19 Lockdown in Southeast Nigeria

S/N	Agricultural Input Affected	Frequency (n)	Percentage (%)
1	Fertilizers	347	88.7
2	Improved crop seeds	335	85.7
3	Agrochemicals (herbicides, pesticides and fungicides)	321	82.1
4	Farm machinery and equipment	298	76.2
5	Livestock feed	284	72.6
6	Organic manure/soil conditioners	269	68.8
7	Irrigation equipment	251	64.2
8	Veterinary drugs and vaccines	239	61.1
9	Planting materials/seedlings	228	58.3
10	Farm tools (hoes, cutlasses, sprayers, etc.)	214	54.7

Implications of Disruptions in Agricultural Input Supply for Sustainable Food Production in Southeast Nigeria.

The results show that participants viewed decreased crop yield and agricultural efficiency as the most important outcome of disturbances in the supply of agricultural resources, with 349 participants (89.3%) acknowledging this. Following this, the rise in food production expenses (337; 86.2%), food scarcity and decreased food accessibility (328; 83.9%), and higher food costs (321; 82.1%) were noted. These results indicate that interruptions in agricultural input provision directly impact agricultural produce and food availability. Respondents also highlighted reduced earnings and profitability from farming (79.0%), postponed planting and harvesting operations (75.7%), heightened household food insecurity (73.4%), and decreased adoption of advanced agricultural technologies (69.3%) as key consequences. Furthermore, many participants mentioned an increased reliance on substandard or reused farm inputs (66.2%), diminished sustainability of agricultural production methods (63.4%), heightened susceptibility of small-scale farmers to future crises (60.4%), and a decline in rural livelihoods and job opportunities (57.3%). In general, the results indicate that disruptions in the supply of agricultural inputs jeopardize sustainable food production by diminishing efficiency, raising production expenses, jeopardizing food security, and weakening the resilience of farming households in Southeast Nigeria.

Disruptions in the agricultural input supply chain can have various effects on sustainable food production in Southeast Nigeria. The COVID-19 pandemic and climate change disruptions led to the inadequate supply and timely availability of agricultural inputs such as fertilizers, improved seeds, agrochemicals, animal feeds, irrigation equipment, and farm machinery that were critical for food production. This situation not only affected farmers' ability to purchase these agricultural inputs but also adversely impacted the agricultural output and sustainability of food production systems in Southeast Nigeria [17, 18]. One of the significant effects of disrupted supply chains of agricultural inputs in Southeast Nigeria is the decrease in agricultural production and crop yields. Lack of access to improved seeds and fertilizers leads to low-performance crops, and inadequate supply of agrochemicals causes lower food production due to pests, diseases, and weeds. As a result, farmers experience low agricultural production and yields since they do not harvest food crops that are fit for human consumption, affecting the region's general food security. This effect is detrimental to sustainable food production in Southeast Nigeria [14, 17]. Another effect of inadequate agricultural input supply in Southeast Nigeria is the increase in agricultural production costs and food prices. The insufficient supply of farm inputs affects their market prices, which, in turn, affects the quantity of food produced by farmers. Agricultural production costs in Southeast Nigeria rise as a result of the high prices of agricultural inputs and, consequently, the prices of food products sold in the market also increase [21,20]. This situation decreases the purchasing power of many households and ultimately leads to worse-off poverty levels in the region.

Agricultural input disruptions also cause a decrease in farmers' incomes and sustainability of agricultural production systems in Southeast Nigeria. Farmers experience lower returns from their produce due to lower yields caused by inaccessibility to agricultural inputs and poor on-time planting, which ultimately affects their overall income. In addition, most farmers in Southeast Nigeria are small-scale farmers with limited funds to resume agricultural production after any form of disruption.

Therefore, the disruptions in agricultural input supply have a significant impact on the small-scale farmers, affecting their sustainability in agricultural production, which affects that of the whole region [22]. The disruptions in the supply of agricultural inputs in Southeast Nigeria lead to a decrease in the overall resilience of the food system as a result of the continuous use of inferior-quality agricultural inputs in food production. This effect is crucial to the regional food system because it creates a negative impact on embracing climate-smart agricultural practices and technological developments in sustainable food production systems in the region. Thus, sustainable agricultural production in Southeast Nigeria can only be achieved through the local production of agricultural inputs, improving rural infrastructure, investing in digital platforms for agricultural input supply, and developing contingency plans for agricultural production [21, 14].

Table 4: Implications of Disruptions in Agricultural Input Supply for Sustainable Food Production in Southeast Nigeria

S/N	Implication	Frequency	Percentage
1	Decline in crop yield and agricultural productivity	349	89.3
2	Increased cost of food production	337	86.2
3	Food shortages and reduced food availability	328	83.9
4	Increase in food prices	321	82.1
5	Reduced farm income and profitability	309	79.0
6	Delayed planting and harvesting activities	296	75.7
7	Increased household food insecurity	287	73.4
8	Reduced adoption of improved agricultural technologies	271	69.3
9	Greater dependence on low-quality or recycled farm inputs	259	66.2
10	Reduced sustainability of agricultural production systems	248	63.4
11	Increased vulnerability of smallholder farmers to future shocks	236	60.4
12	Decline in rural livelihoods and employment opportunities	224	57.3

Strategies for Strengthening Resilient Agricultural Input Supply Systems During Future Climate-Related and Public Health Emergencies in Southeast Nigeria.

The results show that the primary suggested approach to enhance resilient agricultural input supply systems was enhancing rural road and transportation infrastructure, (91.0%). Following this, the recommendations included boosting local production of fertilizers, seeds, and agrochemicals (89.0%), creating strategic reserves for agricultural inputs and emergency distribution centers (86.2%), and reinforcing climate-smart agricultural policies and initiatives (84.1%). Additionally, the survey participants proposed expanding digital platforms for ordering and distributing agricultural inputs (81.1%), raising government subsidies for agricultural inputs in times of crisis (78.8%), and improving agricultural extension and advisory services (75.7%). Other notable suggestions involved enhancing cooperation among government bodies, private-sector entities, and farmers' cooperatives (72.6%), promoting private-sector investments in agricultural input supply chains (69.3%), establishing early warning systems and emergency plans (67.3%), enhancing access to agricultural loans and insurance (64.2%), and advocating for climate-resilient seed varieties and sustainable farming technologies (61.1%). In line with above findings, [21,14], pointed that strengthening resilient agricultural input supply systems is critical to ensure uninterrupted food production in the event of future climate-related disasters and public health emergencies.

The combined effect of climate change and COVID-19 pandemic has created significant disruptions to agricultural production resulting from disruptions to input supply chains, weak rural infrastructure, inadequate storage facilities, and inappropriate distribution policies. There is a need to build resilience capacity at various levels including investing in infrastructure, local production of agricultural inputs, policy reforms, and digital technologies to ensure continued availability of key production inputs [21,14].

Promoting local production of agricultural inputs including fertilizers, improved crop varieties, agrochemicals, animal feeds, and other supplies is critical in ensuring continuous food production. Besides promoting domestic production of agricultural inputs, there is a need to create reserves at both national and sub-national levels and develop appropriate distribution systems to ensure there are adequate supplies even when international trade is disrupted due to emergencies such as pandemics and climate-related disasters [22, 21]. Additionally, improving rural infrastructure and logistics including roads, bridges, storage, and transportation facilities to support the smooth flow of agricultural inputs to farmers in case of extreme weather events during the rainy season and prolonged droughts during the dry season. Besides physical infrastructure, digitizing agriculture to ease the distribution processes by enabling farmers to purchase agricultural inputs online or through mobile platforms and offer electronic vouchers to vulnerable farmers during shortages is critical [14,18].

Another effective strategy that can be employed to make the agricultural input supply chain more resilient to future climate-related disasters and public health emergencies is promoting institutional development and adaptation to climate change by building institutional capacity at various levels in agricultural production and input supply chain management. Strengthening extension services to provide appropriate information to farmers, agricultural input dealers, and other stakeholders while at the same time investing in early warning systems, disaster preparedness, and climate information systems, will go a long way in supporting farmers and input dealers in responding to climate-related disasters and pandemics [20, 18]. In addition, there is a need to promote access to credit, insurance, and targeted input subsidies to cushion farmers against the effects of climate change and pandemics on food production. Finally, there is a need to intensify partnerships at the local and international level including private, public, research, farmers' cooperatives, and NGOs, in designing effective strategies for resilient agricultural input supply chains to support continuous food production in case of pandemics and climate-related disasters. Partnerships will promote the development of appropriate technologies for input production, storage, and distribution. Moreover, promoting partnerships at the local level will help in designing and implementing effective adaptation measures including climate-resilient crop varieties, sustainable technologies, and efficient systems for responding to climate-related disasters and public health emergencies. Such collaborations will ultimately increase the ability of farmers to produce food while promoting sustainable livelihoods and enhancing food security in Southeast Nigeria in the wake of future pandemics and climate-related disasters [21,22].

Table 5: Strategies for Strengthening Resilient Agricultural Input Supply Systems during Future Climate-Related and Public Health Emergencies in Southeast Nigeria

S/N	Recommended Strategy	Frequency	Percentage
1	Improve rural road and transportation infrastructure	356	91.0
2	Promote local production of fertilizers, seeds and agrochemicals	348	89.0
3	Establish strategic agricultural input reserves and emergency distribution centres	337	86.2
4	Strengthen climate-smart agricultural policies and programmes	329	84.1
5	Expand digital platforms for agricultural input ordering and distribution	317	81.1
6	Increase government subsidies on agricultural inputs during emergencies	308	78.8
7	Strengthen agricultural extension and advisory services	296	75.7
8	Improve collaboration among government, private sector and farmers' cooperatives	284	72.6
9	Encourage private-sector investment in agricultural input supply chains	271	69.3
10	Develop early warning systems and emergency response plans for agriculture	263	67.3
11	Improve access to agricultural credit and insurance	251	64.2
12	Promote climate-resilient seed varieties and sustainable farming technologies	239	61.1

Conclusion

This study was carried out to investigate the impact of climate change and COVID-19 lockdown on agricultural input supply and their implication for sustainable food production in Southeast Nigeria. The study found that climate change and COVID-19 lockdown each created adverse effects on the availability, access, affordability, and timely use of agricultural inputs in the study area. The study further revealed that climate change had caused a deficit in the supply of agricultural inputs, while COVID-19 lockdown, which imposed strict restrictions on the free movement of people and goods, disrupted the distribution chain, increased the cost of transportation, restricted the use of agricultural inputs, and reduced the number of farmers' markets, especially for fertilizers, improved seeds, agrochemicals, farm equipment, animal feeds, irrigation equipment, and veterinary products. The study concluded that disruptions in the supply of agricultural inputs had adverse effects on agricultural production, such as lower crop yields, higher production costs, increased food prices, reduced farm income, food shortages, delayed planting schedules, and increased food insecurity. It was recommended that agricultural input supply chains be made more resilient to future disruptions and shocks by investing in climate-smart agriculture, building local capacity, ensuring the adoption of digital technologies, creating strategic reserves of essential agricultural inputs, promoting agricultural extension services, providing access to credit and insurance, and strengthening institutional linkages among government agencies, private institutions, research organizations, development agencies, and farmers' cooperatives.

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