Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.14, No.2, 2023

Managing the Sustainable Ecosystems Across the Globe: An Analysis of the United States of America's Initiative Towards the Production of Climate Smart Fertilizer as a Solution to World Food Insecurity

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Abstract
The aftermath of the Covid-19 pandemic occurrence in various aspects of society is undeniable. One aspect of this is the increasing number of food-insecure nations globally (FAO, 2022), these incidents have had a damaging impact on a key sustainable development goal (SDG) of the United Nations (UN) on reducing global hunger by the year 2030 (FAO, 2021). It is estimated that 1 in 3 people do not have access to affordable and nutritious food, whereas energy prices, fertilizer prices, and food prices continue to increase causing significant distress to mostly affect poorer countries of the world (World Bank Group, 2022). This dire situation calls for concern and urgent attention for resolution because the United States (US) as a major player in the global agricultural trade has a moral duty to support optimized agricultural yield and quality that strengthen global food security (The White House, 2022). The ability to produce climate-smart fertilizers that boost productivity with minimal or no environmental damage will likely position the United States as a leader in managing sustainable ecosystems, thereby achieving the thirteenth Sustainable Development Goal (SDG) - Climate Action. Consequently, building the ability to (1) "promote improved access to climate-smart and sustainable fertilizers" and (2) "enable/increase global food security" is essential (UN,2015; White House, 2022). We believe that the United States, with its advanced proprietary technologies, global supply chain systems, and market networks, is capable of resolving the growing issues of food protectionism that impede the export of agricultural produce to meet domestic demand (Espitia et al., 2020) and successfully repositioning as a leading producer and exporter of climate-smart and sustainable fertilizers (Goedde et al., 2020; Pingali, 2012) while increasing her income. Allocating part of the $19.5 billion conservation funds to drive climate-smart agriculture through the United States Department of Agriculture (USDA) will go a long way to develop the production of climate-smart and sustainable fertilizers that helps to reduce global food insecurity (USDA, 2022). This paper presents analytical insights on how the US can take on the challenge of producing and exporting sustainable and climate-smart fertilizers to help decrease global food insecurity while keeping the environment safe and maintaining its position as a key contributor to ensuring global food security.
Keywords: Climate Smart Agriculture, Climate-Smart Fertilizers, Sustainable Agriculture, Food security.
DOI: 10.7176/JESD/14-2-03
Publication date: January 31st 2023

INTRODUCTION

Agricultural productivity is declining, and climate change is affecting production systems. Climate-smart Agriculture (CSA) practices will make crop production sustainable and will ensure that agricultural systems are resilient. The United Nations predicted that by 2030, the world's population would reach well over nine billion people (UN, 2020), while the FAO predicts that 70% of the world's population will live in urban areas (FAO, 2021). It is expected that global food demand and production will continue to grow exponentially until 2050. There is an imbalance in the chemical composition of the soil, as well as pollution of water due to over-exploitation of the available arable land. Shah et al. (2002). By emitting greenhouse gasses (GHG) and depositing toxic soil, excessive fertilizer and chemical use contribute to global climate change. Climate-smart

fertilizers play an indirect role in agriculture and food security.

As the population grows and food demands increase, farmers use fertilizers to increase their yields. By 2050, there will be an estimated 9 billion people in the world who will need 70% more food (World Bank, 2022). There are 19-29% of greenhouse gases that cause global climate change that is generated by agriculture and agricultural activities. Agricultural practices include planting, weeding, maintaining, harvesting, processing, and distributing food before, during, and after. Producing and utilizing climate-smart fertilizer will reduce emissions and the effects of climate change by 2030 (World Bank 2022). It was reported by the FAO in 2020 that the Covid-19 pandemic affected the food and agriculture sector, threatening the food security of billions of people (Zurayk, 2020). Food security was threatened on many levels and by several factors. Food resources were not available, stable, accessible, and sustainable due to a restraint on movement and low purchasing power.

The effects of food insecurity vary by country and region around the world. In 2020, the World Bank identified some of these food security hot spots. A sustainable strategy to manage nutrient depletion in the soil can be achieved using plant growth-promoting rhizobacteria (PGPR) and soil-dwelling microbes (Shah et al., 2021). Statistics prove that maize yield in Iowa has declined by about 10-20% between the 20th and 21st centuries due to climate change (Xu, 2016)**.** Climate change is responsible for these changes in air temperature and precipitation. US agricultural proc must be environmentally friendly to help achieve sustained/desired crop growth. Although food security is of great importance, several critical issues hamper its actualization, creating an imbalance in the food system. The top of the list includes climate change, economic instability, population explosion, water scarcity, energy scarcity, and COVID-19. There is no doubt a strong correlation between the environment and food security, and as the world's population increases, there is an exponential rise in food demand, which puts an even greater strain on available resources. Farmers are heavily dependent on fertilizer because of rising food demand. According to statistics, 40%-60 percent depend on fertilizers. Most of these fertilizers (pesticides inclusive) are synthetic in nature, which ignores the negative impacts these chemicals (fertilizers and pesticides) have on human health and the environment. (Davies, 2021).

The trend toward clean labels and transparency in everything consumers consume has led to an increase in consumption. After assessing the futuristic opportunistic value of organic fertilizers and considering these benefits of organic approaches, Persistence Market Research (PMR), in its latest business intelligence, assesses how environmentally friendly fertilizers are altering agricultural practices, thus shaping organic fertilizer market growth prospects. Our study of the foregoing shows how population growth promotes an increase in food demand, which results in farmers engaging in unhealthy agricultural practices that affect the environment and climate. Developing sustainable and climate-smart fertilizers (organic), having established this foundation, it becomes imperative to develop actions to grow the sustainable and climate-smart fertilizer industry. Given the US's position as the fourth largest nitrogen fertilizer producer (The Fertilizer Institute, 2019), the United States is well positioned to lead such a move. Considering the triple bottom line (people, planet, and profit), the US is a leader in developing innovative solutions that are based on sustainability.

This study is significant because it focuses on how to improve research and development, which leads to technological solutions to increase CSF production at an affordable price through innovative research and development. Smallholder farm families produce 29 percent of the world's crops. The food produced on farmlands ranging from 2-199 hectares accounts for 70-81 percent of the food produced globally (Zandt, 2021). One quarter (24%) of the world's agricultural land is devoted to this goal. Using precision agricultural, slow-release fertilizers, engineers and scientists are working on developing innovative technology to improve crop growth. Additionally, US President Biden has committed $22 billion to improve sustainable agricultural practices in his first week in office (The Whitehouse, 2021). The Nutrient Expert (NE), and GreenSeekers (GS) methodologies are helping smallholder farmers practice sustainable agriculture in India. It is imperative to switch to organic fertilizers over the years due to excessive nitrogen in the air and water due to agricultural runoff from synthetic fertilizers. In 2018, PMR estimated that the value of the organic fertilizer market reached US $6,179.9 million, recognizing both the upside-down journey of organic fertilizer coupled with its steady uptake. Market research firm PMR predicts organic fertilizer will grow at 1.8X between 2019 and 2029, at a steady pace. The health and wellness trend is building a strong foundation for organic food, with more health-conscious consumers seeking higher food safety and quality. Farmers are searching for organic substitutes for synthetic fertilizers as consumers become increasingly aware of the harmful effects of synthetic fertilizers on their food. Meanwhile, little is known in the literature about synthetic fertilizers and its implications on the climate and the global market. As a result, this study is used to present the analytical insights on how the US can take on the challenge of producing and exporting sustainable and climate-smart fertilizers to help decrease global food insecurity while keeping the environment safe and maintaining its position as a key contributor to ensuring global food security.

LITERATURE REVIEW

Food Security

A global food crisis began in the early 1970s, and a variety of definitions and research have been conducted (Maxwell and Smith, 1992). According to the Food and Agriculture Organization's 2020 annual report, food security is widely accepted. It encompassed the dimensions of food security that researchers commonly use today. People who are food secure have access to safe, nutritious, and sufficient foods available to them at all times so that they can live an active, healthy, and safe life. It is based on FAO's 2002 report and Peng and Berry's 2019 study. Food safety, sufficient nutrition, and access to food are the two sustainable development goals. Global hunger must be eradicated. Globally, countries have embraced this goal and developed local initiatives to solve hunger problems.

During the World Summit on Food Security, FAO revised this definition. A fourth dimension was added in the new definition, which is stability, which refers to ensuring the short-term availability of food systems to withstand natural and human shocks and feed the population. This report was published by the FAO in 2009. A fifth dimension was added to the definition when sustainability became a concept; ensuring that food is available to the public on a long-term basis. The concept of food security exists when people have the means and means of meeting their dietary needs adequately today and in the future to maintain an active and healthy lifestyle. There are many dimensions to the concept of food security. Food security encompasses these dimensions.

1. A population's access to food is determined by the availability of food. All distribution channels, including shops, markets, and hotels, have enough food to meet demand. In some cases, the food is produced by the farmers themselves, while in others, it comes from groups or nations that have provided aid to the farmers.
2. Accessibility to food is the ease with which individuals can obtain food products through the distribution channel. Markets and grocery stores offer food for sale, as well as gifts, food aid from countries and organizations, and welfare programs. A country can also import food products or produce its food through subsistence or large-scale farming. Money or planting or production are the most important means of gaining access to food products.
3. Consumption of food. Food processing and storage and how the body extracts nutrition from food products are discussed. Food is used by the body in different ways depending on its health status, storage, and processing methods, and availability of clean water.
4. Food supplies are stable when they are readily available and accessible.
5. Sustainable food is one of the most recent dimensions of food security and it implies the availability of food for present and future generations. In contrast to stability, food is readily available and food insecurity or famine is unlikely.

The concept of food security is a pathway linked to the process by which food is produced; starting from the process of planting and production of food resources to the storage, transportation, distribution, and final consumption by individuals. The process starts with the production of food. Production of food involves all the processes of planting food, management of the farm, harvest of farm produce, and making value from the harvest. Then the food products are transported to retail stores and warehouses; where it is stored before it is being sold to the final consumers. Food security must maintain its entire dimension along this pathway; it must be available, accessible, properly utilized, stable, and sustainable

Food Security before the pandemic

Food security is the first goal of sustainable development. The availability of food at all times ensures that no one goes hungry. In light of this, FAO has published a report titled “The State of Food Security and Nutrition in the World” since 2017. The report marks an effort by organizations worldwide to eliminate hunger, food insecurity, and malnutrition. More than 800 million people still suffer from hunger or malnutrition despite the goal of zero hunger by 2030 (SDG 2015). There was still a significant percentage of undernourished people around the world, even though these statistics declined greatly between 2009 and 2019. (FAO 2019). It has been documented that food has been lost throughout the food chain, including production, transportation, storage, and consumption. Global food security and accessibility are affected by these losses. The amount of food lost around the world is measured in two ways: the total amount lost globally, and the per capita amount lost in each country (Guo et al., 2021).

Global food loss had a gradual upward trend between 1961 and 2019, while global annual per capita food loss had an undulating trend and then increased between 2006 and 2019 (Guo et al., 2021). There is evidence that the global food system is volatile and vulnerable, especially in Africa and south Asia, and that this trend is likely to continue.

Food Security During the Pandemic

In December 2019, China was hit by the Covid-19 pandemic. Asia and the rest of the world were affected by the

pandemic, which was fatal. Over 210 countries were affected by the pandemic within 120 days (Willy et al., 2020). Globally, the pandemic caused multiple deaths, crop losses, property damage, and business losses. (Mouladj, Bouarar & Fechit, 2020). Even though the loss was fatal and affected all businesses, the most important need of people at the time was food (Mouloudj, Bouarar & Fechit 2020). There was a continued loss of life as a result of the pandemic, which affected the health and socioeconomic sectors. To curb the spread of the disease, all activities were halted globally. The virus forced businesses, tourism, travel, sports events, manufacturing, and other activities to stop. Social media outlets reported long queues in stores after the pandemic was declared fatal and dangerous, prompting a lockdown and quarantine. Economically developed and underdeveloped countries both experienced food shortages in the form of fear of doing without food (Mouloudj, Bouarar & Fechit 2020). Food security for billions of people worldwide was put at risk by the Covid-19 pandemic reported by the FAO in 2020 (Zurayk, 2020). Several aspects and factors of food security were threatened, making it an urgent issue. The movement was restricted, and purchasing power was low; which is the availability, stability, accessibility, and sustainability of food.

The effects of food insecurity can be felt in different countries and regions around the world. According to the World Bank (2020), some of these hot spots are causing food security concerns.

1. A region that is vulnerable to war and is affected by it. The pandemic has further widened this gap and placed more pressure on a country's food distribution channels. Before the pandemic, these countries faced logistics issues, food distribution issues, and other issues.
2. Those countries with extreme weather conditions fall into the second category. Agricultural production in these countries has been affected by the weather and climate. They were also restricted from moving and frightened of the virus during the pandemic, which further reduced their ability to produce food.
3. Food-insecure countries that already existed before Covid-19. Most of the people in these countries are grossly malnourished, and they are classified as poor and vulnerable countries.
4. A depreciating currency made it more difficult for countries to import food because it cost more to import. Commodity-exporting countries are also affected. Economic activities were halted, and the border was locked, which threatened available currency and food imports. Food imports and exports of other commodities and resources were the only sources of income for these countries.

War-torn countries and poor countries were especially vulnerable to the effects of Covid-19 due to their malnutrition before the pandemic. Almost 10% of the grain needs of Arab countries, which were large exporters, were met through reduced production. There were also closures of market stalls, hotels, hostels, tourism centers, and restaurants due to a shutdown of economic activities. A 20% drop in agricultural produce prices resulted from this closure (Bhosale, 2020). There was a challenge to the sector's resilience.

People's incomes and purchasing power decreased as economic activities closed. Farmers were unable to compensate them for their production and buy agricultural produce. The United Nations World Food Program estimated that by the end of 2020, about 265 million people would suffer food security due to the pandemic. (World Bank, 2020). Farmers suffered large losses in perishable produce because of the increased food security. Buyers were restricted and could no longer trade with them. This is based on the World Bank's 2020 report. The plight of farmers and agriculturists in developed countries and developing countries are different. Human labor reductions, efforts, and productivity levels were not as severe for most developed countries since they rely on technology. The situation is different for developing countries, however, as they were more susceptible to the pandemic's effects. The human labor force shrank dramatically. This affected their productivity and output and the availability of food resources (World Bank, 2020).

In recent years, human labor has shrunk significantly globally, with the impact affecting the level of import and export of food commodities. During the pandemic, customers hoarded food supplies, stocked food products at home, and found other ways to get their food supply (Schmidt et al., 2020a). In his research, Siche (2020) was able to gather sufficient evidence to confirm that Covid-19 had a significant impact on the food supply chain, food security, and ultimately the most vulnerable populations. According to Kolodinsky et al., 2020, citizens of the USA have also changed the source of their food supply and where they eat (Kolodinsky et al., 2020). During the pandemic, the distribution channels lapsed and showed the frailty of the distribution chain. While some channels and stores had a greater supply of some produce, other channels and stores had a lower supply; some stores were closed, shutting out supplies, while others were partially open, receiving only minimal supplies.

Food prices are highly volatile worldwide, which has a significant impact on food security (Lacirignola, Adinolfi & Capitanio, 2015). People's preferences, incomes, and prices play a huge role in determining how much food is purchased and demanded after the pandemic. As a result of the pandemic-caused economic slump, food prices around the world decreased for four straight months (FAO 2020).

Food Security Post Pandemic

During Covid-19, the economic slump affected people's incomes and financial capacities. Those with higher

incomes are more likely to have access to food, according to Cranfield (2020). Post-pandemic food security is heavily influenced by purchasing power (Cranfield, 2020). Consequently, food supplies will be distributed differently, and supply channels will need to be considered post-pandemic. In the aftermath of the pandemic, farmers will have a higher supply since demand will be higher and purchasing power will be higher. To mitigate this effect, local food production can be increased, and distribution channels restricted (Seleiman et al., 2020). When prices rise, the demand for commodities decreases proportionally. It is the quality, selection, price, and suitability of different food products that determine how consumers will economize and how much they will be willing to spend on the specific food item.

DISCUSSION AND ANALYSIS OF CLIMATE-SMART FERTILIZER

In what ways does sustainable climate-smart fertilizer contribute to Agriculture prosperity?

It is important to use sustainable climate fertilizers because they reduce climate change's effects on the environment. This fertilizer will serve the entire purpose of reducing climate change and its impact everywhere, which is goal 12 of the sustainable development goals. The environment in general benefits from fertilizers, despite their positive effects on plant growth, yield, productivity, and harvest. Consequently, crops suffer, soil quality deteriorates, nutrients are lost, microbial activity is diminished, erosion, leaching, and runoffs occur, and adverse effects are felt on the final consumers of the products. Climate-smart fertilizers will reduce these effects by replacing or reducing some of the ingredients in fertilizers. There will be a positive impact on crops, the land, and humans as consumers because of fertilizers. The goal of climate-smart fertilizers is to achieve a green economy by integrating economic, social, and environmental dimensions. Consequently, local solutions are applied to global and local issues with long-term effects. (FAO, 2012). Climate change issues are indirectly mitigated by indirect mitigation of its effects on agricultural practices, along with issues of food security and availability of healthy and nutritious foods. Developing climate-smart fertilizers has continued and will continue to take the efforts and coordination of researchers, farmers, private sector companies, governments, public sector companies, civil societies, non-governmental organizations, international communities, and other stakeholders (FAO 2012).

The agriculture industry continues to contribute to the gross domestic product of any country, as well as to sustainable development and poverty reduction (World Bank 2008). A farm produce and value chain generate 29% of a country's GDP and employs about 65% of its people. The number of people living in households engaged in agriculture, whether it is for subsistence or large-scale production, is currently about 2.5 billion. Thus, investing in fertilizer is an investment in agriculture, which will improve yields and increase the profits of such countries (FAO, 2012). This makes resources more efficient and resilient. Other sectors linked to the agricultural sector and value-added products are indirectly affected by the efficiency of agricultural products. Rural and urban communities will benefit from this by creating jobs and opportunities. A country's involvement in sustainability issues also involves investing in the green economy. Innovative and green ideas have been the focus of investments, and the development of climate-smart fertilizers will open investment opportunities for scientists and researchers (FAO, 2012). Investments will come from both the public and private sectors, as well as from international organizations.

Moreover, it expands the scope of scientific and professional research work. The improvement of research has a positive effect on the economy and allows other stakeholders to invest. As agriculture is vulnerable to climate change, research into one of its major inputs is a way to mitigate its effects (World Bank 2022). Investments in climate-smart fertilizer are investments into one of the major inputs and determinants of agricultural products. Fertilizers are used by farmers to increase productivity due to the growing population and demand for food. Approximately 9 billion people will require 70% more food by 2050 (World Bank, 2022). An estimated 19-29% of greenhouse gasses that contribute to climate change are generated by agriculture and agricultural activities. Food products are produced before, during, and after planting, harvesting, processing, and distribution. The production and utilization of climate-smart fertilizer will be an action towards reducing emissions and achieving the goal of reducing the effects of climate change globally by 2030 (World Bank 2022). To better understand the concept of climate-smart fertilizer to support agricultural food production, there is a need to discuss the connection it has with Climate Smart Agriculture (CSA), CSA is one of the possible regenerative approaches to agricultural production systems that transform and supports the process of building a resilient practice that positively responds to the climate changes without further depleting the reserve, and reducing GHG emissions (FAO, 2010).

CSF generates lower emissions of greenhouse gases both during production and after application (SPRPN, 2022). It has been demonstrated that CSF is not only environmentally friendly but also renewable, and biodegradable, enhancing soil organic carbon, and soil structure, improving soil water holding capacity, and providing nutrient release slowly and consistently, which increases crop yield and driving economic growth (Lu et al., 2014; Cen et al., 2020). By using the 4Rs of nutrient stewardship (right source, right rate, right time, right place), crop yield plays an important role in reducing the negative impact on the environment. However, some

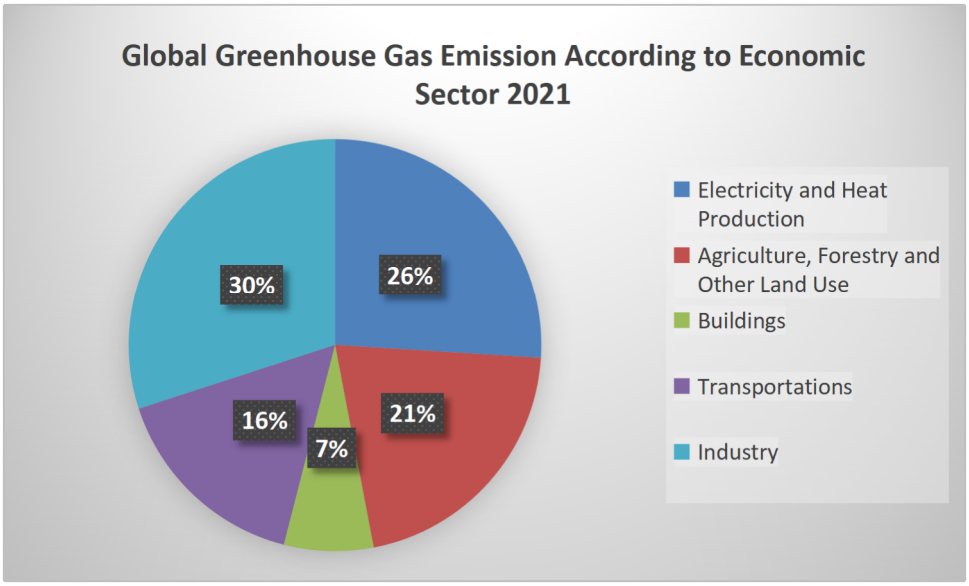
schools of thought argue that a blend of chemical and organic fertilizers is needed to meet the rising food demand (Kong et al., 2014). The growing demand for food is driving farmers to expect greater yields from the same amount of land they have been using for farming. The use of fertilizers and other actions carried out with/on the soil play a very significant role in altering the microbiological, physical, and chemical components of the soil (Boafo et al., 2020). Fertilizer's infiltrated into the environment and can lead to water eutrophication and toxicity, groundwater pollution, air pollution, soil quality degradation, and even change the ecosystems, raising questions about the sustainability of modern agriculture (Tilman et al., 2002; Khan et al., 2008; Wen et al., 2016).

The purpose of climate-smart fertilizers is to improve soil nutrient profile and enhance crop growth by using natural sources of plant and animal nutrients. The fertilizer industry is experiencing growth in climate-smart fertilizer exports. According to Volz, 20,817 export shipments have been achieved so far globally, with Japan, China, and India as the top exporters. In terms of imports, Vietnam accounted for 7,746 with 7,243 shipments, the United States accounted for 3,243 shipments, and India accounted for 2,374 (Volz, 2022). Manufacturing CSFs at an affordable price and achieving continuous production and export to other markets around the world can contribute to global food insecurity and climate change. This paper focuses on actions that improve the innovative R&D that drives technological solutions to achieve increased CSF production at an affordable price especially given that the smallholder farm families account for 29 percent of the world's crops measured in kilocalories, achieving this using one-quarter (24%) of the world's agricultural land altogether, food produced on farmland that ranges from 2- 199 hectares accounts for 70-81 percent of the food produced globally (Zandt, 2021)

Using precision agricultural, slow-release fertilizers, engineers and scientists are developing better ways to achieve optimum crop growth. In his first week in office, US President Biden committed $22 billion to improve sustainable agricultural practices (The Whitehouse, 2021). CSA practices are being adopted by smallholder farmers in India using Nutrient Expert (NE) and GreenSeekers (GS) methodologies. There are approximately 820 million chronically malnourished people in the world and over 90 million underweight children (World Food Programme, 2022). According to the Zero Hunger Sustainable Development Goal (United Nations Development Programme, 2030), all forms of hunger and malnutrition should be eradicated by 2030. Enhancing productivity and yield can be accomplished by using sustainable agricultural practices and improving agricultural technology. According to UNDP, the Climate Action sustainable development goal emphasizes supporting developing countries and vulnerable regions to cope and adapt to climate change. In addition, it encourages investments in low-carbon development to limit the increase in global temperatures, including cutting greenhouse gas emissions.

Decreasing Greenhouse Gas Emissions Using Sustainable Climate-Smart Fertilizer In Agricultural Production

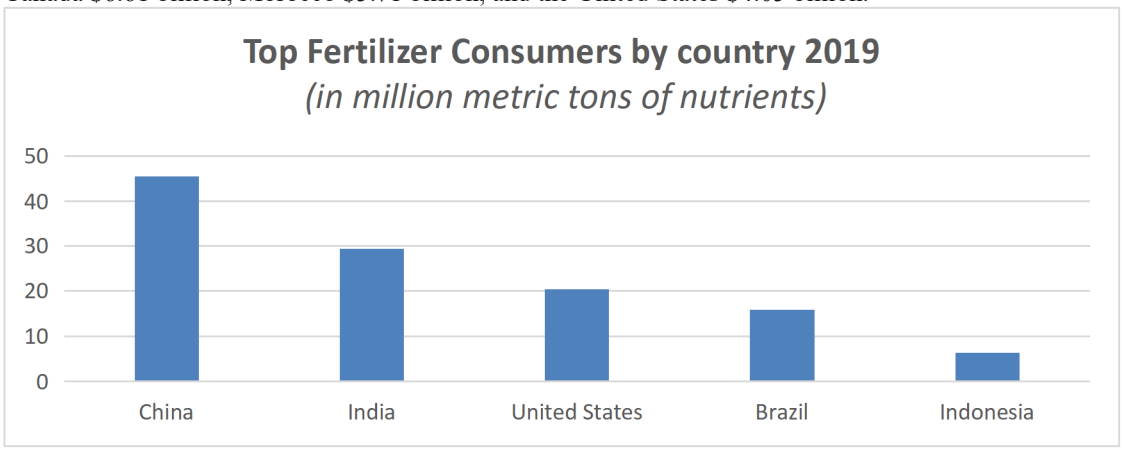
Global climate change has resulted in more unfavorable weather. In the current global food insecurity environment, prolonged droughts and unpredictable precipitation are the most influential factors. The use of unsustainable fertilizers in farming, including both synthetic and organic fertilizers, has significantly increased greenhouse gas (GHG) emissions (methane, nitrous oxide, and $CO_{2)}$ and caused growing the climate change concerns, although the synthetic fertilizers have helped to achieve guarantee increased agricultural production and yield. Systematic increases in food production and decreases in global food insecurity are the main causes of climate change. According to the US EPA, fertilizers are the second largest contributor to total global GHG emissions, contributing up to 24 % (US EPA, 2022). While agriculture does not contribute the most to GHG emissions, it is the sector most conducive to achieving net-zero emissions, which is the balance between GHG emissions produced and taken out of the atmosphere. By 2050, it is expected that all man-made GHG emissions will be eliminated from the atmosphere, starting with a reduction of 45% by 2030 and reaching net zero by 2050 (UNEP, 2022). The US emits more greenhouse gases than China, India, the EU, Indonesia, Russia, and Brazil combined. The combined emissions of these countries accounted for more than half of the global GHG emissions (UNEP, 2022). Brandt (2018) describes "climate-smart agriculture" as a global development goal that can help reduce food insecurity and revert climate change through sustainable production systems (Brandt, 2018).



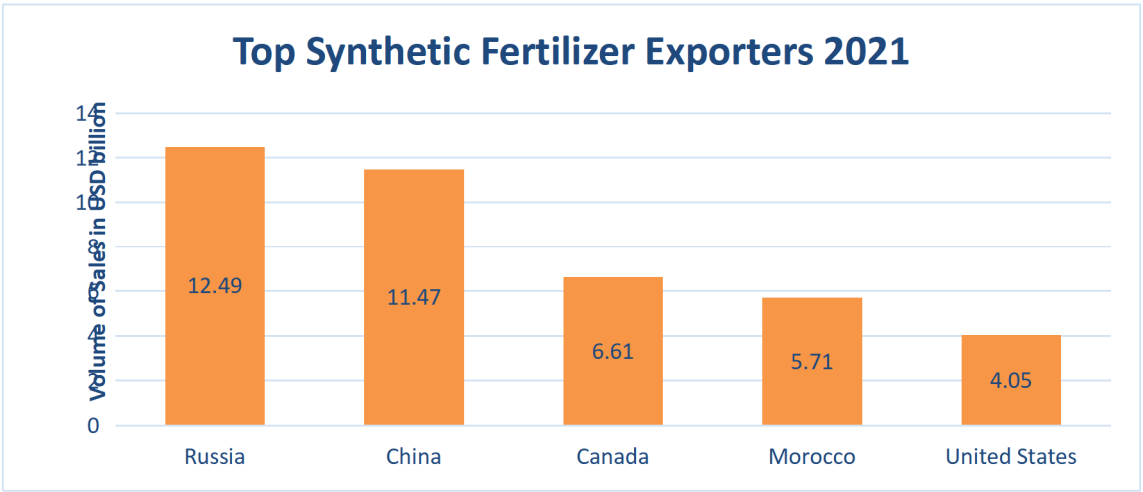
Source: (Environmental Protection Agency, 2022)

Advanced Economies That Are At The Forefront Of Challenging Global Food Insecurity

According to FAOSTAT (2014), China uses the most chemical fertilizers to meet the global food demand (Wang et al., 2018; FAOSTAT, 2014). Based on value, Russia exports $12.49 billion in fertilizer, China 11.47 billion, Canada $6.61 billion, Morocco $5.71 billion, and the United States $4.05 billion.



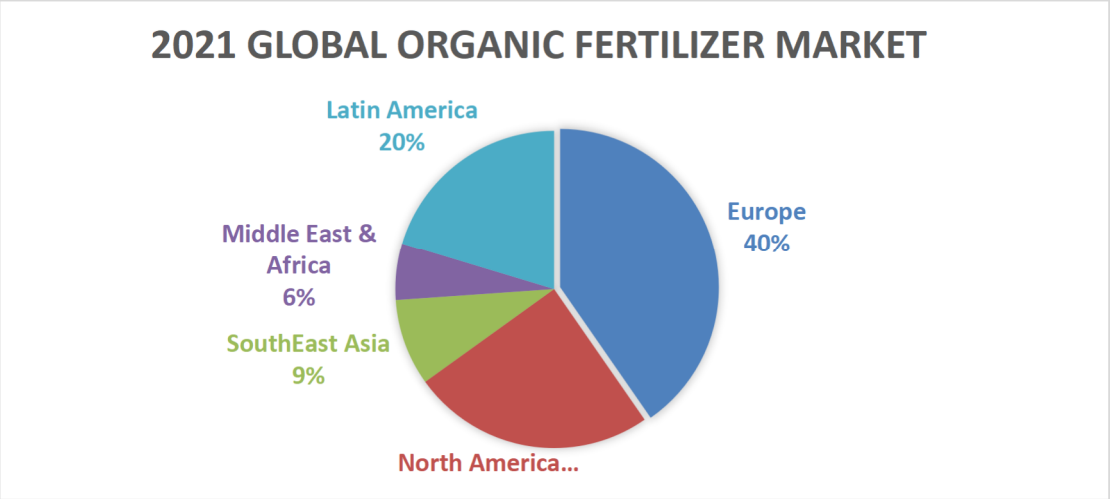
Source: (Statista, 2022)



Source: (Statista, 2022)

Although these activities serve as a great source of revenue for these countries, but they are posing huge

environmental and climate concerns. Research according to Nadia et al., (2017) has shown that with adequate resource and support, the organic fertilizer is able to produce similar yields as the synthetic fertilizer. There has been an increase in food production due to the use of organic fertilizer (Hui et al., 2017; Nadia et al., 2017). The following countries are major producers of organic fertilizers: Belgium, Spain, Germany, Italy, Netherlands, France, United Kingdom, the U.S., Canada, India, and Southeast Asian countries (Indonesia, Malaysia, Thailand, and Singapore). Below is a chart showing the global organic fertilizer market, with Europe accounting for 40 percent of the market.



Source: (Market Data Forecast, 2022)

Among the strategies adopted by governments to grow this industry among the top players in the advanced economies are subsidies on agricultural input conversion, raising awareness about the benefits of organically grown food among consumers, and finally advocating for the environmental benefits of organically grown food among consumers (PR Newswire, 2017).

As Vilsack highlighted USDA initiatives and investments at the UN Climate Change Conference in 2022, the US is on top of innovative partnerships with farmers to contribute meaningfully to sustainable agriculture, which caters to both farmers in all 50 states as well as small and underserved farmers. A total of $20 million has been allocated for the Fertilize Right initiative through the global fertilizer challenge. Brazil, Colombia, Pakistan, and Vietnam have all pledged to work with the USDA to improve fertilizer efficiency and nutrient management. A further $5 million has been committed to supporting the efficient fertilizer consortium in collaboration with the private sector towards research and development for efficient fertilizer products and practices (USDA, 2022).

A climate-smart fertilizer is derived from natural plant and animal sources and is rich in essential nutrients. It improves the soil's nutrient profile and improves the quality of crops. Exports of climate-smart fertilizers are growing in the fertilizer industry. There have been 20,817 million metric tons export shipments globally, with Japan, China, and India being the top exporters. As far as imports are concerned, Vietnam has 7,746 shipments, the United States has 3,243 shipments, and India has 2,374 (Volz, 2022).

POLICY RECOMMENDATIONS AND IMPLICATIONS

There must be a public-private partnership that allows for collaboration among stakeholders in researching the production of agricultural products in commercial sizes. Stakeholders such as agriculturists, scientists, farmers, extension workers, researchers, the government, and others must work together in developing and producing inputs like climate-smart fertilizers, pesticides, herbicides, seeds, and other inputs in large quantities and making them available to the farmers. Statistics have shown the US to be a top importer of both synthetic and organic fertilizer and other inputs, but this can be reversed via the domestic production of sustainable and CSF. The stakeholders must focus on innovative research and development that yields technological solutions to increase the consumption of sustainable farm produce that are safe and environmentally friendly. Furthermore, the obvious disruption to the global food system as a result of the COVID-19 lockdown, Russia-Ukraine war, labor shortages, amongst other geo-political tensions should present a platform for the US to lead a resilience and sustainable transformation in its food production capacity building, which considers the environment, and serve the international food markets transparently. The US government can divert funds to the amount spent on fertilizer export (the equivalent of $4.05billion as of 2014) into climate-smart agriculture (FAOSTAT, 2014). This will set the pace for prosperity in all other aspects of the economy. It will increase the rate of employment in the country as more people will be employed in the production and value-chain industries. Also, it will create a value chain that will yield revenue for the recipients from the production to its distribution and final use by farmers and agriculturists. The production of climate-smart fertilizers will also be a source of revenue for the

country as it will contribute to the GDP and economy of the country.

With the rise in global food demand and consumption, (Shah et al., 2002), for the benefit of the practice of climate-smart agriculture to be actualized, the use of CSF must be practiced across commercial and subsistence farming. Climate-smart agricultural practices must be encouraged to ensure the resilience of the agricultural systems. Research has shown chemical composition imbalance of the soil (FAO, 2021), shrinking arable agricultural land (FAO, 2021), and increased cases of greenhouses gases emission (World Bank, 2022) as major factors affecting agricultural productivity. This calls for a climate-smart in agricultural practices all through the distribution chains to ensure the availability of food and reduce emissions of climate-related issues. The practice of CSA will reduce these issues and proffer solutions to the agricultural problems encountered in the agricultural sector.

The government must prepare for economic, social, and environmental eventualities like instability, water, and energy scarcity, pandemics, and other issues by creating reserves. As there is a strong correlation between food security and the environment; the country must be fortified against these issues must be fortified. The preparation will not strain the available food resource and will not affect food security in the country.

CONCLUSION

This paper is highlighting the pathways for achieving sustainable food security and reversing the climate warming through the major inputs of climate smart fertilizers for agricultural food production for consumption. Methane and nitrous oxide, two gases other than CO2, account for a disproportionately substantial portion of agricultural emissions. Knowing the role of agriculture in global warming and the potential results of reducing agricultural emissions requires an understanding of how emissions of these gases contribute to temperature change.

We draw attention to these issues in the context of research on environmental and food production sustainability and how advanced economies at the forefront of fighting food insecurity are mostly able to achieve that with majority of private investors taking the lead, and as this sector innovatively evolves. It becomes imperative for the government to join in and collaborate with these stake holders to help achieve a breakthrough that is able to drive down cost and ensure abundant supply of CSF that helps to achieve a sustainable food production that is nutritious and healthy food.

There is a chance now to not just respond effectively to the current crisis, but to scale back distortive, wasteful, and environmentally destructive support, freeing up financial resources for investments in a more productive, sustainable, and resilient food system. Together with legislative reforms, this can help align the food system with natural resource limits, a changing climate, market demand, technology improvements, and "low likelihood, high impact" catastrophic hazards. COVID-19's unanticipated shock highlights the need to change from "business as usual" policies to a more forward-looking policy package that invests in the global food system's productivity, sustainability, and resilience. The limitation of this study is that lack of availability of data, focuses on advanced economies, and the effect of the climate-smart fertilizers on the agricultural sector.

We encourage researchers in the related fields to agriculture and forestry, to be open and forthright about the political, ethical, and social aspects that must be considered when balancing emission reductions from different industries and ensuring global food security.

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