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Agrochemical Implications for Cereal Production, Processing, Public Health, and Food Security in Sub-Saharan Africa

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ABSTRACT

The use of pesticides, herbicides, and fertilizers has dire effects on the environmental sustainability, public health, and food security of sub-Saharan Africa. Although these agrochemicals have improved yields and pest control during harvest seasons, their rampant use has led to soil erosion, biodiversity loss, food contamination through agrochemical remnants, and water pollution. The rural population and consumers, particularly children and expectant mothers, are most at risk from these socioeconomic threats, which, coupled with chronic exposure, cause numerous long-term health issues, such as respiratory problems, neurological damage, endocrine disruption, alterations, and different forms of cancer. Moreover, sustaining long-term food security is impossible because of the perpetual misuse of agrochemicals that deteriorate soil fertility, raise production costs, and induce pesticide resistance. The absence of appropriate legislation or farmer education further exacerbates the situation. Public health outcomes can improve significantly if agrochemical dependency is lessened through training farmers in integrated pest management, organic farming, or other sustainable alternatives. This study specifically identifies the knowledge gap in the current understanding of the long-term, cumulative impact of agrochemical use on both the environment and public health, especially in the context of sub-Saharan Africa. It also proposes actionable solutions to bridge this gap through policy recommendations and farmer education programs. There is an immediate need for policies in agronomic governance to restrict the widespread use of agrochemicals, paired with requisite policy frameworks to monitor compliance toward actionable sustainable agriculture designed to support nutritional security for the region, which this study articulates.

INTRODUCTION

The production of cereal crops, such as maize, sorghum, millet, and rice, is crucial for the economies and food systems of sub-Saharan Africa because these crops are dietary staples for many people. These cereals are important in the smallholder farming economy regarding caloric value and financial return(Górska-Warsewicz et al. 2023). sub-Saharan Africa has the highest percentage of maize consumption and production compared to other cereals, reaching 50% of the total cereal production. The percentage of production is less than that of maize, but millet and sorghum are also cultivated in arid and semi-arid regions because of their drought resistance (Abass et al. 2014). Cereal crops in sub-Saharan Africa, including wheat and rice, are of paramount importance for food security, but yields lag those of the rest of the world in terms of productivity. Agricultural infrastructure, modern technology, reliable external precipitation, soil fertility, and pests have a negative impact on yields. (Jayne & Sanchez 2021).

Agrochemicals are a general term that defines the entire set of agricultural chemicals used to improve crop yield and protect plants from pests, diseases, and weeds. These include pesticides (insecticides, fungicides, and rodenticides), herbicides, synthetic fertilizers, and fumigants (Mitra et al. 2021). Recognizing the role of agrochemicals in increasing agricultural productivity, it is also essential to acknowledge their potentially harmful effects on human health, biodiversity, and the environment from their misuse or over-application (Carvalho 2017).

The adoption of agrochemicals in sub-Saharan Africa has increased over the years to bridge the food production gap. This development follows government-promoted intensification schemes, liberalized markets, and heightened food demand due to population growth and climate change (Sheahan & Barrett 2017). Although the socioeconomic factors are positive, the rampant use of agrochemical products has not been matched by effective regulations and farmer training programs, leading to public unawareness.

This lack of information leads many smallholder farmers to use various chemicals without understanding the dosage, timing, or safety measures, greatly increasing exposure risk and ecological harm (Mengistie et al. 2017). Moreover, control measures for some chemicals used in grain fumigation are carried out without the necessary safety measures, which also endangers consumers and public health (Upadhyay & Ahmad 2011).

Agrochemicals have become increasingly sophisticated in the development of cereal production in sub-Saharan Africa. This complexity, especially their ubiquitousness in a geographical value-chain continuum, necessitates associating available resources and empirically evaluating reasoning broadly. Substantial agrochemical utilization within sub-Saharan Africa correlates with agricultural productivity; however, there are high costs to sustainability in terms of food, ecosystem health, and human life. In light of this, this review aims to characterize the socioeconomic factors that underlie the patterns of agrochemical usage within sub-Saharan African cereal cultivation and processing and to estimate the consequences of exposure to agrochemical policies vis-à-vis health and food safety. In addition, this review aims to review the impact of agrochemical policies on the long-term and permanent state of food availability and propose policies that mitigate and control the use of agrochemicals to improve the adaptability, resiliency, and sustainability of cereal production systems in sub-Saharan Africa.

Highlighting these gaps would add value to the existing literature beyond the scope of core disciplines of the agricultural domain, thereby providing a compelling rationale that defines interdisciplinarity to help protect ethnic self-determination focuses of policy in respect of their reality.

MATERIALS AND METHODS

This review uses a narrative method and combines the available literature to assess the implications of agrochemical use on cereal production, processing, public health, and food security in sub-Saharan Africa. The study examines peer-reviewed journals, scientific conferences, policy reports, and other relevant publications from 2000 to 2025 and highlights the region's agrochemical environmental and health impacts.

A thorough search for relevant literature was conducted using digital platforms such as PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, and AGORA. Keywords used for the search included variations of agrochemicals, pesticides, herbicides, fertilisers, cereal production, food security, health impacts, and sub-Saharan Africa. Additional studies were identified through citation tracking (both backward and forward) and referrals from the reviewed literature.

The author included studies on agrochemical use in cereal production, its environmental impact, public health outcomes, and food security in sub-Saharan Africa. Articles that did not specifically address agrochemical implications on cereal crops or those that did not provide relevant environmental or health data were excluded. The systematic structure of the study design, such as agrochemical application, health outcomes, and environmental consequences, allowed for data extraction and synthesis. A narrative description combined with qualitative research interpretation helped identify emerging themes, contradictions, and gaps in the literature.

To minimize bias, the review addressed potential publication biases through extensive searches of electronic databases, citation searches, and expert referrals. Selection bias was controlled by including studies on the impacts of agrochemicals on cereal production, regardless of sample size or design. Language bias was minimized by accepting only documents published in English.

RESULTS AND DISCUSSION

An Overview: Cereal Production and Agrochemical Use in Sub-Saharan Africa

In sub-Saharan Africa, agriculture and food systems heavily rely on cereal farming, which supports nutrition and provides economic and sociocultural benefits throughout the region. Among the food staples, cereal grains continue to rank as one of the most technologically advanced foods, used as a source of energy, proteins, and vitamins and minerals necessary for several million people (Joshi et al. 2024).

The cereals grown in these regions include maize, sorghum, rice, millet, and teff. In southern Africa, maize is the most dominant and most consumed staple in Zambia, Malawi, South Africa, and Kenya (Erenstein et al. 2022). Drought-resistant sorghum and millet dominate in the semi-arid and arid West Africa and the Sahel. These crops are predominant in Burkina Faso and Nigeria as staples for the food and fodder supply. Although maize is the most produced cereal, an increase in the cultivation and consumption of sorghum and millet is observed in West African countries, such as Mali, Nigeria, and Côte d'Ivoire, due to rising urbanization and changing dietary patterns. In the region, food security is supported by improved cereal varieties introduced by the West Africa Rice Development Association (WARDA) (Seck et al. 2012).

Cereal farming in most regions of sub-Saharan Africa is still subsistence farming. Small-scale farmers depend on seasonal household labor, rain-fed agriculture, and traditional methods, such as intercropping and shifting cultivation. However, larger-scale maize and rice producers are increasingly adopting mechanization, integrated pest management, and high-input production systems focused on increased yields.

Cereal yields in sub-Saharan Africa lag behind the global average. Contributing constraints include inadequate soil fertility, erratic rainfall, pest and disease infestations, limited access to improved seeds and fertilizers, lack of irrigation infrastructure, insufficient agricultural extension services, and the perennial gap in technological leeway (Nyiawung et al. 2019).

The application of agrochemicals, such as synthetic fertilizers, herbicides, and pesticides, has become more common in an attempt to address these problems and improve productivity. Specifically, these inputs can help increase yields and protect crops from diseases. However, the misuse of these inputs poses serious threats to environmental quality, food safety, and sustainable long-term agriculture. Fig. 1 shows the various, sometimes overlapping, routes through which the use of agrochemicals impacts the environment, health, and food security. Neglect, misuse, excessive control, and weak government regulation compromise the protective advantages these chemicals are supposed to offer and lead to an endless cycle of environmental and public health deterioration (Sheahan & Barrett 2017).

In sub-Saharan Africa, cereals occupy nearly 50% of the agricultural land and account for nearly half of the population's caloric intake (Van Ittersum et al. 2016). The cultivation of maize is limited to the southern and eastern wetter regions, whereas millet and sorghum, owing to their drought tolerance, are grown in drier regions (Awulachew 2020, Raheem et al. 2021). Maize meal is consumed in Eastern Africa as *ugali*, *posho*, or *nsima*, whereas in North Africa, fermented cereals such as teff, sorghum, and millet are used to prepare *injera* and flatbreads. West Africans have also transformed sorghum, millet, and maize into dough-like foods, *tuwo* and *oji*. South Africans consume maize meal porridge (pap or mabele pap) with traditional stews during meals. *Mageu* (fermented maize drink) and *umqombothi* (traditional sorghum beer) are also important nutritionally and culturally (du Rand & Fisher 2020).

In addition to domestic use, cereals support a value-adding food industry that produces breakfast cereals, bakery, and snack foods, which is growing with urbanization and changing consumer habits. Millions of smallholder farmers, especially women and the rural population, depend on cereal value chains for their livelihoods. Surplus production of

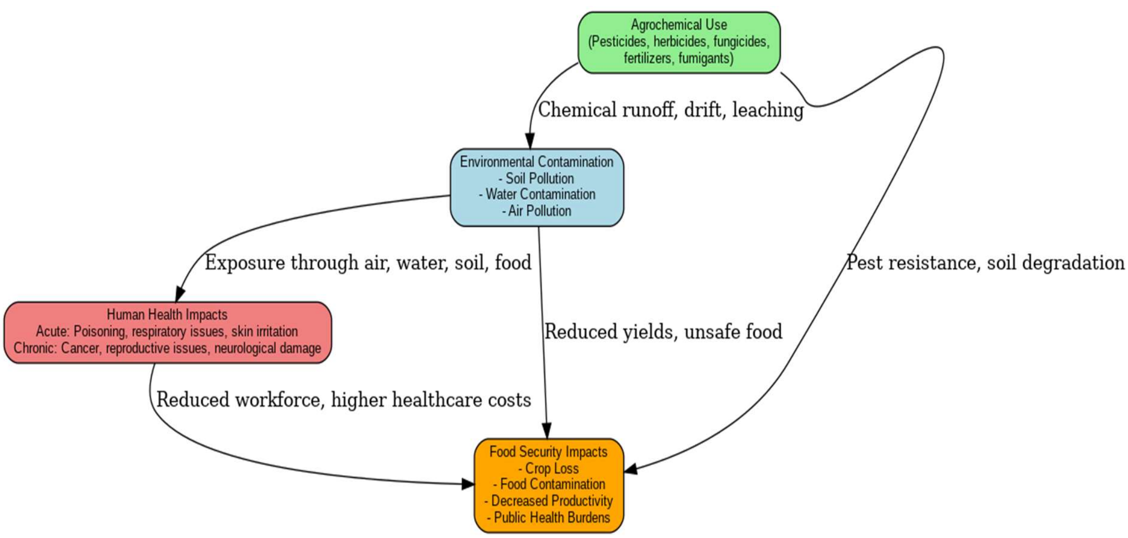

Fig. 1: Pathways linking agrochemical use, environmental, health, and food security impacts.

Table 1: Common agrochemicals used in cereal cultivation in sub-Saharan Africa and their functions.

Agrochemical	Examples	Primary Use	Common Cereals	Potential Risks	Reference
Insecticides	Cypermethrin, Chlorpyrifos, Organophosphates	Control of insect pests (e.g., fall armyworm)	Maize, sorghum	Acute: Poisoning, Chronic: Neurotoxicity	(Anaduaka et al. 2023, Ojelade et al. 2022, Wu et al. 2023)
Herbicides	Glyphosate, Atrazine, Paraquat	Weed suppression	Maize, rice	Acute: Soil toxicity, Chronic: Water contamination	(Ojelade et al. 2022, Oyetunji et al. 2024, Parven et al. 2025)
Fungicides	Mancozeb, Carbendazim	Control of fungal infections	Rice, sorghum	Acute: Residue in food, Chronic: Carcinogenic potential	(Das et al. 2020, Ray et al. 2024)
Fertilisers	Urea, NPK blends, Ammonium nitrate	Improve soil fertility and yields	All cereals	Acute: Soil acidification, Chronic: Nitrate leaching	(Andualem et al. 2024, Yahaya et al. 2023)
Fumigants/ Postharvest Chemicals	Phosphine, Dichlorvos	Grain storage pest control	Maize, millet, rice	Acute: Inhalation hazard, Chronic: Residue in food	(Arora et al. 2023, Das & Hasan 2022)

cereals is sold in local, national, and regional markets, which promotes rural economic development and strengthens food supply chains (Dabkienė 2025, Marson et al. 2023). In addition to their nutritional value, cereals serve as feed for livestock, raw materials for brewing, and in some countries, inputs for biofuel. They are also used in cultural and traditional ceremonies and festivals, which adds to their socioeconomic importance.

In summary, cereals are critical for maintaining food security, health, economic stability, and culture in sub-Saharan Africa. However, the sustainability of these cereal-centric food systems is primarily influenced by strategies, policies, innovations, and capacity-building systems concerning agrochemicals and land degradation mitigation.

Forms and Usage of Agrochemicals in Cereal Cultivation

The need for food production increases with population growth, urbanization, and climate change in sub-Saharan Africa. This has increased dependence on agrochemicals in cereal-growing areas. Multiple fertilisers, pesticides, which include insecticides, herbicides, fungicides, and growth regulators, are used as agrochemicals (Table 1).

These agrochemicals constitute a major component of modern agriculture in sub-Saharan Africa. These chemicals are essential to improve their productivity and ensure adequate food supply, but regarding these chemicals and their use patterns, risks, and governance frameworks associated with them, adequate attention is not paid to environmental sustainability and public health, which arise as key challenges.

The classification of agrochemicals applied to cereal production throughout sub-Saharan Africa can be aggregated into three main groups: fertilizers, pesticides, and seed treatments or growth supplements (Anaduaka et al. 2023). In a geographical area endowed with extensive agriculture, plant growth-stimulating agrochemicals are being marketed alongside compounds to reduce the effects of phytopathogenic microorganisms. The classification of fertilizers represents a significant step towards improving agricultural outputs. Fertilizers such as nitrogen, ammonium nitrate, superphosphate, and potassium focus on assisting crops during the most critical parts of their growth cycle: nutrient absorption (Yahaya et al. 2023). To improve maize yields, especially those affected by the fall armyworm *Spodoptera frugiperda*, cypermethrin and permethrin are the most widely utilized. Glyphosate, atrazine, and paraquat herbicides are extensively used to control weed organisms and vibrant crops such as rice and sorghum, which occupy scarce resources such as water, nutrients, and sunlight, and pose stiff competition to other crops within the cereal family. *Mancozeb* and *carbendazim* are not extensively applied but are crucial fungicides for rice and sorghum crops. In addition, coating seeds with fungicides and insecticides, known as seed treatment, is steadily being accepted as a reliable method to enhance germination, coupled with early-stage defense. Plant growth-regulating hormones and specialized nutrient synergies are widely used, particularly in areas exposed to advanced mercantilist agricultural systems (Sheahan & Barrett 2017).

Agrochemicals are underutilized in sub-Saharan Africa, although their usage is increasing steadily over the years and currently occupies a relatively lower position when compared nationally. For instance, the amount of fertilizer applied in sub-Saharan Africa increased to 20 kg per hectare in 2020, marking a more than twofold increase from 8 kg per hectare in 2000, although still lower than the 135 kg global average

(Njoroge et al. 2023). Ochieng et al. (2023) reported that the usage of pesticides has also increased worldwide owing to the outbreak of the desert locust invasion and the spread of the fall armyworm. Ochieng et al. (2023) reported that the usage of pesticides has also increased all over the world due to the outbreak of the desert locust invasion, as well as the spread of the fall armyworm. Nonetheless, practices regarding application regionally continue to be poorly coordinated and often not monitored. Most small-scale farmers purchase pesticides from informal agro vendors, which means that substandard or expired products are often used, and they have not been adequately trained in safe handling or appropriate dosages (Pretty & Pervez Bharucha 2015). With regard to the application of agrochemicals, these are more prominent in the high-value cereal production zones of central Kenya, where maize is grown, or in the Niger River Basin of Nigeria, where rice farming occurs. Such farmers have better market access, credit, agricultural extension services, and agronomists. In contrast, subsistence and rain-fed farming systems are still largely practiced in the arid and semi-arid regions, and these are highly traditional and low-input systems.

Certain factors are interconnected within themselves, which contribute to aggravating the use of agrochemicals in cereal production in sub-Saharan Africa. One of the main drivers is the maximization of productivity and yield. As land expansion is not feasible, agrochemicals are regarded as critical assets for improving yields per hectare and attaining food security objectives. Fertilizers increase soil fertility, and pesticides reduce yield losses due to infestation (Jayne & Sanchez 2021). The rising occurrence of pests and diseases, such as fall armyworm, stem borers, and parasitic weeds such as *Striga*, has further accelerated the adoption of chemical pest control. In sub-Saharan Africa, many governments and development partners have, in response, provided emergency pesticide aid for distribution during pest surges (Day et al. 2017). Climate change and irregular rainfall patterns also promote the use of agrochemicals. For instance, herbicides assist in reducing labor and providing timely weeding within shortened planting periods resulting from unpredictable rains (Midega et al. 2018). Moreover, the need for commercialization and market opportunities drives farmers to use agrochemicals, particularly those aimed at urban and export markets, where consistent quality is mandated, post-harvest losses are a concern, and safety stock levels are higher.

The control and regulatory policies of agrochemical use in sub-Saharan Africa are usually poorly enforced, fragmented, and lack proper harmonization with other relevant bodies, which alone brings inefficiencies. The countries in the region have developed domestic legislative instruments that provide for the registration, distribution, and application of pesticides and fertilizers. These instruments are, in some ways, in line with multiple international conventions, such as the Rotterdam Convention on Prior Informed Consent (PIC) Procedure for Hazardous Chemicals and the Stockholm Convention on Persistent Organic Pollutants (POPs), and the FAO/WHO Codex Alimentarius concerning pesticides and residues (Dinham 2020, Jansen & Dubois 2014). Nevertheless, there remains a lack of uniform application of these regulatory structures across the region. The region suffers from problems such as the illegal importation of banned substances and the wide availability of fake or substandard agrochemicals (Chukwugozie et al. 2024). In Kenya, the Pest Control Products Board (PCPB) and the National Agency for Food and Drug Administration and Control (NAFDAC) of Nigeria, which are responsible for controlling crop protection products, are often understaffed and underfunded to the extent that they are unable to perform inspections, monitoring, and farmer education. Activities directed at improving governance and the responsible use of agrochemicals include the Africa Fertilizer and Agribusiness Partnership (AFAP) and the Economic Community of West African States (ECOWAS) regional regulatory integration (Iddrisu et al. 2021). These initiatives are aimed at enhancing input quality assurance and transboundary regulatory facilitation. However, significant gaps persist, for example, in farmer training, extension service provision, and market post-surveillance regarding the health and environmental effects of agrochemical use (Demi & Sicchia 2021).

Overall, the application of agrochemicals in cereal crop production across sub-Saharan Africa is increasing owing to the need to improve food production and control pest outbreaks. Although applying these inputs improves agricultural productivity and food security in the region, it is done with little or no care for the application procedures, monitoring, regulation, and education provided to farmers. Such practices endanger human health, food safety, and environmental protection. It is vital to improve regulatory controls, farmer training, and integrated pest and soil fertility management systems to ensure the region's safe and effective use of agrochemicals.

Impacts of Agrochemicals on Cereal Cultivation and Processing

Although agrochemicals are essential for increasing cereal productivity and protecting crops from diseases and pests, they raise significant concerns about soil quality, health, crop quality, and post-harvest handling and processing. In the sub-Saharan Africa region, where maize, rice, sorghum, and millet are staples, the rising use of fertilizers and pesticides has sparked worries about their long-term environmental impact, food safety, and public health (Table 2).

Table 2: Mechanisms of human exposure to agrochemicals and associated health risks.

Exposure Pathway	Affected Group(s)	Source	Health Impacts	Reference
Inhalation during application	Farmers, farm workers	Spraying without PPE	Respiratory disorders, headaches	(Aksüt & Eren 2024, Lari et al. 2023)
Dermal contact	Farmers, storage workers	Mixing/loading pesticides, handling crops	Skin irritation, chemical burns	(de-Assis et al. 2021, Sachan 2023)
Dietary ingestion	Consumers (all age groups)	Residues in cereals and processed products	Endocrine disruption, cancers, developmental delays	(Nica-Badea 2022, Tang et al. 2025)
Contaminated water	Rural households, children	Runoff from fields, leaching into wells	Methemoglobinemia, gastrointestinal illness	(Criswell et al. 2025, Singh 2024)
Indoor contamination	Families of applicants	Storage of pesticides in homes	Chronic exposure, reproductive issues	(Al-Alam et al. 2022, Aparicio et al. 2025, Vessa et al. 2022)

These effects are limited to the cultivation phase and carry over into post-harvest operations, impacting trade, consumer safety, and regulatory compliance.

Effects of Agrochemicals on Soil and Crop Productivity

The continuous use of agrochemicals, particularly synthetic fertilizers, adversely affects soil properties, including its structure, organic matter content, and nutrient balance. Over-dependence on nitrogenous fertilizers, such as urea and ammonium nitrate, fosters soil acidification, decreases microbial populations, and impairs critical biological processes, such as nitrogen fixation (Zhang et al. 2015).

The lack of organic amendments worsens nutrient cycling and disrupts the balance of macronutrients (N, P and K) and the depletion of micronutrients (Khan et al. 2008). Such disturbances may gradually deplete the soil's fertility and deteriorate the resilience of cereal cropping systems.

Also, applying pesticides has an adverse effect on the soil microbial biodiversity. Broad-spectrum insecticides and fungicides can wipe out beneficial soil organisms, such as mycorrhizal fungi, earthworms, and nitrogen-fixing bacteria, which are instrumental in nutrient sedimentation, soil structure, and augmenting the nutrient value of soil (Kumar et al. 2025). Biodiversity depletion compromises soil protection mechanisms, heightening exposure to pest attacks, erosion, and overall productivity decline.

The absorption of pesticides and heavy metals in the edible portions of plants is a major drawback of agrochemical use in cereal cultivation. If the preharvest intervals are not strictly adhered to, pesticides, organophosphates, and pyrethroids, which are employed in sub-Saharan Africa for armyworm pest control, can contaminate cereal grains (Aktar et al. 2009). Residual agrochemicals not only endanger food safety but also threaten the quality of cereal products, which can impact germination potential for seeds, nutritional value, and taste. These residues are highly toxic, especially when the primary source of food is cereals, which results in chronic exposure and bioaccumulation of endocrine-disrupting chemicals (Malalgoda & Simsek 2021).

Summarily, the pervasive application of agrochemicals threatens the well-being of soil, microbial life, and food safety within cereal cropping systems, demonstrating the immediate need for sustainable agricultural practices and stronger regulatory frameworks. In all cases, mitigating the adverse effects of agrochemicals on soil composition, nutrients, and food quality requires a transition to integrated pest control systems, organic farming, and more stringent ecological and health impact assessments.

Post-Harvest Handling and Processing of Agrochemicals

Post-harvesting stages, including drying, storage, milling, and packaging, are critical points at which agrochemical residues may remain or increase in concentration in value-added products. Research has indicated that pesticide residues, particularly protective pesticides such as dichlorvos and malathion, outlast retention periods in cereal flour and its derivatives (Bajwa & Sandhu 2014). These residues commonly evade detection because of insufficient prophylactic monitoring, relaxed enforcement practices for controlling maximum allowable residue limits (MRLs), and underdeveloped laboratory infrastructure endemic to many sub-Saharan African countries.

Heat treatments, such as baking, extrusion, and boiling, are claimed to reduce some pesticide residues; however, their efficacy is not universal across all compounds, especially systemic pesticides, which permeate the tissues of grains (Kaushik et al. 2009). Thus, breakfast cereals, biscuits, and other processed cereal products may still contain pesticide residues, which is particularly concerning for sensitive populations, such as infants and unborn children. In addition to incurring initial residues from field applications, cereals are at risk of exposure to contamination during storage and processing. Residues emanating from the superficial portions of the grains, which include the bran and husk, may be transferred to the flour during milling if not properly removed. Residues emanating from the superficial portions of the grains, which include the bran and husk, may be transferred to the flour during milling if not properly removed. In addition, non-food-grade packaging not constructed from food-safe materials may also leach chemical residues, especially if pesticides were used on the cereals post-harvest and were packed while still off-gassing volatile chemicals (Pandhi & Paul 2021).

In addition, cross-contamination occurs through equipment and surfaces that are not properly cleaned or maintained within milling plants, particularly when both treated and untreated grains are processed together. These elements contribute to increasing concerns about food safety and restrict trade, especially in markets where strict systems to monitor residues are implemented.

Many challenges are associated with monitoring and controlling agrochemical residues in cereal production and processing throughout sub-Saharan Africa. Most residue-testing laboratories, personnel, and monitoring equipment are absent, especially in rural areas where cereals are produced. Mekouar (2020) reported that control agencies, such as food control authorities and pesticide boards, often work in poorly funded and fragmented systems, weakly enforcing maximum residue limits (MRLs) and labelling rules.

Farmers and processors lack knowledge of safe pesticide application techniques, adequate dosages, pre-harvest intervals, and appropriate storage and handling protocols. In addition, informal markets dominate the cereal value chains in sub-Saharan Africa, making compliance with international food safety standards difficult. These challenges pertaining to monitoring have led to the rampant circulation of contaminated products in local markets, while restricting cereal product exports from the region.

To resolve the ongoing issues concerning agrochemical residues in the processing of cereals, it is imperative to advance existing monitoring, enforcement, and education systems related to the safe handling of agrochemicals in sub-Saharan Africa. This altered approach will mitigate the active threats posed by agrochemical residues through reinforced legislation, upgraded post-harvest agro-laboratories, guaranteed compliance with safe food and trade standards, and globally accepted market access for cereal products.

Public Health Implications of Agrochemical Use in Cereal Production

The modern cultivation of cereals is enhanced by the application of herbicides, pesticides, and fertilizers containing agrochemicals. However, their prevalent and, at times, unlawful use in sub-Saharan Africa is highly hazardous to human health. These dangers arise via exposure pathways, particularly affecting susceptible groups, such as children, women during pregnancy, and rural laborers and farmers, both directly and indirectly. In areas where monitoring of food safety standards and residue limits is rudimentary, the consequences on public health can be highly detrimental and enduring.

There are several pathways through which one can be exposed to agrochemicals, each with a unique level of danger. The most unprotected exposure for farmers and agricultural workers occurs during pesticide application, when they are often not provided with sufficient protective equipment or proper education (Matthews 2008). The main routes for acute and chronic poisoning among farmworkers include dermal absorption, inhalation, and accidental ingestion (Ngowi et al. 2007). Across sub-Saharan Africa, lax enforcement of pesticide regulations allows dangerous agrochemicals to be misused. Meanwhile, the common practice of repurposing empty pesticide containers for household purposes further amplifies public health hazards and environmental damage (Table 3).

Table 3: Public health and environmental impacts of agrochemical misuse in sub-Saharan Africa.

Impact Area	Manifestation	Contributing Factors	Affected Region	Reference
Soil health	Acidification, reduced microbial activity	Overuse of nitrogen fertilisers	Kenya, Nigeria	(Asefa et al. 2024, Zhang et al. 2024)
Water contamination	Nitrate and pesticide residues in rivers/wells	Runoff, leaching, and poor irrigation practices	Ethiopia, Ghana	(Assegide et al. 2022, Talema 2023)
Biodiversity loss	Decline in pollinators, soil fauna, and beneficial insects	Use of non-selective insecticides, habitat degradation	Southern and West Africa	(Amani et al. 2021, Mone et al. 2025)
Human health	Acute and chronic illnesses among farmers and consumers	Lack of PPE, residue accumulation, and informal market sales	Tanzania, Burkina Faso, South Africa	(Henson et al. 2023, Okova et al. 2024)

Typically, consumers obtain a higher level of exposure via the ingestion of cereal grains or foods made from cereals contaminated with pesticide residues. Alwasiyah (2025) stated that chronic low-level exposure, particularly to persistent organophosphates and carbamates, poses a serious threat to public health. Poor post-harvest handling practices, including the use of fumigants and storage chemicals, further exacerbate the risk of chemical residues in food.

Water systems are also important pathways of exposure to agrochemicals. Agrochemical runoff from agricultural fields contaminates rivers, lakes, and underground aquifers, thus polluting drinking water sources (Jadon et al. 2022). In several rural sub-Saharan African communities, untreated surface water or groundwater serves as the primary drinking water source, and contamination with nitrates and pesticides has been associated with methemoglobinemia and several hormonal disorders (Garcia Torres et al. 2022).

Health impacts of exposure to agrochemicals include acute poisoning as well as chronic long-term conditions. Acute effects involve headaches, dizziness, nausea, muscle weakness, and difficulty breathing. These symptoms are typical among applicators and handlers of pesticides in sub-Saharan Africa (Donham & Thelin 2016). A more serious consequence of high exposure to organophosphates and pyrethroids is having seizures, going into a coma, or dying.

Chronic exposure is more common among the general population, as well as farming families, which is associated with various illnesses such as cancer, particularly non-Hodgkin lymphoma, neurodevelopmental disorders, endocrine disruption, reproductive toxicity, and immunotoxicity (Mostafalou & Abdollahi 2013). Guyton et al. (2015) stated that certain pesticides used in cereal farming, especially chlorpyrifos and glyphosate, have been associated with reduced cognitive performance and potential cancer.

In addition, fertilisers have the potential to leach high amounts of nitrate into cereals or water, which may contribute to blue baby syndrome in infants, as well as an increased risk of gastrointestinal cancer (Ward et al. 2005). The combined impact of several agrochemicals, also called the synergistic mixture effect**,** complicates risk assessment and increases toxicity even when individual chemicals are present in amounts below legal limits.

The adverse effects of agrochemical exposure are greatest in children and pregnant women. The developing organs of children, when combined with the lower body weight and greater metabolic rates, make them particularly vulnerable to the toxic effects of pesticides and other agrochemicals (Landrigan & Goldman 2011). In many parts of sub-Saharan Africa, children who live near or work on farms commonly have access to significant amounts of pesticides, which can hinder their growth, cognition, and the balance of hormones in their bodies.

The health and neurological risks associated with pesticides extend to pregnant women as well. These women are likely to suffer from miscarriage and congenital disabilities, while also being at risk of preterm labour.

Studies indicate marked risks of developmental delays along with congenital anomalies in the children of women exposed to pesticides during pregnancy (Wickerham et al. 2012).

Farmers in rural areas represent one of the most vulnerable populations to the effects of agrochemicals. They tend to use agrochemicals without training and lack proper protective gear. This group is known to keep pesticides in the home, apply them with bare hands, and mix them without any hygiene. Moreover, there is limited access to healthcare services, resulting in underreported and untreated pesticide-related poisoning, as reported by Atreya (2007).

Different epidemiological studies and field studies conducted within sub-Saharan Africa demonstrate the public health concerns related to the use of agrochemicals in cereal production. Ngowi et al. (2007) reported that rice farmers in Morogoro, Tanzania, suffered greater cholinesterase inhibition levels than controls. Symptoms included fatigue, eye irritation, and shortness of breath. Most sub-Saharan African farmers were not using protective gear while applying agrochemicals, contaminating people. In Ghana, Bempah and Donkor (2011) reported finding widespread pesticide residues in cereal grains. Some samples were above the international maximum residue limits (MRLs), which confirms that chronic exposure is responsible for increasing endocrine-related disorders. Contaminating the environment is also a significant problem. The case of Ethiopia, where Sedlak (2023) reported an increase in atrazine and nitrate levels in shallow wells in cereal-producing regions, which is significant, as these correlate with an increased diarrhoea and reproductive health issues in women. The widespread nature of the problem and the insufficient surveillance system make these cases so alarming and illustrate the regional interventions needed to mitigate agrochemical health problems.

The public health implications of agrochemical use in cereal production are far-reaching and multifaceted. Exposure pathways affect multiple populations, most especially farmers, children, and pregnant women, through direct contact, dietary intake, and environmental contamination. Acute poisoning and chronic illnesses related to agrochemical residues in cereals are well-documented in sub-Saharan Africa, yet response mechanisms remain inadequate. Enhanced regulation, community education, adoption of safer alternatives, and establishing residue monitoring systems are essential to mitigating health risks and safeguarding public health in the region.

Food Safety and Food Security Dimensions

The use of agrochemicals in cereal production has far-reaching consequences for food safety and food security in sub-Saharan Africa. Spraying these chemicals helps increase crop yields and control pests; however, mishandling them poses risks to human health, the environment, and the sustainability of the food system. In sub-Saharan Africa, the challenge is twofold. There is an immediate need to increase food production while ensuring the safety, reliability, and sustainability of the food supply chain.

Food Safety, Challenges, Regulations, and Public Awareness on Agrochemicals

Concerns about food safety regarding the use of agrochemicals arise mainly due to the contamination of food products, especially cereals, which are widely consumed in sub-Saharan Africa. Maximum Residue Limits (MRLs) represent the residue tolerance levels of pesticides on food crops defined by international guidelines such as those laid by Codex Alimentarius of FAO and WHO. The overriding problem in sub-Saharan Africa is the non-compliance of laboratory monitoring infrastructure with these standards, coupled with poor regulatory control and inadequate technical skills of the authorities that govern food safety (Njiru et al. 2025).

Some studies from the sub-Saharan African region have indicated that pesticide residues in some cereal grains are quite high, particularly in maize and rice. These studies highlight the extensive use of pesticides in agriculture to ensure food security, which raises concerns about environmental contamination and potential human health risks (Ogah et al. 2024). These factors lead to inefficient risk mitigation strategies and endanger consumer health, ultimately leading to diminished dependability of food safety systems.

Consumer perception of the dangers posed by agrochemicals is relatively low in most parts of sub-Saharan Africa. Most consumers do not recognize the existence of pesticide contamination or its health effects in most household staple foods. In addition, trust in informal markets, where most consumers purchase food, is mainly based on cost and availability, not quality or safety (Kikulwe et al. 2009). There is a need to redefine food risk advocacy at the intersection of food regulators and consumers, advocating for safer food practices. In this case, the absence of clear labelling or certification does not enhance decision-making in the consumer market.

Social-economic perceptions also play a role in consumer perceptions. Often in low-income regions, the urgency of obtaining food tends to overshadow concerns about the health implications stemming from agrochemicals. Hence, food safety becomes less of a priority, leading to the acceptance of unhealthy practices, such as consuming unwholesome, discolored grains or chemically treated grains (Matthews 2008).

Most countries in sub-Saharan Africa have implemented food safety policies in accordance with international agreements, such as the Codex Alimentarius, the Stockholm Convention on Persistent Organic Pollutants, and the Rotterdam Convention. South Africa and Kenya have advanced food control legislation and inspection systems, whereas other countries lack the institutional capacity to manage enforcement across the entire value chain (Njiru et al. 2025).

At the continental level, the African Union and regional economic communities, such as the Economic Community of West African States (ECOWAS), have attempted to unify food safety and pesticide regulations. The effectiveness of these frameworks lacks political support, limited resources, and inadequate inter-border collaboration, which still pose significant challenges to these initiatives (Anaduaka et al. 2023).

The food safety problem in sub-Saharan Africa, especially regarding agrochemicals, remains important because of excessive pesticide residues in staple cereals, such as maize and rice. There are still gaps in laboratory monitoring infrastructure, compliance controls, and consumer education, underscoring the need for stricter enforcement of international benchmarks, regulations, and increased public awareness of pesticide contamination. These measures are critical for protecting public health and ensuring confidence in food safety systems in the region.

Food Security, Benefits, and Risks Using Agrochemicals

Agrochemicals have alleviated pest damage and nutrient availability issues, which have increased cereal yields, at least temporarily. In undergoing shifts in sub-Saharan African countries, government programs that subsidise fertilisers and distribute pesticides have significantly raised yields (Sheahan & Barrett 2017). Regardless, these benefits have trade-offs, particularly when considering the health of soil, water, and longer forms of ecological sustainability. Soil degradation through the use of pesticides fosters organic matter depletion, soil biodiversity decline, and acidification, which can dismantle the very productivity gains these practices offer (Zhang et al. 2015). Widespread use of pesticides creates pest resistance, and this dependency leaves farmers in a lose-lose loop, forcing them to spend more on stronger chemicals while receiving diminishing returns.

Agrochemicals impact different aspects of food security because of their availability, accessibility, and stability. Agrochemicals can mostly increase available food since they enhance production and lower crop losses. However, suspiciously low levels of agrochemicals may hinder food accessibility because food-grade cereals may be barred from circulation, particularly in international markets. For example, European Union (EU) countries are known to reject African agricultural exports because they contain excessive pesticide residues or do not meet the set food safety standards (Biénabe et al. 2011). Food stability is lost due to trust loss or health-related incidents from agrochemical recalls. Moreover, substandard post-harvest pesticide application, such as storing grains in high doses of fumigants, severely undermines cereal shelf life and quality, escalates food waste, and diminishes household food security.

Although agrochemicals improve productivity, they are expensive and incur debt for smallholder farmers, most of whom produce cereal in sub-Saharan Africa. Prices for inputs are often high and volatile relative to market returns, which are hanging on the uncertain prices of cereals, shocks from climate, and poor storage or credit facilities (Jayne et al. 2018). Because of this, many farmers take out loans to purchase inputs that do not guarantee additional yields or income. In addition, inadequate application of agrochemicals may damage crops, degrade soil quality, and diminish a farmer's health, further hampering productivity and eroding economic resilience. The multi-faceted impact of pesticides is worryingly severe, combining health-related productivity losses from time-off work due to treatment, increased dependency on chemicals instead of means of cultivation, and agricultural output, all of which converge to undermine food security and boost economic vulnerability in the context of rural regions with scant healthcare facilities and extend services (Mafakheri et al. 2021).

In sub-Saharan Africa, the use of agrochemicals has increased cereal yields in conjunction with government subsidies and distribution programs due to better pest control and nutrient availability. However, these improvements are accompanied by considerable trade-offs, such as soil degradation, pesticide resistance, and other unsustainable environmental practices. These concerns also impact the availability and accessibility of food, market opportunities, and consumer confidence in the global supply chain. Some of these problems may be solved with sustainable agricultural practices that focus on productivity while considering the long-term environmental and economic impacts.

Environmental and Ecological Concerns of Agrochemical Use

There is growing ecological concern due to the uncontrolled application of agrochemicals on cereal crops in sub-Saharan Africa. Regardless of the region, agrochemicals that have made fertilisers, herbicides, and pesticides a household name, containing numerous crops, tend to increase yield and pest control, while concurrently managing crop diversity. As a matter of fact, the long-term repercussions from such practices as the use of agrochemicals are more dangerous than severe water body pollution, disruption of local biodiversity, eroded ecosystem services, chronic ecological disintegration, and the list goes on.

Agrochemical Leaching and Contamination of Water Bodies

The excessive use of agrochemicals has far-reaching environmental impacts, particularly concerning the pollution of water bodies. In sub-Saharan Africa, which experiences seasonal rains and has farmlands adjacent to rivers, lakes, and wetlands, agrochemicals, especially fertilisers with phosphates and nitrates, leach into the groundwater or are transported by runoff into surface water systems.

According to Kapsalis & Kalavrouziotis (2021), the excess contribution of nitrates into water bodies causes algae blooms, eutrophication, and large-scale oxygen depletion, resulting in fish kills. These effects tend to degrade the aquatic ecosystem and potentially the habitat of these water bodies while tremendously impacting a plethora of those who depend on fishing, drinkable water, or irrigation. Alongside atrazine, glyphosate, and organophosphate residues have also been detected in the surface and ground waters in sub-Saharan Africa, which in some concentrations are greater than the WHO recommended standards for drinking water (Sishu et al. 2022). These chemicals have a serious impact on the aquatic ecosystem. They also contaminate drinkable water sources, leading to health complications such as reproductive and neurological disorders in humans (Syafrudin et al. 2021).

Inadequate water treatment infrastructure and insufficient monitoring systems further exacerbate the problem. Most rural communities in sub-Saharan Africa do not have access to treated water and are directly exposed to water contaminated with agrochemicals, escalating their susceptibility to chemical hazards associated with waterborne diseases.

Cumulative Ecological Effects Over Time

The long-term ecological impacts of agrochemical application tend to be underestimated, and it is slower and more complex to resolve. These include the gradual accumulation of persistent organic pollutants (POPs) in soils and waters, their bio-amplification in organisms, and progress toward new constituents and functions of ecosystems. Carvalho (2017) stated that non-biodegradable pesticides can remain in the soil for decades, given the geological and climatic conditions present in some areas of sub-Saharan Africa.

The consequences of over-relying on these controls include greater susceptibility to pest resistance, which in turn requires higher doses or more toxic alternatives to overcome. An increase in expenses is detrimental to farmers, but also contributes to ecological degradation (Pretty & Pervez Bharucha 2015). The regular use of pesticides and fertilisers alters the balance of microbial communities within soil (Zhang et al. 2015), which, with the changing conditions of climate stress ailing the ecosystem, erodes the soil's resiliency, hampers nutrient cycling, and diminishes the soil's resilience.

Moreover, the effects of cumulative exposure are often greater than those of a singular system element. For instance, the runoff of agrochemicals is likely to amplify aquatic ecosystem destruction, water supply pollution, and the weakening of terrestrial food webs. All of these factors interact in a self-reinforcing, synergistic manner, which can push a system beyond recovery. This absence of long-term ecological monitoring in numerous sub-Saharan African countries further exacerbates the issue by allowing the unchecked decline of ecological factors, persisting unnoticed until remediation is impossible.

Sustainable Alternatives and Mitigation Strategies

The excessive and often dangerous application of agrochemicals in cereal farming throughout sub-Saharan Africa has significantly increased concerns regarding ecological devastation, food security, and population health. Despite the clear benefits in yield and pest control associated with agrochemical usage, the viable alternatives and substantial risk management methodologies required for long-term sustainability necessitate a paradigm shift.

To achieve safe, resilient, and high-quality food systems, the region needs to shift towards more comprehensive Integrated Pest Management (IPM), organic and ecological farming practices, as well as better education and enforcement of rules.

Integrated Pest Management (IPM)

Integrated Pest Management (IPM) combines various biological, mechanical, and cultural methods of pest control to minimise risks to cost, health, and the environment, making it more sustainable in nature. Unlike traditional methods, which rely heavily on pesticides, IPM employs an ecosystem approach that focuses on prevention through alteration of the environment, use of resistant crop varieties, and biological control agents (Pretty & Pervez Bharucha 2015).

Within sub-Saharan African cereal farming systems, adopting IPM has successfully minimised the use of chemical pesticides. The International Centre of Insect Physiology and Ecology (ICIPE) developed push-pull technology, which includes intercropping maize with the repellent Desmodium and Napier grass, which functions as both a trap and fodder. This strategy contributes to managing stem borer infestations and Striga weeds while enriching soil fertility (Khan et al. 2012).

Furthermore, IPM enhances the level of control over pesticides when deemed necessary, encouraging controlled usage that remedies overapplication and pesticide resistance. Farmers are able to take action based on monitoring and environmental assessment, which in turn helps in improving productivity while minimising damage to human health, biodiversity, and ecosystems.

Organic and Ecological Farming Approaches

Organic farming systems do not employ synthetic fertilisers or pesticides but instead rely on natural inputs and ecological methods. Even though organic farming is still developing in sub-Saharan Africa, it is greatly beneficial for improving soil and water resources and providing safe and quality food (Lillian 2024). Organic practices also include pest control using botanicals like neem extract, which has been proven effective against major cereal pests (Isman 2006). Ecological farming is a more encompassing term that integrates modern science and indigenous knowledge while creating biodiversity-rich, resilient, and regenerative agroecosystems. Farmer-led ecological approaches such as agroforestry and conservation agriculture have been advanced in sub-Saharan Africa to address issues of land degradation, food security, and minimise inputs (Giller et al. 2009).

Systems that are organic or ecological may yield lower than their conventional counterparts in the beginning phases, but they become increasingly stable over time. These systems are more resilient to external shocks like pest outbreaks and climate variability compared to their high-input counterparts. In addition to these advantages, there is a reduced environmental footprint and no harmful residues in food and water.

Capacity Building and Education for Safe Agrochemical Use

One of the main challenges facing the agricultural sector in sub-Saharan Africa is the lack of sufficient knowledge and awareness among farmers regarding application methods, protective gear, pharmacological control, empathetic compartmentalization, and disposal techniques. Various researchers have observed that a large portion of farmers do not receive formal training in handling agrochemicals, which causes them to engage in practices that threaten their health and the environment (Ngowi et al. 2007).

Farmers' responsibility to protect the environment and their own well-being can be significantly improved by enhancing their skills through digital platforms, farmer field schools, and agricultural extension services. Training sessions focusing on suturing personal protective equipment (PPE), measuring releasable propellant-controlled nozzles, level counting, and pest indicator recognition could greatly assist farmers in adopting safe, cost-effective strategies (Vasco 2025).

In addition, developing new agripreneurs requires the inclusion of some sustainable farming and pesticide safety modules within the curriculum of vocational and agricultural colleges. It is the responsibility of research institutions, NGOs, and public-private partnerships to create context-specific materials designed in local languages and culturally relevant to the community, and to train them.

Strengthening Regulatory Enforcement and Research

The effective management of risks associated with agrochemicals requires advanced systems capable of enforcing regulations on pesticide registration, quality control, and residue monitoring. In sub-Saharan Africa, many countries have laws, but enforcement remains weak due to a lack of resources, institutional fragmentation, and limited monitoring capabilities (Chukwugozie et al. 2024). Enforcement policies fail to ensure consistent implementation of these laws because of insufficient funding, poor coordination between agencies, and inadequate capacity for monitoring and compliance enforcement. Furthermore, despite the existence of regulatory frameworks, these regulations often remain inconsistent, leading to an over-reliance on unregulated agrochemicals, which harms both health and environmental outcomes.

To address these issues, strengthening regulatory enforcement is essential. This can be done by making sure all agrochemicals are properly registered, tested for effectiveness, and labeled correctly. Regulatory agencies should be given the authority to perform regular market inspections, ban the sale of hazardous chemicals, and impose fines for violations. Successful examples of this include Kenya, where the Pest Control Products Board (PCPB) has played a key role in regulating pesticide use, ensuring proper registration, and enforcing market inspections. Additionally, Nigeria's National Agency for Food and Drug Administration and Control (NAFDAC) has effectively limited the sale of unregistered agrochemicals, greatly reducing cases of food contamination caused by harmful chemicals. chemicals (Igbokwe-Ibeto 2015).

Furthermore, regional harmonization efforts under the Economic Community of West African States (ECOWAS) and the African Union's Programme for the Harmonization of Agrochemical Regulations (AU-PHARM) could enhance cross-country cooperation, simplify regulations for businesses, and improve enforcement across borders (Anaduaka et al. 2023). For instance, the ECOWAS pesticide regulation program has led to the standardization of pesticide registration processes across member countries, facilitating easier compliance and enforcement (Chen et al. 2023). These efforts enhance regulatory capacity and foster a collaborative environment for shared standards and practices.

Alongside enforcement, research plays a critical role in monitoring the environmental impact of agrochemicals, developing safer pest control methods, and finding alternative solutions. Insufficient research funding and infrastructure limit the ability to make informed decisions about sustainable agrochemical use. National agricultural research systems in sub-Saharan Africa require significant investment to build an evidence base that guides policy and encourages innovation. For instance, the collaboration between the International Institute of Tropical Agriculture (IITA) and the African Development Bank (ADB) has successfully developed integrated pest management (IPM) strategies that decrease reliance on agrochemicals in West Africa (Barrera 2020). These innovative, research-based solutions have proven effective in lowering chemical use while increasing crop yields and farmers' livelihoods, serving as a model for other regions. Similarly, the development of biopesticides in Ghana by the Council for Scientific and Industrial Research (CSIR) has helped cut pesticide dependency while offering an effective alternative for farmers (Ediagbonya et al. 2025).

Addressing the shortcomings in enforcement and research is crucial for improving agrochemical management in sub-Saharan Africa. Strengthening regulatory frameworks, ensuring consistent enforcement, and investing in research and innovation are essential to achieving sustainable agricultural practices and safeguarding public health and food security.

Gaps and Future Research

The use of agrochemicals in cereal production across sub-Saharan Africa has significantly boosted crop yields. However, growing concerns about health, environmental protection, and the resilience of food systems emphasize the need to shift toward safer and more sustainable farming practices. Sadly, efforts to develop and implement effective policies and technical solutions are often hindered by substantial knowledge gaps, especially in areas like data collection, long-term studies, impact evaluation, and the development of new agrochemicals. To support the region in making informed decisions, these critical knowledge gaps must be closed through targeted research and evidence gathering.

One of the main challenges in understanding and addressing the impacts of agrochemicals in sub-Saharan Africa is the lack of comprehensive, reliable data broken down by specific contexts. Data on agrochemical use—such as application rates, chemical types, application frequencies, and geographic distribution—is either missing or outdated in many countries. When data does exist, it is often inconsistent due to the absence of standardized methodologies, coordinated efforts, and unified approaches among institutions. This situation hampers efforts to assess exposure risks, environmental contamination, and the overall effectiveness of policies. Most existing research focuses on a few countries like Nigeria, Kenya, Tanzania, Ethiopia, and South Africa, leaving significant gaps in knowledge about Central Africa and the Sahel region.

The limited scope of data, particularly regarding gender and regional specifics, restricts the development of inclusive policies and training programs targeted at these areas. Women, who are directly involved in many production and post-harvest activities and are among the underrepresented groups in sub-Saharan African agriculture, are frequently overlooked in pesticide use studies.

Research on agrochemical use in sub-Saharan Africa primarily focuses on immediate outcomes such as profit and health issues related to daily activities. There is a notable lack of research on the long-term, cumulative effects of agrochemicals on human health, ecosystems, and agriculture. Chronic exposure to these chemicals can lead to serious health problems, including cancer, endocrine disruption, reproductive issues, and neurodegenerative diseases, which develop over decades.

Regarding environmentally induced changes on human health, the sub-Saharan African region still faces an unexplained gap in understanding the effects of agrochemicals on soil and water. Degrading soil from expanding agriculture remains a persistent yet under-recognized threat to both regional soil reserves and global biodiversity, beyond the general processes of soil formation and sediment erosion. Deeper regions of the earth are rich in pesticides and fertilizers. Persistent residues can alter soil microbial communities, biodiversity, and ecosystem services like nutrient cycling and pest control. Unfortunately, the region lacks long-term ecological monitoring systems. There is little investment in collecting baseline data, tracking contamination trends over time, building laboratory facilities, or acquiring analytical instruments.

Agro-climatic factors have often obscured the understanding of the agrochemical paradigm in sub-Saharan Africa. Variations in rainfall, rising temperatures, and more extreme weather events influence agrochemical behavior in the environment, leading to changes in pest and disease cycles. These conditions create a foundation for adaptive research focused on climate-agrochemical interactions.

Given the issues associated with traditional agrochemicals, exploring safe and sustainable agricultural alternatives is essential. This is especially true in sub-Saharan Africa, where supporting the development of innovative solutions and adapting them to local agroecological conditions is a top priority. Biopesticides, botanical extracts, microbial inoculants, and organic fertilizers have shown promise in maintaining productivity while reducing chemical dependency. For example, modified biopesticides and microbial biofertilizers have been effective in managing cereal pests and improving soil fertility, but their adoption is often limited by a lack of awareness and regulatory support. Research should aim to develop tailored pest control and soil amendment strategies for specific cereal crops and climatic zones. Involving farmers, extension agents, and researchers in the design process can also boost adoption rates.

Beyond product innovation, there is a need to improve delivery methods. Mobile technology, digital tools, and community-based distribution approaches can increase access to inputs and optimize practices among smallholder farmers. Exploring the socio-psychological factors involved in agrochemical use can also help develop communication and policy frameworks that promote the adoption of less harmful, more sustainable resources.

CONCLUSIONS

The study explains the advantages and significant risks linked to using agrochemicals in cereal production and processing in sub-Saharan Africa. Synthetic fertilizers, pesticides, herbicides, and fumigants, which fall under agrochemicals, have greatly improved food supply, pest control, and crop yields in the region. They are vital for smallholder and commercial cereal farms trying to meet the needs of growing populations or adapt to climate-related challenges.

However, misuse, overdependence, and poor regulation of agrochemicals are common across much of sub-Saharan Africa. This leads to soil erosion, nutrient loss, biodiversity decline, and the buildup of harmful residues in cereals and the environment. Additionally, poor post-harvest handling and processing keep chemical residues in cereal foods, posing serious health risks. These health effects include respiratory problems, endocrine disorders, reproductive health issues, and certain cancers, especially among children and pregnant women. These vulnerable groups, many of whom are impoverished rural farm workers, are most exposed to agrochemical residues and rely heavily on agriculture.

Uncontrolled agrochemical use raises concerns about food safety and security. Although they boost productivity and reduce pest losses, agrochemicals threaten the sustainability of food systems. Continuous environmental contamination, rising input costs, and market bans on contaminated products jeopardize food availability and stability. Economically, smallholder farmers suffer from dependence on costly inputs and health issues, which weaken rural livelihoods and development.

This study's policy implications are urgent and clear. Governments across sub-Saharan Africa must act swiftly to close gaps in regulations concerning agrochemical production, distribution, and use. This includes residue monitoring, banning hazardous pesticides, improving labeling standards, and tackling counterfeit inputs. Policies should promote sustainable practices like Integrated Pest Management (IPM), organic farming, or ecological intensification, supported by relevant policies and programs. There is also a need to boost investment in research and extension services, advocate for farmers, and develop safe local alternatives to synthetic agrochemicals.

Finally, collaboration among agriculture, public health, environmental management, and education sectors is essential to address this critical issue. Since agrochemical problems are sectoral, responses must involve cooperation between ministries of agriculture and health authorities to monitor and manage pesticide-related health issues. Safety campaigns should address health concerns, while environmental monitoring and scientific research should inform policy development. Civil society, businesses, and entrepreneurs also have roles in raising public awareness, fostering innovation, and building capacity to access new markets.

Shared responsibility and streamlined regulations are key to fostering sustainable cereal production and food systems in sub-Saharan Africa, without abandoning agrochemicals entirely. With unified efforts, political will, and investments in alternative technologies and knowledge resources, we can protect both people and the environment while ensuring food security.

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