

Review

# Sustainable Agricultural Practices in Sub-Saharan Africa: A Review of Adoption Trends, Impacts, and Challenges Among Smallholder Farmers

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**Abstract:** Sustainable agricultural practices (SAPs) remain the panacea to addressing challenges relating to climate change, low rainfall, and low agricultural productivity in many rural parts of sub-Saharan Africa (SSA). These practices include but are not limited to crop rotation, intercropping, cover cropping, and conservation tillage. The aforementioned practices have been scientifically proven to enhance crop productivity while safeguarding environmental resources. This review assesses the trends, effectiveness, and challenges associated with the adoption and utilization of SAPs among smallholder farmers in the SSA region, analyzing the literature and reports from 2000 to 2024 sourced from databases such as Google Scholar and Scopus. The inclusion criteria focused on key concepts such as SAPs, adoption, and challenges. Findings indicate that crop rotation, intercropping, improved seed varieties, manure, and mulching are among the most adopted practices. In reality, practices such as conservation tillage, agroforestry, and water harvesting systems remain the least adopted practices in many rural parts of SSA. The review further reveals that challenges relating to land tenure insecurity, lack of knowledge, training, and limited access to financial institutions all have a direct or indirect influence on farmers' choice of adoption. Overcoming the aforementioned challenges through policy interventions and capacity building is vital for improved crop productivity and rural livelihoods.

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## 1. Introduction

The agricultural sector in sub-Saharan African countries is predominantly controlled by smallholder farmers who possess limited or no innovative farming practices and related technologies [1]. Nonetheless, this sector continues to be the most significant industry in SSA, employing between 65 and 70 percent of the region's active population and providing livelihoods for 90 percent of the population. Furthermore, agriculture serves as a substantial contributor to foreign exchange reserves and accounts for an average of 15% of Africa's gross domestic product (GDP), although there are notable variations in this figure between nations [2]. For example, in Uganda, the sector contributed 21% of the country's total GDP in the year 2019/2020. The percentage rose to 24.1% in the 2021/2022 period and was projected to further increase in the subsequent financial year of 2022/2023 [3]. This indicates that the nation relies solely on agriculture. However, Giller et al. [4] opined that the agricultural sector in SSA is not fully used and falls far short of its potential. The region's progress in improving land, labour, and productivity is slower than in other regions, especially developed ones.

SSA countries are deemed to be negatively impacted by the rapid increase in population. For instance, the United Nations Department of Economic and Social Affairs [5]

projects that the current global population of 7.6 billion will increase by 1 billion individuals by the year 2030. This is mainly attributable to the expansion of the global population, particularly in African nations. Consequently, with the growth of the global population, there is a substantial rise in the need for food, leading to a significant number of individuals experiencing food insecurity [5]. Moreover, the SSA regions are presently grappling with elevated temperatures, which, in conjunction with their heavy reliance on rain-fed agriculture, unsustainable farming practices, and poor economic conditions, have contributed to a decelerated rate of agricultural productivity growth in comparison to other global regions [6,7]. Therefore, adopting a scientifically integrated approach that can effectively tackle the aforementioned interconnected challenges is necessary to enhance agricultural productivity in the African region. Consequently, SAPs remain a unique panacea to agrarian transformation in the African region.

Moreover, there is a global consensus on the positive effects of SAPs on different aspects such as agricultural productivity, income, food security, and soil quality [8]. SAPs are defined by Coulibaly et al. [9] as “farm management practices that satisfy the current food and textile demands of society while safeguarding the capacity of future generations to provide for their own needs”. Sustainable practices encompass the reduction in environmentally hazardous inputs and a transition towards utilizing locally accessible resources, all while ensuring the competitiveness and economic sustainability of agriculture. For instance, according to Sinyolo and Mudhara [10], soil fertility is enhanced by applying sustainable practices such as inorganic and organic fertilizers. Additionally, the use of hybrid and improved seed varieties has been found to enhance resilience against pests and diseases, enabling crops to thrive in regions with little rainfall [11]. Furthermore, it has been demonstrated that crop rotation, mulching, and cover crops all contribute significantly to the preservation of soil moisture and the prevention of pest and disease accumulation in crops. This underscores the crucial role of SAPs in enhancing agricultural productivity while also ensuring that the environmental resources are not depleted [12].

#### *Problem Statement*

According to Lehtonen et al. [13], the introduction of modern practices and the utilization of SAPs such as “agroforestry, soil conservation practices, crop rotation, improved seed varieties, and intercropping” in certain developed countries has effectively enhanced agricultural productivity and substantially alleviated food insecurity and poverty. This is because SAPs have been scientifically proven to boost farmers’ livelihoods [14], while safeguarding environmental resources. As stated by Cele [15], SAPs remain a viable option for improving agricultural productivity among smallholder farmers in developing countries, where the agricultural system is characterized by limited productive capacity due to inadequate adoption of modern technologies and sustainable practices. Similarly, Moswetsi et al. [16] further emphasize that when considering SAPs, it is important to not just focus on future output growth but also on protecting the quality of the environment, water, and soil. Thus, the adoption of SAPs has been proposed as a means to enhance the productivity and resilience of crop production in smallholder farming systems while also preserving environmental and natural resources.

Nevertheless, despite the benefits of SAPs mentioned earlier, statistics indicate that a significant number of smallholder farmers worldwide, particularly in rural parts of SSA, have yet to adopt these practices fully [14,16–18]. Research conducted in the African region indicates that these smallholders continue to be firmly established in traditional farming practices that have undergone the test of time. For example, Oni [19] observed in his empirical study that a considerable number of smallholder farmers in Nigeria are thought to be unenthusiastic about adopting sustainable practices such as conservation agriculture. This is attributed to their constrained financial means and lack of drive to prioritize agricultural innovation over ineffective conventional methods. Danso-Abbeam et al. [20] observed a comparable pattern in Ghana, wherein a mere 40% of farmers adopted improved seed varieties, leaving the remainder to rely on traditionally conserved

seeds. These results are consistent with those of Feyisa [18], who observed that the majority of Ethiopian farmers continue to have difficulty adopting modern and sustainable farming practices.

Additionally, as pointed out by various scholars, research studies documenting SAPs' adoption trends, impacts, and challenges among smallholder farmers in SSA are very scarce. For instance, a recent study by Fadeyi et al. [21] investigated "factors influencing technology adoption among smallholder farmers in Africa", while a study by Rosário et al. [22] evaluated the "farmers' adoption of sustainable agriculture innovations: A systematic literature review in Africa". Nonetheless, none of these studies specifically analyzed the adoption trends, impacts, and challenges associated with the adoption of SAPs by smallholder farmers. Therefore, there is a need to build an understanding of the adoption, impacts, and underlying challenges behind the low utilization of SAPs in smallholder farming in SSA in order to bridge the identified research gap.

Agriculture and food security issues are thoroughly integrated within the Sustainable Development Goals (SDGs). There exists a distinct objective within the SDGs' framework aimed at promoting sustainable agriculture and ensuring food security and adequate food availability and accessibility for all Africans while also protecting the quality of the farming environment. Thus, this study seeks to offer valuable insights and information to the Ministry of Agriculture and rural development stakeholders in various sub-Saharan African countries regarding the adoption of SAPs, which have the potential to achieve the SDGs. The study will further offer empirically guided policy recommendations for developing interventions to enhance the adoption and utilization of SAPs that have been scientifically proven to improve crop yields while preserving environmental resources. Given these considerations, the study sought to provide answers to the following research questions (RQs):

RQ1. What are the environmental factors or conditions that exist in smallholder farming necessitating the adoption of SAPs?

RQ2. What are the adoption trends of SAPs across SSA?

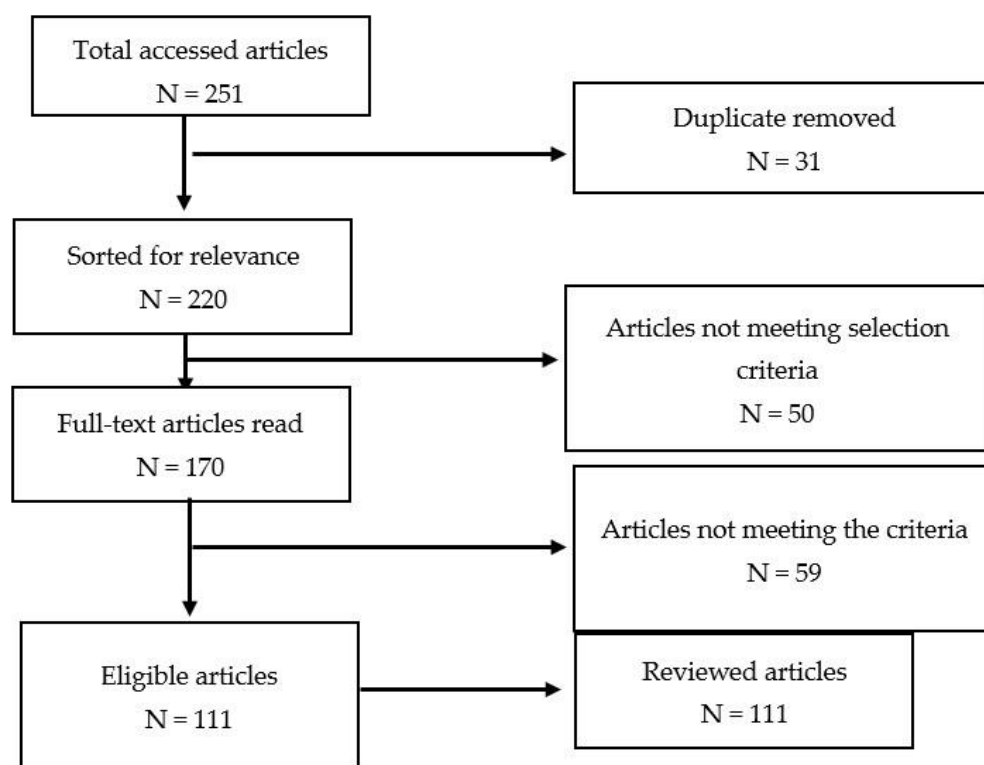
RQ3. How does SAPs' adoption impact the livelihoods of smallholder farmers in SSA?

RQ4. What are the challenges associated with the adoption of SAPs by smallholder farmers in SSA?

## 2. Materials and Methods

### 2.1. Research Design

This study utilized a systematic review technique following the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines to examine the adoption trends of SAPs, as well as the impacts and challenges faced by smallholder farmers in SSA. A PRISMA flow diagram (Appendix A and Figure 1) illustrates the study selection process. A systematic review was suitable for summarizing the literature and identifying adoption trends, gaps, impacts, and challenges across various sources. This method ensured a thorough and objective analysis of the knowledge level on the subject. The adoption of the PRISMA framework enhances the transparency, accuracy, and replicability of the research process, as supported by previous studies [23]. The review comprised two primary stages: systematic searching and selection of pertinent literature, followed by the meticulous management, coding, and analysis of data extracted from the chosen studies.



**Figure 1.** Flow diagram of the reviewed studies on SAPs in SSA. Source: Authors.

### 2.2. Data Collection Methods/Literature Search

The literature from significant academic databases, including Google Scholar and Scopus, was included in the review. Furthermore, reports from agencies like the Food and Agriculture Organisation (FAO), International Fund for Agricultural Development (IFAD), and World Bank, and sources such as articles, book chapters, conference papers, and reviews, were consulted for more information.

A wide range of search phrases were employed, such as sustainable agricultural practices, adoption, benefits, challenges, impacts, SSA, climate change, land degradation, pests and diseases, and smallholder farming. These phrases were combined in several ways to ensure a comprehensive and inclusive search. The research focused predominantly on studies conducted between 2000 and 2024, studies conducted in English, research on sub-Saharan Africa (SSA), and research on sustainable agricultural practices, and peer-reviewed papers, reports, and theses were all reviewed. We first reviewed titles and abstracts against predefined inclusion and exclusion criteria. Studies that did not meet the criteria were excluded, and we assessed the full texts of the remaining articles for relevance. Our review focused on studies conducted in sub-Saharan Africa that specifically focused on SAPs' adoption, impacts, and challenges among smallholder farmers. Lastly, research concentrating on areas outside of SSA, non-English publications, and studies unrelated to the adoption of sustainable agricultural practices by smallholder farmers was excluded.

### 2.3. Inclusion and Exclusion Criteria

As presented in Table 1, we carefully defined the inclusion and exclusion criteria for selecting review articles to ensure the relevance and quality of the studies analyzed. We included only publications in English to increase readability and to align with the researchers' language proficiency. Geographically, the review focused exclusively on papers related to SSA, excluding studies from other regions to maintain the scope of the systematic review. While access restrictions limited our ability to include some potentially

relevant studies, we acknowledge that many references are available through other universities' online catalogs. Even abstracts and keywords from these sources can provide valuable insights. For this review, we focused on articles published between 2000 and 2024 to ensure that our analysis reflected the most current research on SAPs' adoption, impacts, and challenges among smallholder farmers in SSA. The research was limited to papers that addressed adoption trends, impacts, conditions/factors, and challenges among smallholder farmers. We included only peer-reviewed journal articles, conference papers, and review papers and excluded papers reporting results from regions outside of SSA.

**Table 1.** Summary of the inclusion and exclusion criteria.

Selection Parameter	Inclusion Criteria	Exclusion Criteria
Language	English	Non-English
Literature type	Original studies The article was not a duplicate version of another article	Not original literature review and analysis The article was a duplicated version of another article in the dataset
Publication year	Published between January 2000 and March 2024	Published before 1 January 2000
Location of the study	Reporting results from SSA regions	Reporting results from regions outside SSA
Article availability	Available on Google Scholar and Scopus databases	Having paywall restrictions
Article title	Titles addressing sustainable agricultural practices adoption, impact, and challenges among smallholder farmers	Titles addressing coping with improved agricultural practices and utilization of sustainable farming practices

#### 2.4. Data Extraction

The initial search identified publications of potential interest based on their titles and abstracts. Two reviewers conducted independent eligibility screening of these articles to ensure accuracy and reduce bias. Data from each selected study were collected using a standardized extraction form. The information encompassed the authors and year of publication, study location, objectives, methodology, sample size, and key findings related to the adoption, impacts, and challenges of SAPs among smallholder farmers.

#### 2.5. Data Analysis Method

Key themes from all the included papers were found and compiled using thematic analysis. This method allowed for a systematic examination of SAPs' adoption, impacts, challenges, and conditions necessitating the adoption of these practices. The retrieved data were coded to find recurrent themes and grouped into more general groups.

#### 2.6. Background of the Study Area

Sub-Saharan Africa (SSA) is geographically and ethnoculturally the area of the African continent that lies south of the Sahara [24]. SSA is defined by the United Nations [25] as all African territories and countries situated entirely or partially south of the Sahara. SSA comprises 47 of the 54 countries that make up Africa, excluding Tunisia, Algeria, Egypt, Morocco, and Somalia (see Figure 2). Northern African countries are excluded from this region because they bear a stronger resemblance to the Middle East than to other African regions [26]. Moreover, this region has a wide range of agro-ecological conditions, including the desert drylands of northern Mali and the humid tropics of the Congo [27].

Furthermore, sub-Saharan Africa's present population of 800 million renders it one of the least densely populated areas and also the region with the most rapid population growth. Compared to other regions, agriculture continues to be the primary driver of the rural economy in sub-Saharan Africa. In 2005, agriculture in SSA (excluding South Africa) employed 62% of the population and contributed 27% to the GDP of these nations [27].

Smallholder farms form the foundation of these agricultural production systems. Important household production tasks, including pruning, harvesting, and processing, are carried out by a significant proportion of these smallholders who identify as women.

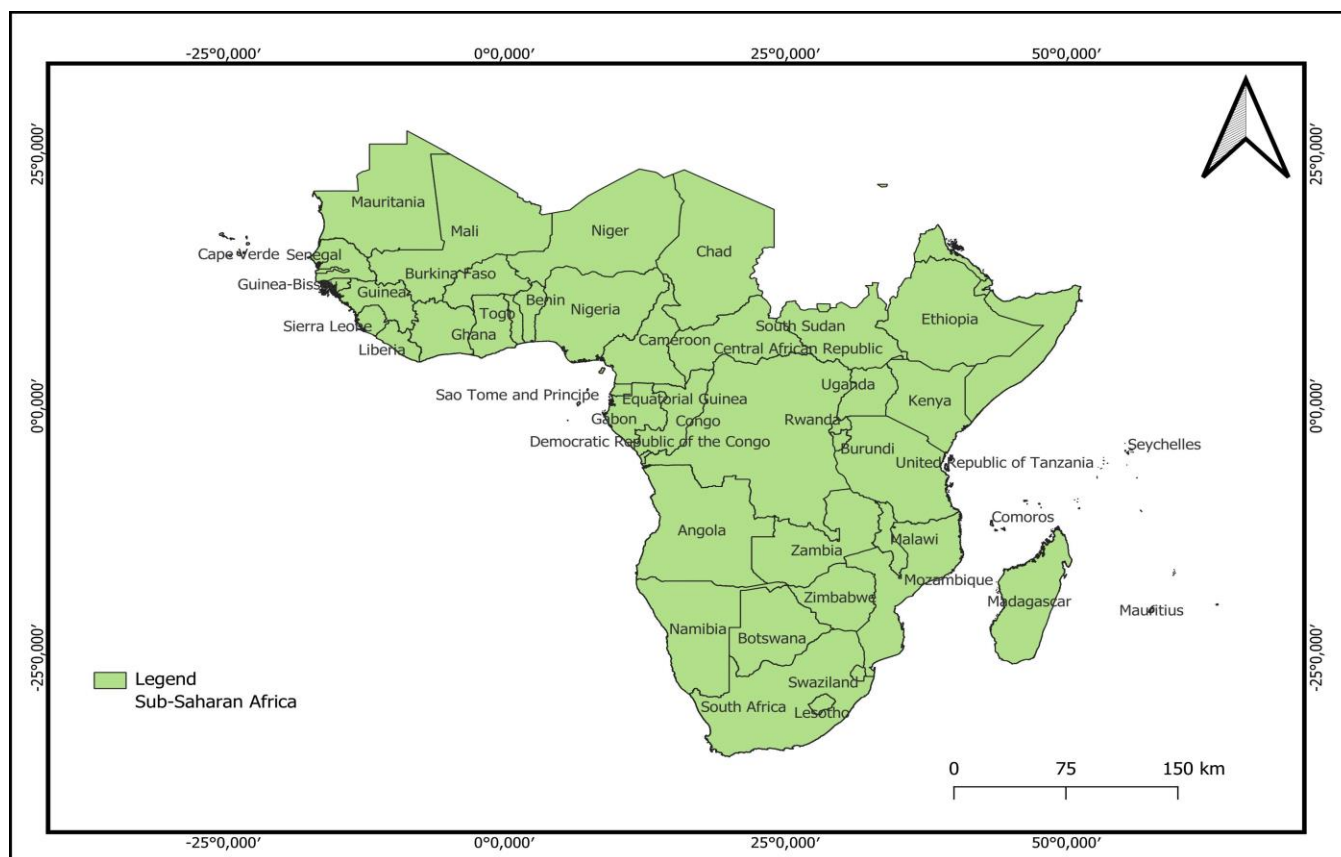


Figure 2. Map of sub-Saharan Africa.

### 3. Review Synthesis of Environmental Factors/Conditions of Smallholder Farming That Necessitate the Adoption of SAPs Across SSA

The smallholder farming sector is essential in ensuring food security and sustaining livelihoods in many rural parts of SSA [6,28]. In addition, the scholars opined that approximately 60% of households residing in the majority of SSA rely on smallholder farming as the primary source of income. According to Jellason et al. [29], these households are estimated to be accountable for almost 80% of the crops produced in SSA. In Ethiopia, for example, about 95% of primary agricultural produce, such as cereals, pulses, oilseeds, vegetables, root crops, fruits, and cash crops, are cultivated by smallholder farmers [30]. Additionally, Kamara et al. [6] opined that smallholders continue to play a pivotal role in supporting rural economies in several parts of developing countries, with SSA being no exception. They sustain their households and local marketplaces by cultivating products on plots of land that are smaller than three hectares. Although the smallholder farming sector offers numerous benefits to many societies, its productivity is hindered by several complex biophysical challenges, including but not limited to climate change and variability, inadequate soil fertility, the high prevalence of pests and diseases, land degradation, and insufficient rainfall [31,32]. Thus, this section of the review seeks to provide a detailed synthesis of the environmental factors or conditions that exist within the smallholder farming sector, necessitating the adoption of SAPs as a panacea to the aforementioned conditions. Also, the articles that have studied the environmental factors or conditions that exist within smallholder farming in SSA necessitating the adoption of SAPs are summarized in Table 2.

**Table 2.** Summary of the empirical studies on the environmental factors or conditions that exist within smallholder farming necessitating the adoption of SAPs across SSA.

<b>Environmental Factors or Conditions</b>	<b>Country</b>	<b>Key Findings</b>	<b>References</b>
Climate change and variability	Ethiopia	Reduction in the total annual rainfall	[33]
	South Africa	Uneven distribution of rainfall	[34]
	Kenya	High temperature resulted in a reduction in maize revenue	[35]
	Ghana	Reduction in crop yields and farm income as a result of changes in rainfall patterns	[36]
	Lesotho	Reduction in crop yields as a result of the changing climate	[37]
Pest and disease prevalence	Kenya	Reduction in maize yield	[38]
	Tanzania	Chronic pre-harvest maize losses due to rodent infestation are estimated to be approximately 15%	[38]
	Tanzania	Reduction in maize and millet yield due to pest and disease outbreaks	[39]
	Rwanda	Crop losses due to pests and diseases for sweet potato, banana, potato, and cassava were estimated at 26%, 29%, 33%, and 36%, respectively	[40]
Land degradation	Burundi	Significant reduction in sweet potato and banana yield due to pests and disease	[40]
	South Africa	Changes in soil organic matter and loss of top fertile soil	[41]
	Nigeria	Reduction in land productivity	[42]
	Mali	Decreased productivity and decreased soil fertility	[43]

### 3.1. Climate Change and Variability

Climate change is a significant and urgent threat to the global agricultural system [44]. Climate change encompasses the alterations in climatic patterns at both regional and global scales, which can be attributed to either natural variations or human actions. Climate change typically impacts cultivation practices by inducing extreme weather events, such as heatwaves and flash floods, as well as altering rainfall amounts and patterns. Consequently, these changes lead to shifts in the duration and timing of growing seasons, as well as variations in the occurrence and intensity of pests, diseases, and weeds. According to Serdeczny et al. [45], SSA has been identified as a region that is highly susceptible to the consequences of extreme events, specifically climate change, which is predominantly evident in the form of droughts and floods. Drought in SSA is distinguished by less precipitation, shorter and erratic rainy seasons, and heat-induced strain. These characteristics exhibit significant variation across different sub-regions [46].

Furthermore, Chalchisa and Sani [47] have observed a present decrease in precipitation in the semi-arid region of SSA. For example, in their study, Sani et al. [33] observed a reduction of 46.75 mm in the annual total precipitation in western Ethiopia. A similar point was made by Chipfupa and Wale [34] when they noted that drought has developed in certain regions of southern Africa as a consequence of climate change and variability. The scholars observed that South Africa experiences a significantly uneven distribution of

yearly rainfall, with an average of around 500 mm, which is lower than the global average of 860 mm. As a result of smallholders' reliance on rain-dependent agriculture, the livelihoods of many rural households and economies of numerous African nations are vulnerable to the effects of climate change. Across several countries in SSA, the combination of climate change and variability has led to a rise in temperatures and a decrease in average rainfall. Consequently, this makes smallholder farmers dreadfully susceptible to erratic and fluctuating climatic conditions, resulting in low agricultural production [26,44].

### 3.2. Pest and Disease Prevalence

The presence of insect pests in the SSA regions continues to cause significant damage to crop productivity. According to Kariathi et al. [48], a significant obstacle in the pursuit of food security and well-being in rural SSA is the detrimental impact of pest-induced crop losses. The detrimental effects of both long-established pests resulting from insufficient control measures and the consequences of new and emerging pests present a significant obstacle to crop growth and yield. Although crop pests are a problem in all cropping systems around the globe, their impact is significantly greater in many rural parts of SSA. In Kenya, for instance, Swanepoel et al. [38] reported that rodents, an insect nuisance, have caused maize crop losses ranging from 20 to 30 percent, with outbreaks resulting in 34 to 100 percent losses. Similarly, chronic pre-harvest maize losses in Tanzania due to rodent infestation are estimated to be approximately 15%, with seedling and sowing damage potentially surpassing 40% [38].

Furthermore, Laizer et al. [49] reinforce this notion by stating that insect pests pose a significant obstacle to the cultivation of common beans in northern Tanzania, specifically in smallholder agricultural systems. Both in the field and while stored, common beans have been documented to be susceptible to insect infestations. During storage, bean bruchids (*Acanthoscelides obtectus*) are the most prevalent insect parasites, whereas bean stem maggots (*Ophiomyia phaseoli*) are the most significant in the field. Food security and livelihoods of many rural households are further jeopardized in Nigeria by the significant impact that insect pests and plant diseases have on crop yields. Tobih et al. [50] reported that the presence of insect pests and diseases in yams led to an average annual yield reduction of 25%. Therefore, effective pest management is crucial for African agriculture, as the majority of households are smallholders with limited access to farm inputs and resources, thus resulting in reduced crop yield [51]. According to El-Heneidy et al. [17], synthetic pesticides and herbicides are commonly used by farmers as the primary and favoured approach for managing and controlling insect pests and weeds. Nevertheless, the majority of smallholders in SSA have difficulties in adopting the methods mentioned above due to reasons such as high monetary costs, insufficient knowledge, and limited research on alternative products [52]. Therefore, there is a demand for more cost-effective and accessible environmentally sustainable methods to control crop pests.

### 3.3. Land Degradation

Land degradation is a global problem that threatens agricultural productivity and food availability. As defined by Xie et al. [53], land degradation is the decline in land productivity and its capacity to offer services due to both natural and human-induced factors. These variables impact soil quality and the land's productivity, perhaps leading to famine among smallholder farmers. According to Tully et al. [54], most of the effects of land degradation are felt in various regions of developing countries where a significant portion of the households depend on agriculture or the soil for a living; SSA is no exception. For example, in their study, Tesfa and Mekuriaw [55], referencing Berry's work, observed that in Ethiopia, 85% of the population directly derives their livelihood from the soil. Nevertheless, the agricultural productivity of these farmers is being significantly diminished by modern and unsustainable land management methods, both in areas dedicated to food crops and in grazing fields. These unsustainable land management methods, together with natural anthropogenic forces, frequently lead to land degradation. Land



degradation is a significant issue in both Tanzania and Malawi. A study conducted by Le et al. [56] reveals that areas with high levels of land degradation encompass around 51% and 41% of the land area in Tanzania and Malawi, respectively.

Furthermore, in semi-arid regions of Southern Africa, substantial soil degradation has resulted from the decline in soil organic matter content caused by drought and traditional agronomic practices utilized by smallholder farmers [57]. For example, in South Africa, there have been concerning changes in soil fertility and quality over the past thirty years. These changes include the loss of soil organic matter, decreasing nitrogen levels, increasing soil acidity, and the expansion of saline and alkaline areas [41]. Furthermore, Adenle et al. [58] observed that Nigeria has one of the highest rates of land degradation in West Africa, with a biomass decline of approximately 400,000 ha annually and agricultural productivity losses. Sustained reversal of the downward trajectory of land degradation is unattainable unless the majority of the smallholders adopt economically viable and ecologically sustainable livelihood approaches that place less strain on forest resources compared to existing agricultural practices.

#### **4. SAP Adoption: A Panacea to Climate Change Among Smallholder Farmers**

Smallholder farmers in developing countries, notably in SSA, are very vulnerable to climate change and variability due to their reliance on rain-fed agriculture, which is sensitive to climatic conditions [59]. There are detrimental impacts that climate change has on both agricultural production and the environment. Severe land degradation, depletion of nutrients and organic matter, eutrophication and water contamination, and biodiversity loss are among the adverse effects [60]. In addition, Serdeczny et al. [45] noted in their study that the frequency and severity of natural disasters have increased over the past decade due to rising temperatures, sea levels exceeding 1 m, and irregular precipitation. Moreover, across the majority of SSA, the collective impact of unsustainable farming practices such as conventional tillage, along with climate variability and change, has resulted in poor soil fertility and subsequently low crop productivity [61]. However, a consensus has been reached by many scholars that the effective adoption of SAPs offers numerous potential solutions to the aforementioned challenges.

The adoption of SAPs has gradually enhanced smallholder farmers' ability to adapt to climate change's impacts [62]. This notion is further supported by the research of Recha et al. [63], which emphasizes the pressing need for smallholders, particularly in rural parts of SSA, to take advantage of the opportunities presented by SAPs to aid in mitigating the effects of climate change and variability. Additionally, the author emphasizes that adaptation to climate change can be accomplished by adopting and using sustainable practices that are more adaptable and resistant to climate change, as well as through various measures that increase both flexibility and responsiveness to change. For example, SAPs such as mulching and cover cropping have been scientifically proven to enhance the infiltration of rainfall into the soil and improve its ability to retain water, such as by increasing soil organic matter. These practices also protect the soil against extreme weather conditions such as high temperatures and heavy rainfall [64]. Therefore, smallholders should leverage these practices to mitigate the impacts of climate change and variability, thereby enhancing their crop production and overall farm income.

Moreover, Coulibaly et al. [9] contend in their empirical study that the adoption and use of sustainable practices is essential for enhancing the productivity and economic viability of traditional rice and wheat cropping systems. During a three-year research project, the authors integrated sustainable tillage methods with tailings and water resource management to enhance economic yields and profitability. The authors found that using sustainable practices in maize and wheat production leads to significant water conservation and yield improvements. Specifically, the application of these practices resulted in a 12% increase in yields and a 34% boost in economic profitability compared to conventional crops like rice and wheat. This demonstrates the significance of SAPs as a crucial concept that many rural households, particularly smallholders, must be aware of, as they play a

vital role in enhancing crop productivity and farm income while also safeguarding the environmental resources within the smallholder farming environments.

### 5. Adoption Trends and Impacts of Sustainable Agricultural Practices in SSA

Table 3 shows the articles that have studied the adoption and socio-economic impacts of SAPs in SSA. Crop rotation, intercropping, integrated pest management (IPM), utilization of genetically modified seeds, conservation agriculture, cover crops, mulching, manure, water harvesting systems, and enhanced varieties are among the SAPs implemented by smallholder farmers in SSA for crop production. As demonstrated in Table 3 and the subsequent flowchart (Figure 3), these practices are crucial for promoting crop growth and yields while preserving environmental resources such as soil quality.

**Table 3.** Summary of the empirical studies on adoption of sustainable agricultural practices in SSA.

Region	Country	Area(s) of Impacts	Sample Size	Reference(s)
Southern Africa	South Africa	Labor-saving benefits	368 farmers	[65]
	South Africa	Improved resistance to pests and diseases	Nine <i>S. frugiperda</i> populations	[66]
Western Africa	Ghana	Enhanced crop yield	150/750 households	[67,68]
	Ghana	Increased crop yield	N/A	[69]
	Burkina Faso	Improved soil fertility	124 papers	[70]
	Nigeria	Suppressed weeds and pests and increased crop yields.	200 arable farmers	[71]
	Senegal	Increased farmers' resilience to climate change	3123 households	[72]
	Ethiopia	Enabled water conservation and increased yield and profit	90 farmers	[73]
	Malawi	Increased maize grain yield	72 plots in 24 farmers' fields	[74]
Eastern Africa	Zambia	Increased maize yield and farm income	800 households and 3000 plots	[62]
	Kenya	Reduced pests and increased finger millet yield	384 finger millet growers	[75]
	Tanzania	Maximized the use of resources such as water and sunlight	N/A	[76]
	Ethiopia	Increased yield productivity	N/A	[77]
	Malawi	Increased the profit efficiency of maize farmers	108 farmers	[78]
	Mozambique	Increased crop yield and farmers' profits	638 farmers	[79]
	Tanzania	Improved livelihoods	681 farm households	[80]
Kenya	Increased farmers' resilience to climate change	300 farmers	[81]	

Uganda	Increased yields and reduced use of pesticides	124 papers	[70]
Zimbabwe	Improved maize productivity and farmers' livelihoods	601 households	[82]

Sustainable agriculture is of paramount significance in the food system due to its pivotal function in enhancing agricultural profits and guaranteeing food availability for many rural households, specifically in developing countries located in Africa [83]. In several sub-Saharan African regions, sustainable practices such as conservation agriculture (CA) are reportedly acquiring considerable momentum. For instance, according to one of the reviewed articles, it has been observed that CA has been implemented in Ethiopia for the past two decades, and its acceptance and utilization among smallholder farmers has grown [84]. Around 70,000 smallholder farmers in the Wolaita area have implemented CA as a means to manage soil erosion, enhance soil fertility, and mitigate the effects of climate change and variability [84]. In addition, the results of a study conducted by Micheni et al. [85] demonstrated that while the initial expenses for CA establishments, particularly for weeding, were expensive during the first two seasons, the overall crop yield and income from no-tillage systems were considerably greater compared to traditional tillage methods in the long run. This indicates that while CA has the capacity to maintain crop productivity, it also plays a crucial role in assuring a profitable return on investment for farmers.

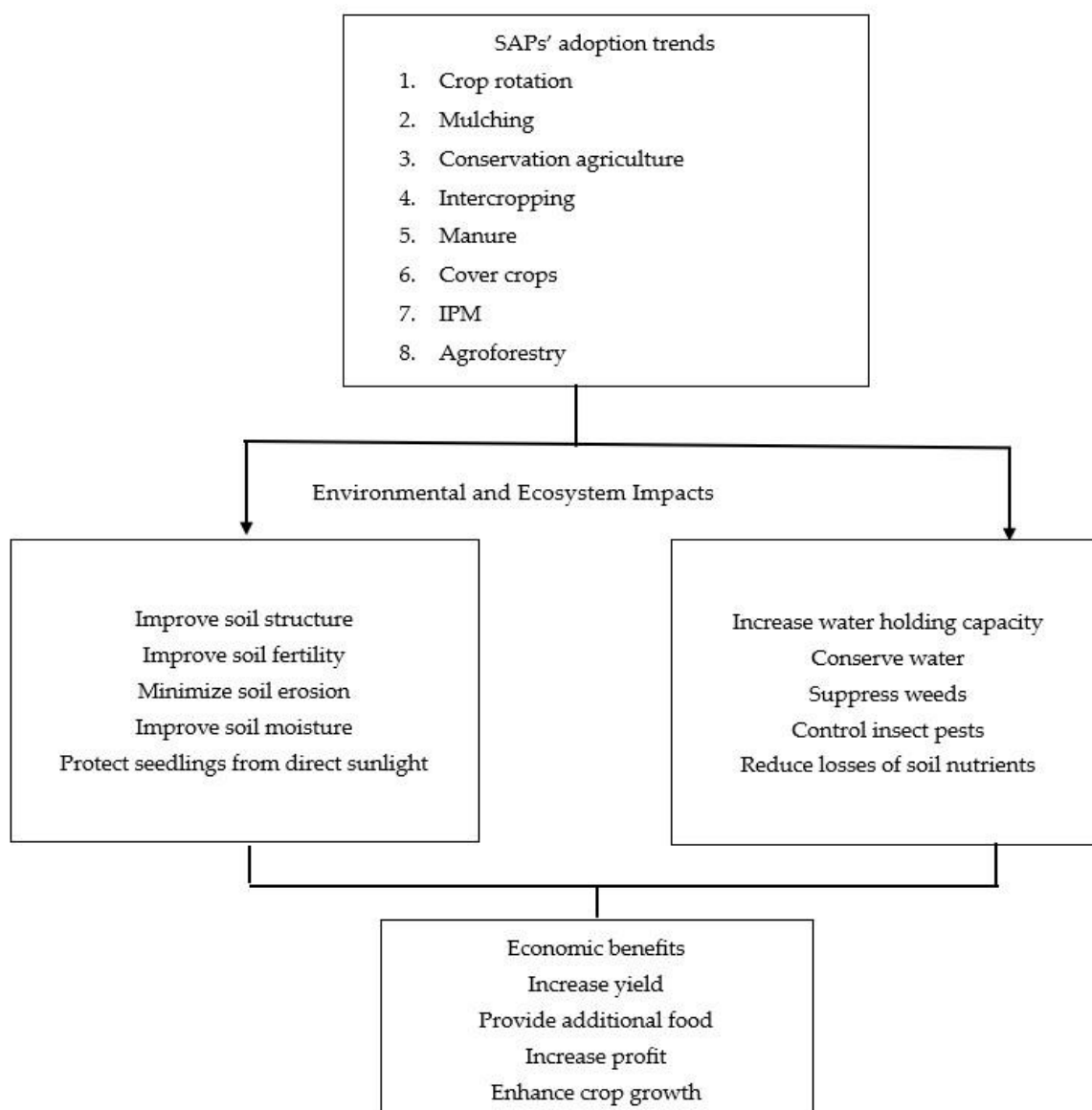
Moreover, according to Massawe et al. [76], the adoption of intercropping, a prevalent technique among smallholder farmers in Africa, is of paramount importance in optimizing critical resources, including space, water, sunlight, and nutrients. Furthermore, the significance of intercropping has increased, according to Daryanto et al. [86], as a consequence of the reduction in landholding sizes brought about by the accelerated population growth, specifically in African nations. Pigeon peas (*Cajanus cajan* L.), beans (*Phaseolus vulgaris* L.), and cowpeas (*Vigna unguiculata* L. Walp) are common legumes intercropped with cereal in Eastern Africa. For example, in Tanzania, Massawe et al. [76] observed that smallholder farmers intercrop cereal and legume crops, including beans, cowpeas, pigeon peas, green peas, and Bambara nuts, to optimize vital environmental resources.

Scholars worldwide hold the belief that improved seed varieties can effectively tackle the issue of malnutrition in various regions of Africa. For example, Sadiq et al. [67] observed that the predominant strategy for adapting to climate change is the utilization of improved varieties. The Council for Scientific and Industrial Research—Crops Research Institute (CSIR-CRI) of Ghana has developed and distributed several improved maize varieties to farmers, including Dadaba, Okomasa, and Obatanpa, which exhibit varying maturities. These varieties were designed to cater to the specific requirements of growers residing in the diverse ecological zones of Ghana. Farmers employ these strategies to mitigate the risk of crop failure, given that they cultivate various commodities with distinct climatic demands. Furthermore, in regions of Eastern Africa, such as Ethiopia, where rainfall exhibits significant variability in distribution, the use of water harvesting systems has demonstrated considerable efficacy [87,88]. Water harvesting is widely recognized as an effective strategy for mitigating the challenges posed by frequent, unpredictable precipitation and arid spells, which frequently lead to agricultural crop failures in various regions of Africa, including Ethiopia, where smallholder farming is the primary source of livelihoods for many households. In Ethiopia, for instance, Teshome et al. [73] observed that the implementation of water harvesting systems resulted in a 5% increase in household income for farmers engaged in tomato and onion production in the Tigray region. In the Amhara area of Ethiopia, onion agriculture with water harvesting systems resulted in a better annual income compared to rain-fed teff and wheat cultivation [41].

Moreover, agroforestry has emerged as a viable approach to sustainable land management in SSA, specifically targeting the issue of soil fertility loss and land degradation that frequently beset smallholder farmers [89]. Agroforestry is a sustainable practice that

combines the cultivation of crops and livestock with the presence of trees and bushes. Agroforestry enables smallholder farmers to efficiently generate a diverse array of goods and services by integrating different agricultural and forestry practices, effectively meeting a wide range of demands. In addition, the adoption of sustainable practices such as green manure or cover crops has also been recognized as a significant method for sustainable land management. The utilization of green manure and cover crops is prevalent in organic vegetable production systems across most regions of SSA. Both techniques have demonstrated their importance in augmenting the organic composition of the soil, hence promoting soil fertility. A study conducted in Nigeria showed that the use of green manure resulted in increased tomato yields and improved nutritional content [90]. As stated by Moswetsi et al. [16], the utilization of green manure/cover crops has been recommended for the African region because of its positive effects on soil characteristics and weed control. Additionally, a study by Adenle et al. [70] demonstrated that the adoption and utilization of SAPs, such as water and soil conservation techniques, resulted in enhanced soil fertility, increased water use efficiency, and higher crop yields in sub-Saharan African nations, specifically Uganda, Kenya, Malawi, Burkina Faso, and Tanzania. The scholar observed that efficient water use and soil conservation practices led to reduced land degradation, which in turn increased annual cereal yield in central Burkina Faso. The implementation of water harvesting technologies led to an increase in millet and groundnut yields from 300 to 900 kg/ha. This highlights the significance of sustainable practices in enhancing the livelihoods of many rural households, particularly smallholder farmers across different African regions.

Based on the comprehensive analysis of the SAPs' adoption trends, it is evident that the adoption of SAPs by smallholder farmers in SSA exhibits variability both between and within countries. The comparative analysis of SAP adoption provides important insights into the adoption and use of SAPs across the SSA regions. The findings indicate that eastern African countries are marginally more advanced in the adoption and utilization of SAPs compared to their western and southern African counterparts. In West Africa, commonly adopted practices encompass cover cropping, improved varieties, crop rotation, and manure application. In eastern Africa, prevalent practices include climate-smart techniques, intercropping, mulching, enhanced seed varieties, and soil management strategies. The findings align with those of de Jalon [91], who identified a significant difference in the adoption of modern practices between East and West Africa. The author noted that the adoption rate was significantly higher in East Africa than in western and southern Africa. The disparities in the adoption of SAPs throughout the SSA region can be attributed to several factors and challenges, which are discussed in the following section.



**Figure 3.** Flow diagram of the perceived benefits of SAPs. Source: Authors.

## 6. Challenges to Sustainable Agricultural Practices' Adoption Among Smallholder Farmers in SSA

According to Manda et al. [62], adopting SAPs can benefit farmers economically by increasing crop yields and household income. Additionally, SAPs can reduce transaction and input costs while also boosting food security and promoting economic growth. SAPs' significant impact on the sustainability of the ecosystem has received much attention. For instance, sustainable practices such as cover cropping, crop rotation, and minimum tillage offer environmental advantages such as reducing nutrient runoff and erosion and promoting insect pollination [78]. Despite the benefits mentioned above, the mainstreaming and the adoption of sustainable practices are confronted by many challenges [14,62,65,88], as indicated in Table 4. Thus, in this section, the most common challenges hindering the adoption of SFPs are discussed in relation to the reviewed articles from various SSA countries.

**Table 4.** Challenges to SAPs' adoption in SSA.

SAPs	Challenges to Adoption	References
Water harvesting system	Lack of awareness and insufficient information. Complexity and difficulty in constructing water harvesting structures.	[92]
Climate-smart practices	Land tenure insecurity. Lack of access to off-farm income.	[84]
Mulching	Land tenure insecurity. Lack of property rights.	[93]
Improved irrigation practices	Slow return on economic investment.	[94]
Intercropping	Lack of resources. Market access to legume crops.	[95,96]
Conservation agriculture	Uncertain about its profitability. Farmers lack relevant skills, knowledge, and equipment.	[97,98]
GM/hybrid varieties of seeds	Lack of training and lack of knowledge. Gender disparities.	[99]
Improved maize varieties	Lack of off-farm income. Labour demand.	[100,101]
Integrated pest management	Low level of education, insufficient training, and technical support for farmers.	[102]

Based on the reviewed articles, one of the most identified limitations in adopting SAPs are issues related to land tenure insecurity [88]. Tenure insecurity is a significant obstacle to the adoption of sustainable practices as it is caused by the absence of formal land use rights, which is a result of the failure of statutory law to acknowledge customary tenure systems [70,103]. Harvey et al. [97] observed that the size of the land holding poses a significant obstacle for Ethiopian smallholder farmers when it comes to adopting modern farming practices such as SAPs. Similarly, Adesida et al. [104] observed that farmers in Southwest Nigeria who obtained land through borrowing, gifting, leasing, and sharing rather than purchasing and inheritance generally face lower levels of security when engaging in long-term agricultural activities. This lack of security or title deeds hinders their ability to invest and adopt certain SAPs. Moreover, Cheesman et al. [105] opined that smallholder farmers who have uncertain land rights are vulnerable to land loss and, as a result, are hesitant to make long-term investments in their land to enhance its productivity. Instead, the focus is on maximizing immediate benefits while disregarding potential long-term drawbacks. This indicates a necessity for the government to expedite the land distribution without compensation, ensuring that individuals in remote rural areas have sufficient agricultural land to support their livelihoods.

According to Oyinbo et al. [106], the availability and provision of Rural Advisory Services (RASs) is a significant factor affecting the adoption of modern farming practices by smallholder farmers in many rural parts of developing countries. Extension officers are crucial in facilitating the adoption of innovative agricultural practices. As postulated by Bese et al. [14], smallholders place their trust in extension officers as they impart

knowledge and valuable information that aid in the improvement of their agricultural endeavors, thereby facilitating the farmers' adoption process. Nevertheless, according to Myeni et al. [107], a significant proportion of farmers (99%) lacked access to extension services, and a mere 1% were provided with extension advisory services pertaining to agricultural production. The findings substantiated that smallholder farmers had restricted availability of extension services via formal organizations and Department of Agriculture extension advice. In addition, Myeni et al. [107], citing the work of Ortmann and King, found that government extension advisers in KwaZulu-Natal only make annual visits to smallholder farmers, and their educational qualifications are significantly lacking. Consequently, there is a significant necessity for African leaders to re-evaluate the existing extension programs to guarantee an adequate number of extension practitioners to meet the requirements of smallholder farmers. This would facilitate the adoption of modern farming practices, such as SAPs, by smallholders in various African nations.

Furthermore, according to Mohammed [84], an additional limitation that hinders progress in the adoption of SAPs is the ineffective dissemination of knowledge, expertise, and technologies from development agencies and governmental institutions to the local agricultural communities. Smallholder farmers are frequently apprehensive about adopting modern farming practices such as SAPs unless they have witnessed concrete evidence of their efficacy and received comprehensive explanations and training regarding the advantages and potential drawbacks of these practices. For example, the implementation of water harvesting methods and small-scale irrigation technologies in Ethiopia continues to present a significant obstacle. This is partially attributable to farmers' lack of access to information regarding the benefits of the water harvesting methods, which include increased household income, employment opportunities, agricultural diversification, and participation in community decision-making [92]. Additionally, despite the benefits of SAPs such as CTPs, Nkala et al. [108] observed that the adoption of SAPs such as CA and CTPs has been sluggish in Mozambique due to various factors. These factors include but are not limited to inadequate skills and knowledge among farmers, limited extension services, and widespread poverty [108]. The farmers' knowledge of SAPs significantly affects their decision to adopt or not adopt these practices. Therefore, change agents and rural development stakeholders must ensure that the information and knowledge provided to smallholders is accurate and reliable. This can be achieved by ensuring that change agents possess an adequate understanding of the use, implementation, and benefits of SAPs.

Moreover, Saliem et al. [109] contend that the predominant rationale behind farmers' adoption of modern practices is probably economic and financial concerns. Conversely, the adoption of a particular sustainable practice may be significantly impeded by the presence of confusion concerning the economic or financial benefits that correspond to it. Mohammed [84], for instance, identified the slow return on investment associated with climate-smart agriculture (CSA) as one of the most significant obstacles to its widespread adoption in Ethiopia. Several CSA practices, including agroforestry, require a period of time to yield concrete benefits for farmers. However, given the current economic downturn and limited financial resources, the majority of smallholder farmers require immediate benefits from a particular technology or practice. Moreover, Oni [19] observed that many smallholder farmers in Nigeria are believed to exhibit limited enthusiasm in embracing SFPs, such as conservation agriculture, due to their limited financial resources and lack of motivation to prioritize agricultural innovation over inefficient conventional practices.

Additional positive factors identified in the reviewed articles that influenced the adoption of SAPs by smallholder farmers included financial constraints and the high cost associated with SAPs' inputs such as fertilizers [64]. For instance, in Nigeria, specifically in the districts of Shika and Bassawa, smallholder farmers were asked to provide reasons for their reluctance to use SAP technologies. The farmers identified and prioritized financial constraints as the major obstacles that hinder the adoption and implementation of certain modern practices such as SAPs [64]. Additionally, the study conducted by Olayemi

et al. [64] found that financial restrictions were unanimously identified as the primary obstacle to implementation. This was followed by the high costs of fertilizers and the extreme poverty level in the study area. Similarly, Djibo and Maman [110] reported that the elevated cost of agricultural inputs and machinery has a detrimental impact on the adoption of improved seeds by smallholder farmers in Niger. This highlights the necessity for change agents and rural development stakeholders to dedicate greater effort towards securing funds and donations for smallholders to enable them to acquire capital and labour-intensive SAPs and technologies.

## 7. Success Factors for Scaling up the Adoption of SAPs

Sustainable practices are crucial for enhancing crop yields and farmers' livelihoods. However, the adoption of these practices is constrained by many factors, necessitating well-guided profit-oriented interventions that consider the needs of smallholders. The following factors or innervations have been empirically demonstrated to enhance the adoption of SAPs.

### 7.1. Clear Tangible Benefits from SAPs

Clear tangible benefits of SAPs are essential for facilitating their adoption by smallholders. Miller and Connel [111] observed that farmers rapidly adopt and utilize modern practices that provide immediate solutions to issues associated with reduced crop yields, climate change, and pest and disease incidence. Mitigating the identified obstacles will likely enhance crop yields and improve farmers' livelihoods. Conversely, farmers exhibit hesitance in adopting practices that require extended periods to produce the desired benefits or those whose outcomes remain uncertain. Therefore, change agents must ensure that the benefits of the proposed sustainable practices align with the minimum requirements of smallholder farmers.

### 7.2. Access to Resources Related to Sustainable Practices

Access to agricultural inputs, information on sustainable farming practices, credit facilities, and market opportunities are critical factors influencing the adoption of sustainable practices. Farmers with access to credit facilities can obtain loans to acquire inputs and resources necessary for sustainable farming, especially those that require significant capital and labour. For instance, Djibo and Maman [110] observed that the increased costs of farming inputs and machinery negatively affect the adoption of improved seeds. However, the availability of credit may enhance technology adoption by alleviating financial constraints. Therefore, availability and access to these resources is essential for adopting SAPs; thus, African governments must establish structures to facilitate resource distribution that addresses the needs of farmers.

### 7.3. Support from the Government and Relevant Stakeholders

Government support, along with assistance from rural development agencies and change agents, has been shown to significantly improve the adoption of modern farming practices, including SAPs. Robust support facilitates the adoption process, thereby enhancing the success rate. The presence of a support structure enables farmers to access information on sustainable practices and facilitates the provision of essential inputs and resources necessary for the adoption of these practices. These inputs include the provision of input vouchers and subsidies that can facilitate the adoption of these practices. Thus, the presence and availability of a farmers' support system from various stakeholders is likely to ensure that farmers have the necessary resources to adopt sustainable agricultural practices, especially those that are capital- and knowledge-intensive.



## 8. Conclusions and Recommendations

In many parts of sub-Saharan Africa, agriculture remains the primary source of livelihood for about 65% to 70% of the working population, with 90% depending on farming for their basic needs. In recent years, significant improvements have been made in the smallholder farming sector to elevate it to better heights and increase agricultural productivity. Nevertheless, more changes are still needed to ensure sufficient crop production to sustainably feed the rapidly growing population around the globe while simultaneously mitigating the adverse effects of environmental degradation, pest and disease incidence, and climate change and variability. Several African countries are currently facing issues such as climate change, land degradation, rapid population growth, and food insecurity. To address these challenges, various sustainable practices have been suggested as potential solutions. These practices include crop rationing, cover crops, intercropping, agroforestry, conservation agriculture, and the use of improved crop varieties. The benefits of these methods include, but are not limited to, enhancing soil structure, increasing fertility, improving water holding capacity, enhancing soil moisture, increasing crop yields, and boosting farm revenue. However, despite the aforementioned benefits of these practices, the adoption of sustainable practices in sub-Saharan Africa is hindered by several challenges, leading to a low level of adoption. These challenges involve diverse factors, including, but not limited to, land tenure insecurities, insufficient provision of extension services, lack of knowledge, limited access to financial institutions, and inadequate financial and policy support from the government.

The benefits of SAPs and associated technologies will only be achieved if a significant number of smallholder farmers adopt these practices. Nonetheless, it is important to recognize that the adoption of these practices, despite the previously mentioned benefits, will require facilitation due to the challenges outlined earlier. This paper advocates for increased focus on the critical challenges and environmental conditions influencing the adoption of SAPs within the smallholder farming sector. Moreover, given the complexity of smallholder farming systems in sub-Saharan Africa, there is a pressing need for research to actively inform and support the adoption decision-making process. In addition, change agents and rural development stakeholders need to collaborate with farmers to identify and prioritize locally appropriate SAPs and create an enabling environment conducive to adopting and sustaining these practices within the smallholder farming sector.

Furthermore, based on our findings, it can be concluded that SAPs are extremely complex, and a wide range of socio-economic factors influence their adoption and utilization. Considering that the use of SAPs requires a significant amount of capital and knowledge, it is important for policymakers and the government in African countries, through rural financial institutions, to provide financial services to smallholders who do not often meet the minimum requirements for financial credit. This will improve the accessibility of financing for these farmers and empower them to adopt SAPs and related technologies, hence accelerating the adoption of these practices among smallholder farmers. Furthermore, considering the presence of a knowledge deficit among smallholder farmers about SAPs, it is imperative to enhance the farmers' technical knowledge of SAPs by offering both formal and informal training programs. This will help them adopt SAPs more easily and ultimately lead to improved agricultural yield.

## 9. Limitations

The review may be subject to publication bias, as studies with positive results are more likely to be published. Also, limiting the review to English-language publications and studies conducted from 2000 onwards may have excluded relevant research published before 2000. Furthermore, there is a lack of relevant literature review on the adoption trends, impacts, and challenges associated with the adoption of SAPs in smallholder farming in SA. Nonetheless, a large number of studies on SAPs in SSA were used in this

study in order to circumvent the problem of generalization of the results. This was conducted to ensure the accuracy of the data. Also, the amount of studies reviewed was sufficient and thus made it possible to draw a broad conclusion about the adoption trends, impacts, and challenges associated with SAPs' adoption in SSA.

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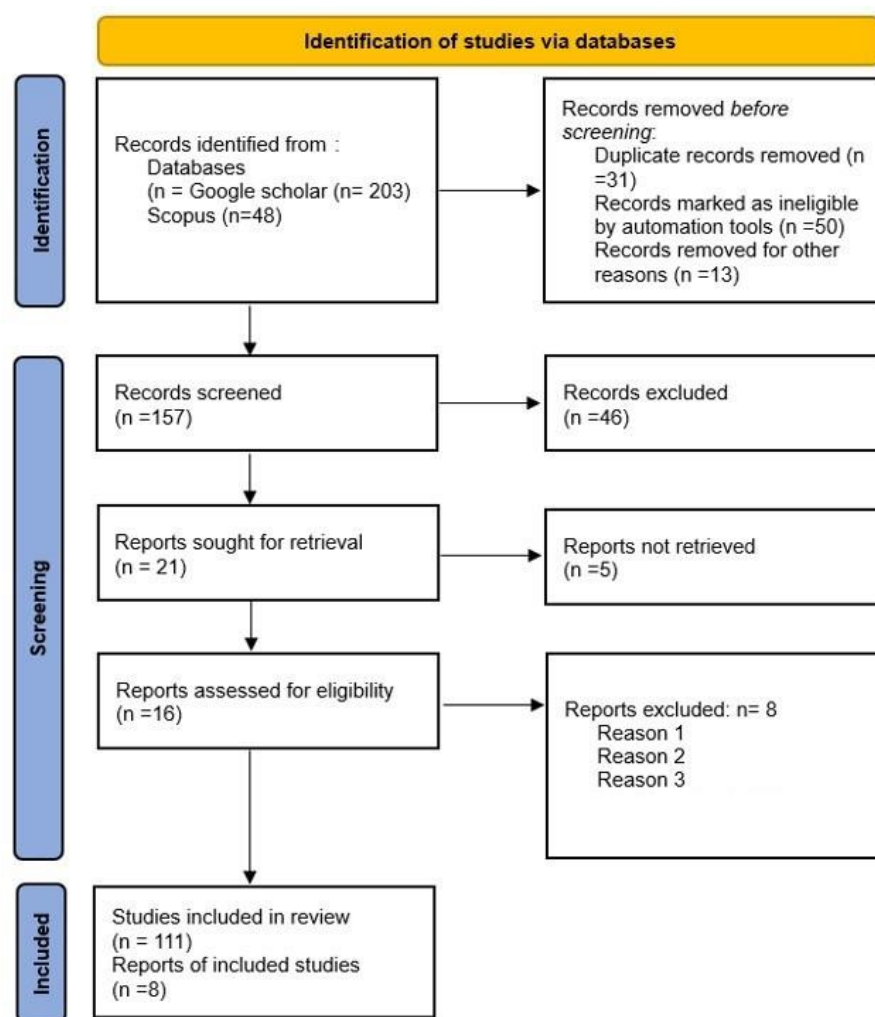
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## Appendix A



**Figure A1.** Flowchart of a systematic process for the identification of pieces of literature used in the review ( $n$  = number of articles) following PRISMA guidelines.

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