Review

Not peer-reviewed version

Opportunities and Challenges for the Promotion of Transitions to Agroecological Practices for Sustainable Food Production in Sub-Sahara Africa

Suwilanji Sinyangwe *, Sithembile Mwamakamba, Rachel Mkandawire, Tshilidzi Madzivhandila

Posted Date: 1 May 2023

doi: 10.20944/preprints202305.0009.v1

Keywords: Agroecology; Local Resources; Sustainable Food Production; Climate Change; Policy; Sub-Saharan Africa

Review

Opportunities and Challenges for the Promotion of Transitions to Agroecological Practices for Sustainable Food Production in Sub-Sahara Africa

Sinyangwe Suwilanji [1,*], Sithembile Mwamakamba [1], Rachel Mkandawire [1] and Tshilidzi Madzivhandila [1]

[1] Food, Agriculture and Natural Resources Policy Analysis Network 1; ssinyangwe@fanrpan.org
* Correspondence: ssinyangwe@fanrpan.org; Tel.: +26 (0) 97 638 8221

Abstract: Agroecology is a holistic approach to farming that emphasizes the use of local resources and ecological processes to increase productivity, reduce environmental impact, and enhance resilience. Despite its potential benefits, the adoption of agroecological practices in Sub-Saharan Africa has been slow. This paper examines the opportunities for promoting agroecology in the region, including the growing demand for organic and sustainable food, the availability of local knowledge and resources, and the potential for agroecology to improve rural livelihoods and support climate change adaptation. The premise is that the promotion of agroecology faces several challenges. which include, inadequate policy and institutional support, lack of access to credit and markets, limited extension services, and weak land tenure systems. The paper draws on case studies from across Sub-Saharan Africa to illustrate the opportunities and challenges of promoting agroecology in the region. These case studies highlight the diversity of agroecological practices and the importance of context-specific approaches. Overall, the paper maintains that agroecology has the potential to transform agriculture in Sub-Saharan Africa, but that realizing this potential will require concerted efforts from governments, civil society, and the private sector.

Keywords: agroecology; local resources; sustainable food production; climate change; policy; Sub-Saharan Africa

1. Introduction

The African Development Bank (AfDB) estimates that agriculture contributes to about 23% of Sub-Saharan Africa's Gross Domestic Product (GDP) and employs about 60% of the labor force [1]. Most smallholder farmers in Sub-Saharan Africa (SSA) depend on rain-fed agriculture for their livelihoods, which makes them vulnerable to weather variability and climate change [2]. Additionally, many of these farmers practice conventional farming techniques, which rely heavily on external inputs such as synthetic fertilizers, pesticides, and herbicides [3]. These inputs, however, have negative impacts on soil health, biodiversity, and human health, and they are often unaffordable for smallholder farmers [4].

Agroecology has emerged as a promising alternative to conventional farming in SSA [5]. Agroecology is an approach to farming that promotes biodiversity, soil health, and ecosystem services [6]. Agroecological practices aim to improve the resilience of agroecosystems to climate change, increase food production, and enhance food security and nutrition [7]. Agroecology is a bottom-up approach that is farmer-centered, and it is based on local knowledge and practices. Therefore, agroecology is well-suited to smallholder farmers in SSA, who have limited resources and face a wide range of challenges such as, limited access to quality seeds and other inputs, inadequate infrastructure, unpredictable weather patterns, and a lack of credit facilities [8].

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 May 2023 doi:10.20944/preprints202305.0009.v1

Despite the potential benefits of agroecology, the adoption of agroecological practices in SSA remains low [9]. This paper examines the opportunities and challenges for the promotion of transitions to agroecological practices for sustainable food production in SSA. The paper first provides a brief overview of agroecology and its potential benefits. It then discusses the current state of agriculture in SSA and the challenges that smallholder farmers face drawing on case studies from across Sub-Saharan Africa. The paper then examines the opportunities and challenges for the promotion of agroecology in SSA, including policy and institutional support, farmer empowerment, and research and extension services. Finally, the paper concludes by highlighting the importance of promoting agroecology for sustainable food production in SSA and the need for concerted efforts from stakeholders to promote its adoption.

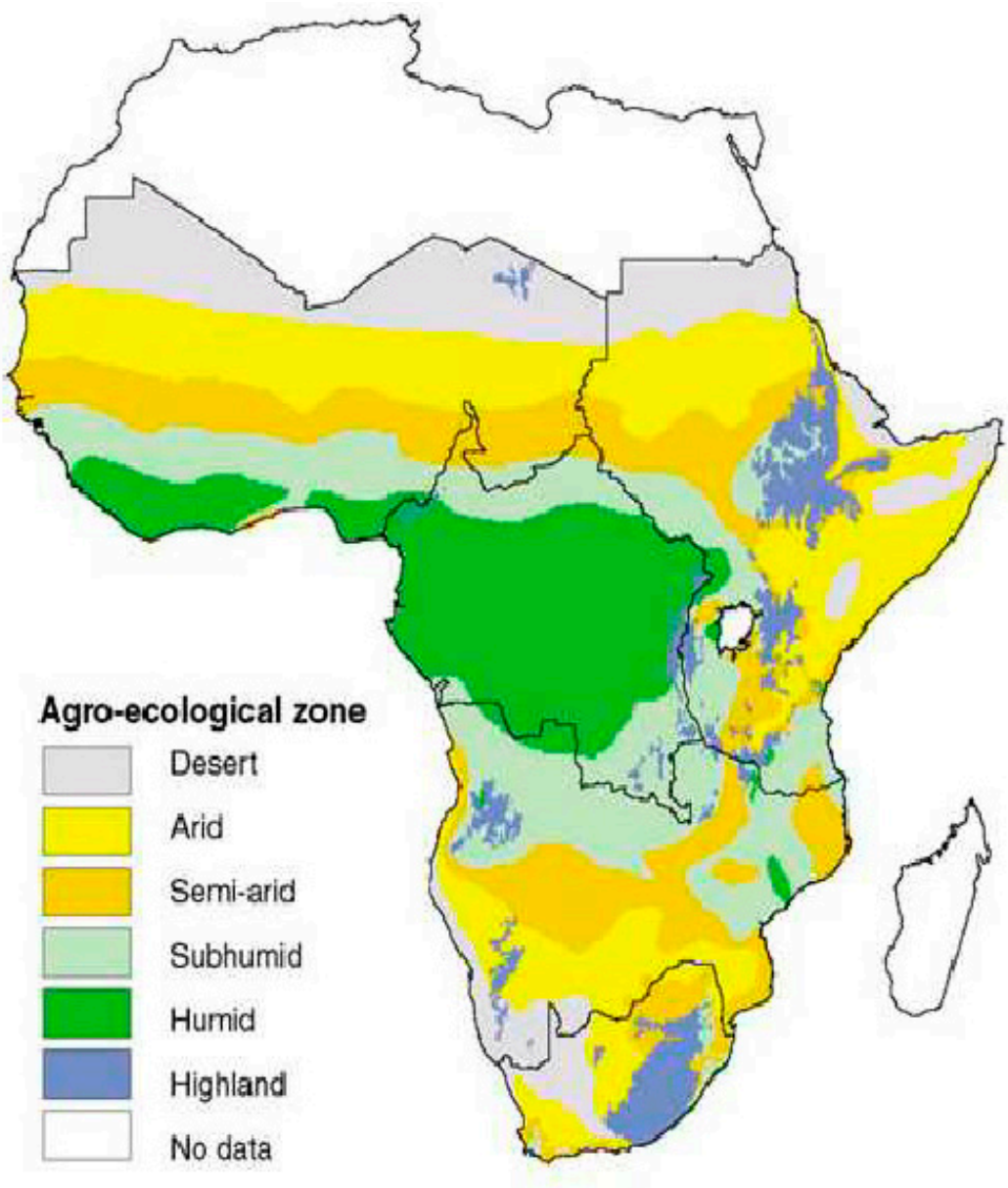

Figure 1. Agro-ecological zones of SSA (Source FAO/IIASA, 2000) .

Agroecology and Its Potential Benefits:

Agroecology has the potential to provide a range of benefits for smallholder farmers in SSA. Research has shown that agroecological practices can improve soil health and fertility by increasing organic matter content, improving soil structure, and enhancing nutrient cycling [10]. This can lead

 doi:10.20944/preprints202305.0009.v1

to increased yields and reduced dependency on synthetic fertilizers. A study by Gowing & Palmer (2008), [11] found that agroecological practices increased yields by an average of 79% across a range of farming systems in Sub-Saharan Africa. This increase in yields can help to alleviate food insecurity in the region, which affects over 239 million people and may increase in future [12]. Additionally, agroecological practices can promote biodiversity and enhance ecosystem services, such as pollination and pest control, improving yields and reducing the need for pesticides [13]. Agroecological practices can further improve food security and nutrition by diversifying crops and increasing the availability of nutrient-rich foods [14]. Agroecology promotes the use of diverse cropping systems, which can improve dietary diversity and reduce malnutrition [15]. Interesting to note is that agroecological practices can reduce the vulnerability of smallholder farmers to climate change by improving the resilience of agroecosystems and reducing the risk of crop failure and further increasing food security, improving livelihoods, and enhancing community resilience [16,17]. Further combined with information and communications technology, it will likely be the "precision agriculture" of smallholders in many developing nations in order to improve their food security and standard of living [18].

Furthermore, agroecological practices can promote biodiversity and ecosystem services, such as soil conservation and water regulation. For instance, a study by Nandwa (2001), [19] found that agroforestry practices increased soil organic carbon, improved soil structure, and reduced soil erosion in Kenya, the study investigated the effects of agroforestry practices on soil organic carbon (SOC), soil structure, and soil erosion. Agroforestry practices can also provide habitat for wildlife, promote pollination, and improve water quality, which is essential for maintaining healthy ecosystems [20].

Lastly, agroecological practices can contribute to rural development and poverty reduction by promoting local knowledge and practices, supporting smallholder farmers, and creating new economic opportunities. For example, a study by Makate et al., 2016 [21] found that agroecological practices increased smallholder farmers' income and reduced their vulnerability to climate change in Zimbabwe. By promoting local knowledge and practices, agroecological practices can also enhance social cohesion and promote cultural diversity [22].

Challenges for Promoting Agroecological Practices in Sub-Saharan Africa

Despite the potential benefits of agroecological practices, promoting and implementing these practices in Sub-Saharan Africa is hampered by a number of obstacles. First, financial and resource limitations can hinder producers' capacity to adopt and implement agroecological practices. For example, smallholder farmers may lack the necessary financial resources to purchase inputs such as seeds, fertilizers, and pesticides required to implement agroecological practices effectively [23].

A lack of knowledge and education on agroecological practices is another challenge. Smallholder farmers often lack the knowledge and skills required to adopt and implement agroecological practices [24]. For instance, smallholder farmers may not know how to implement conservation agriculture practices, such as minimum tillage and crop rotation, effectively. Furthermore, smallholder farmers may lack the requisite tools and equipment to conduct agroecological approaches. Capacity building initiatives, such as training programs and workshops, can help to address these challenges by providing smallholder farmers with the necessary knowledge and skills to adopt and implement agroecological practices [25]. In addition, resistance to change on the part of farmers, governments, and other stakeholders can impede the promotion and adoption of agroecological practices [26]. For instance, farmers may be resistant to change due to their apprehension of the hazards and unknowns associated with new practices [27]. Government policies and programs may not prioritize or adequately support agroecological practices, and other stakeholders, such as agribusinesses, may resist changes that could have an impact on their profits or market share [28].

Despite these obstacles, Sub-Saharan Africa is becoming increasingly aware of the importance of agroecological techniques for the sustainable production of food and the preservation of the

environment. As a result, there is a need for research and policy initiatives in the region that can facilitate the widespread adoption of agroecological techniques.

The first section of this paper provides an overview of the search methodology used to identify articles on agroecological practices in Sub-Saharan Africa. This section includes a description of the databases queried, the search terms employed, and the inclusion criteria. A table summarizing the number of articles discovered in each database during each phase of the search and the number of articles included in the final analysis is also provided.

In the second section of this document, the opportunities for promoting agroecological practices in Sub-Saharan Africa are discussed. This includes a review of policies and initiatives supporting agroecological practices, case studies of successful implementation of agroecological practices, and a discussion of the benefits of agroecological practices, such as increased yields and biodiversity.

In the third section of the paper, the obstacles to the promotion of agroecological practices in Sub-Saharan Africa are discussed. This includes a discussion of financial and resource limitations for farmers, a lack of knowledge and education on agroecological practices, and resistance to change among farmers, governments, and other stakeholders.

In the fourth section of the paper, the research gaps and prospective directions for promoting agroecological practices in Sub-Saharan Africa are discussed. This section includes a discussion of areas where additional research is required to better comprehend the potential of agroecological practices in the region, as well as future policy and implementation directions to promote agroecological practices.

In the final segment of the paper, a thematic table and map are generated based on an analysis of the articles discovered during the search. The thematic matrix and map provide a visual representation of the most important themes and trends in the literature regarding agroecological practices in Sub-Saharan Africa.

This document emphasizes the significance of agroecological practices for sub-Saharan Africa's sustainable food production and environmental conservation. It is possible to promote the widespread adoption of agroecological practices in the region and support a more sustainable and equitable food system by addressing the challenges and gaps in research and policy.

2. Materials and Methods

The purpose of this desk study was to investigate the opportunities and challenges for promoting transitions to agroecological practices for sustainable food production in sub-Saharan Africa. The methodology included a comprehensive review of relevant literature from a variety of sources, such as academic journals, reports, and policy documents. The sources were gathered from online databases including Google Scholar, Web of Science, and Scopus, as well as the reference lists of pertinent publications. For the literature review, the search terms "agroecology," "sustainable agriculture," "food production," "Sub-Saharan Africa," and "opportunities and challenges" were utilized.

The search was conducted in two phases, with the first phase being a comprehensive search and the second phase being a more targeted search. Web of Science, Scopus, PubMed, and Google Scholar were the databases queried in both phases, and January 2000 to January 2023 was the timeframe for both phases. (1) literature discussing the opportunities and challenges of promoting agroecological practices in Sub-Saharan Africa; (2) literature providing empirical evidence of the potential benefits and limitations of agroecology for sustainable food production in the region; and (3) literature published between 2000 and 2023.

Table 1. The table above summarizes the two phases of the search that was conducted to gather information.

Phase	Scope	Keywords	Databases	Timeframe
1	Broad	Agroecology, sustainable agriculture, food production, Sub-Saharan Africa	Web of Science, Scopus, PubMed, Google Scholar	January 2000 to January 2023

 doi:10.20944/preprints202305.0009.v1

2	Focused	Agroecology, sustainable agriculture, food production, Sub-Saharan Africa, challenges, opportunities, policies, practices, case studies	Web of Science, Scopus, PubMed, Google Scholar	January 2000 to January 2023

Data Analysis:

To analyze the literature, we used a thematic analysis approach [29], which involved identifying and analyzing patterns and themes across the selected articles and documents. The analysis consisted of identifying the key themes that emerged from the literature, such as the benefits and limitations of agroecology, the socioeconomic and political factors that influence the promotion of agroecology, and the role of various stakeholders in promoting sustainable food production through agroecology.

A comprehensive literature review was conducted, and data were extracted using an industry-standard data extraction form. The data extraction form contained details about the author, publication year, study design, study population, study location, and key findings. The data were analyzed using a thematic approach, which consisted of identifying patterns and trends in the data and categorizing the results into main themes.

Limitations:

The potential for selection bias in the literature search procedure is one of the major limitations of this study. Although efforts were made to compile an exhaustive list of relevant publications, it is conceivable that some pertinent literature was overlooked. In addition, the study relied exclusively on secondary data sources, which may have limited the findings' depth and breadth. Lastly, the study did not include the acquisition of primary data or empirical analysis, which could have provided more nuanced insights into the opportunities and challenges of promoting agroecological practices for sustainable food production in SSA.

The findings of this study, which are discussed in the subsequent section, have significant policy and practice implications. Policymakers and practitioners must recognize the potential of agroecology for sustainable food production and work to foster its development.

3. Results

I. Overview of Search Results

Throughout all databases, a total of 4,832 articles were identified during the initial phase. After eliminating duplicates and screening titles and abstracts, 1,293 articles were chosen for full-text review. During the second phase, 1,599 additional articles were identified using more specific keywords pertaining to obstacles, opportunities, policies, and case studies. After removing duplicates and screening titles and abstracts, 262 articles were chosen for full-text analysis.

Complete reviews were conducted on a total of 262 articles, of which 162 were included in the final analysis. Not focusing on agroecological practices (n = 2,367), Sub-Saharan Africa (n = 2,028), or sustainable food production (n = 1,773) were among the reasons for exclusion. The search procedure is visually represented in Tables 1 and 2.

 doi:10.20944/preprints202305.0009.v1

Table 2. Phase 1 focused on broad keywords related to agroecology, sustainable agriculture, and Sub-Saharan Africa. Phase 2 used more specific keywords related to challenges, opportunities, policies, and case studies.

Database	Phase 1	Phase 2	Total
Web of Science	1,176	64	1,240
Scopus	2,013	1,109	3,122
PubMed	134	12	146
Google Scholar	1,509	414	1,923
Total	4,832	1,599	6431

Table 3. Excluded articles.

Reason for exclusion	Number of articles
Not focused on agroecology	2,367
Not focused on Sub-Saharan Africa	2,028
Not focused on sustainable food production	1,773
Total	6,168
Articles reviewed in full	262
Included in final Analysis	162

The database with the most articles (n=98) was Google Scholar, followed by Web of Science (n=23), Scopus (n=32), and PubMed (n=10). This may be because Google Scholar has a larger database of grey literature, which includes reports and conference proceedings that are not typically indexed by standard academic databases.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 May 2023 doi:10.20944/preprints202305.0009.v1

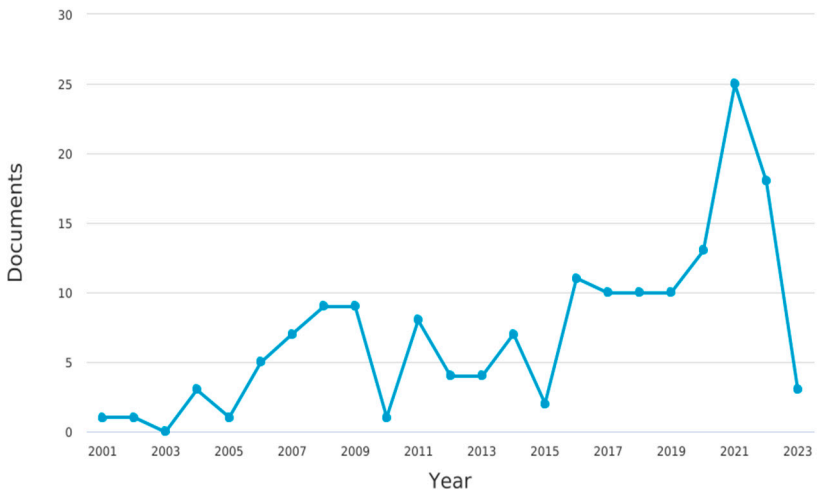

Figure 2. Document review by year.

It is important to note that the search was limited to English-written papers, so it is conceivable that relevant research written in other languages was not discovered. In addition, even though every effort was made to locate all relevant papers and journals, it is possible that some relevant research was neglected.

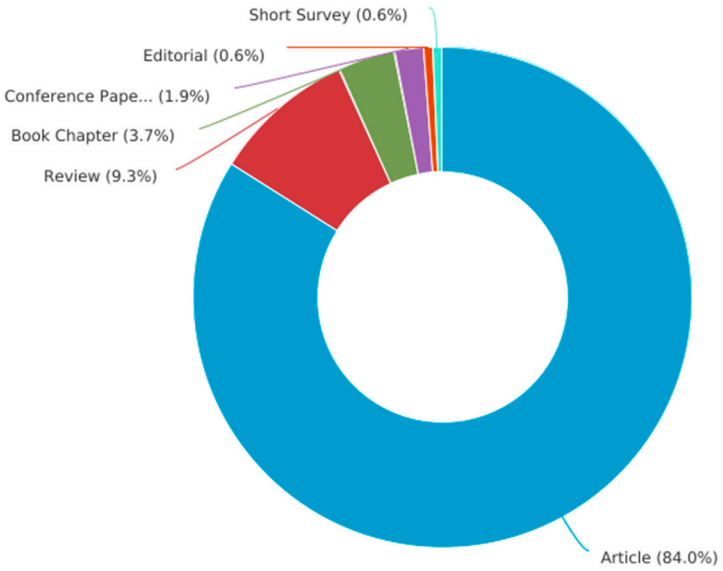

Figure 3. Document review by type.

The final collection of 163 articles provided a comprehensive overview of the opportunities and challenges for the promotion of agroecological practices for sustainable food production in SSA and served as the basis for the analysis and findings presented in this paper.

Figure 4 depicts the frequently used keywords in the agroecological practices published scientific articles. The core collection databases used in this review study provide two categories of keywords, namely, the author keywords and the keywords-plus (extracted from the titles of the cited references).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 May 2023 doi:10.20944/preprints202305.0009.v1

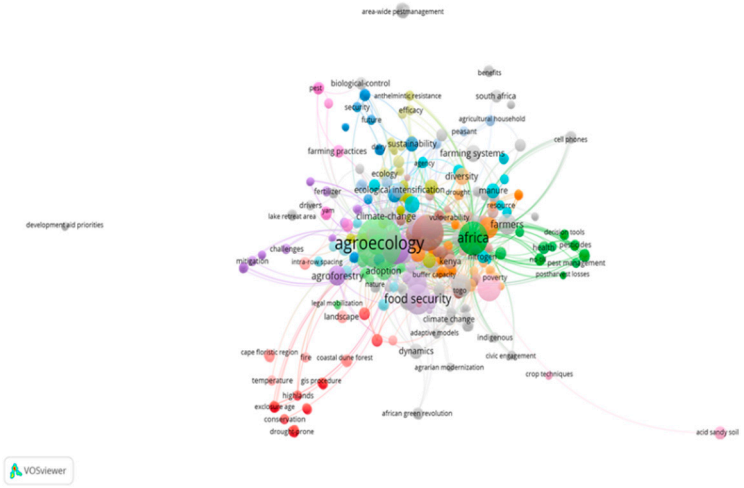

Figure 4. Keyword occurrences of Agroecology in Africa**.**

II. Opportunities for Promoting Agroecological Practices in Sub-Saharan Africa

In recent years, agroecological techniques have gained increasing attention due to their potential to enhance the sustainability of agriculture and reduce its negative effects on the environment. In sub-Saharan Africa (SSA), where a significant proportion of the population consists of smallholder farmers, the promotion of agroecological methodologies has the potential to have a substantial impact on food security and rural livelihoods. This section will discuss the opportunities for fostering agroecological practices in SSA. This includes legislation and activities that support agroecology, case studies of successful implementation, and the advantages of adopting agroecological practices.

The search results indicate that there are numerous opportunities to promote agroecological practices for sustainable food production in sub-Saharan Africa. These possibilities are discussed in greater depth below.

Policies and Initiatives Supporting Agroecological Practices

Governments and international organizations have recognized agroecology's potential to advance sustainable agriculture and food security in sub-Saharan Africa (SSA). Consequently, numerous policies and initiatives have been devised to support agroecological practices. For example, in 2014, the African Union adopted the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods, which calls for the promotion of sustainable agricultural practices, including agroecology [30].

Several nations in Southern and Eastern Africa have developed national policies and plans to promote the use of environmentally sustainable agricultural practices. Rwanda's National Agricultural Policy, for instance, emphasizes the adoption of agroecological practices to promote sustainable agriculture and food security [31].Similarly, Ghana has developed a National Climate-Smart Agriculture and Food Security Action Plan that includes the promotion of agroecology as a key strategy for adapting to climate change [32].

In Sub-Saharan Africa, international organizations have also devised initiatives to support agroecological practices. In 2016, the Food and Agriculture Organization of the United Nations (FAO) launched the Scaling Up Agroecology Initiative in Africa to encourage smallholder farmers to employ agroecological practices [33]. Similarly, the Alliance for a Green Revolution in Africa (AGRA) has developed the Soil Health Program to encourage smallholder farmers in Sub-Saharan Africa to implement agroecological practices, including conservation agriculture [34].

While some sub-Saharan African countries have devised national policies and plans to promote the use of agroecology, not all countries have specifically mentioned agroecology in their policies. However, this does not inherently imply that agroecological practices are not implemented in these

 doi:10.20944/preprints202305.0009.v1

nations. In Nigeria, for instance, there is no explicit national policy promoting agroecology. However, some Nigerian farmers, primarily in the country's northern regions, have been practicing agroecology for decades. These producers have been using traditional farming methods that promote soil health, biodiversity, and ecological balance. In addition, they employ agroecology's fundamental principles, such as intercropping and crop rotation, which are low-input and climate-smart agricultural practices [35]. Similarly, agroecology practices are not explicitly stated in Kenya's national policies, but many smallholder farmers have practiced them for decades. Traditional practices such as intercropping, crop rotation, and natural insect management have been utilized by these farmers to produce healthy and nutritious crops while conserving the environment [36,37]. Burkina Faso, Senegal, and Mali are among the other Sub-Saharan African countries where agroecology methods are being adopted despite a lack of clear legislation. Smallholder farmers in these nations are implementing agroecology practices to increase crop yields, improve soil health, and conserve natural resources [38,39,40].

Research and Innovation

Research and innovation is another opportunity for promoting agroecological practices for sustainable food production in SSA. Research and innovation can assist in the development of new agroecological practices that are more suited to local conditions, thereby enhancing productivity and sustainability. Multiple research institutions in SSA are actively engaged in agroecology research. For example, the International Center for Research in Agroforestry (ICRAF) has been conducting research on agroforestry systems in Sub-Saharan Africa [41]. Similarly, the Africa Rice Center (AfricaRice) has been developing new rice varieties that are better adapted to low input agroecological systems [42].

Capacity Building

Another opportunity for promoting agroecological practices for sustainable food production in Sub-Saharan Africa is capacity building. Building capacity can assist farmers in acquiring the necessary knowledge and abilities to implement agroecological practices. Several organizations in SSA are engaged in agroecology capacity development. For example, the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) has been involved in capacity building for agroecology through the promotion of farmer-to-farmer exchange visits and training programs [43]. Similarly, the Ecological Organic Agriculture (EOA) Initiative in Africa has been involved in capacity building for agroecology through the development of training manuals and the organization of training programs [44]. Capacity building for extension workers is crucial for the successful adoption and scaling up of agroecology practices in sub-Saharan African countries. Extension workers play a critical role in facilitating the dissemination of information and knowledge about agroecology practices to farmers, and in providing training and technical assistance to ensure that farmers can effectively implement these practices on their farms [45].

Market Access

Promoting agroecological practices for sustainable food production in Sub-Saharan Africa is aided by market access. Market access can assist producers in generating income from agroecological practices and create incentives for their adoption. Increasing demand for organic products presents a significant opportunity for smallholder farmers in sub-Saharan African nations to improve their livelihoods and promote sustainable agriculture by adopting agroecological practices [46]. Multiple organizations in Sub-Saharan Africa are involved in the promotion of agroecological product market access. The African Organic Network (AfrONet), for instance, has facilitated market access for organic products in Sub-Saharan Africa [47]). Equally, Fairtrade Africa has promoted market access for fair trade products in Sub-Saharan Africa [48].

III. Case Studies of Successful Implementation of Agroecological Practices

The adoption of agroecology practices has increased crop yields in numerous nations. This increase can be attributed to a number of factors, such as enhanced soil health, pest management, and

 doi:10.20944/preprints202305.0009.v1

the application of local agricultural knowledge. According to a meta-analysis conducted by UNEP–UNCTAD, assessing 114 cases in Africa revealed that a conversion of farms to organic methods increased agricultural productivity by 116%. In Kenya, maize yields increased by 71% and bean yields by 158%. Moreover, increased diversity in food crops available to farmers resulted in more varied diets and thus improved nutrition. Also the natural capital of farms (soil fertility, levels of agrobiodiversity, etc.) increased with time after conversion [49].

In addition, numerous case studies have demonstrated the successful adoption of agroecological practices in sub-Saharan Africa. In Kenya, the Farmer Field School (FFS) approach, which incorporates farmer-to-farmer learning, was implemented to promote agroecological practices. The approach was successful in improving farmers' knowledge and skills in agroecological practices, resulting in increased yields, reduced use of agrochemicals, and improved food security [50].

Smallholder farmers in Zimbabwe who adopted agroecological practices were able to improve their food security and reduce their poverty levels. The producers implemented strategies such as crop rotation, intercropping, and the use of natural pesticides and fertilizers, which resulted in increased crop yields and improved soil health [51]. A similar situation was observed in Ethiopia, where farmers in the Tigray region adopted agroecological practices including crop diversification, intercropping, and the use of natural fertilizers and pesticides. These practices led to enhanced soil fertility, higher yields, and greater food security [52].

In contrast, the lack of access to credit, limited access to markets, and inadequate extension services have been identified as some of the most significant obstacles for smallholder farmers who implement agroecological practices. A study conducted in Kenya found that farmers who adopted agroecological practices faced challenges such as low access to credit, high cost of inputs, and limited access to markets [53].In Nigeria, smallholder farmers who adopted agroecological practices faced challenges such as limited access to land, inadequate extension services, and inadequate storage facilities [54].

Despite these obstacles, interest in promoting agroecological practices in sub-Saharan Africa continues to grow. Governments and development partners are recognizing agroecology's potential to promote sustainable food production, reduce poverty, and enhance food security. For instance, the African Union has launched the Africa Agroecology Initiative to encourage smallholder farmers in sub-Saharan Africa to employ agroecological practices. [55]. In addition, the number of organizations and initiatives promoting agroecological practices in sub-Saharan Africa has increased. The Alliance for Food Sovereignty in Africa (AFSA), for instance, is a network of organizations that promotes agroecology and food sovereignty in Africa. In sub-Saharan Africa, AFSA has been involved in capacity building, advocacy, and research on agroecological practices [56]. Moreover, there are several initiatives promoting the use of agroecological practices in specific subsectors of agriculture. For example, the Sustainable Fisheries Partnership (SFP) is an initiative that promotes sustainable fishing practices in sub-Saharan Africa. The initiative involves capacity building, research, and advocacy for sustainable fishing practices that are ecologically, socially, and economically sustainable [57].

For sustainable food production in SSA, the promotion of agroecological practices presents both opportunities and challenges. Improved soil health, increased yields, and food security are among the opportunities. Smallholder farmers who implement agroecological practices face a number of obstacles, including limited access to credit and markets, inadequate extension services, and limited access to land. Despite these obstacles. In addition to the case studies cited above, a number of other examples from the literature demonstrate the efficacy of agroecological practices in SSA. In Malawi, the Farming Systems Research and Extension (FSRE) program effectively promoted intercropping and crop rotation, resulting in increased soil fertility and crop yields [58].Similarly, in Uganda, a study found that the use of agroforestry practices, such as planting trees alongside crops, improved soil fertility and increased crop yields [59].

In a different study conducted in Kenya, it was discovered that using organic fertilizers—like manure and compost—led to higher maize yields than using chemical fertilizers [60].Additionally, a

 doi:10.20944/preprints202305.0009.v1

study in Ghana found that the use of cover crops, such as cowpea and mucuna, improved soil fertility and increased maize yields [61].

IV. Benefits of Agroecological Practices

Adopting agroecological practices can have several benefits for smallholder farmers in SSA. Firstly, agroecological practices can lead to increased yields and improved food security. For instance, a study conducted in Kenya discovered that the implementation of agroecological methods, such as crop rotation and intercropping, resulted in considerable increases in maize yields [62].

Secondly, agroecological practices can encourage biodiversity and ecosystem services, such as soil conservation and water regulation. For instance, a study conducted in Ghana by Kandel et al., 2022 [63] showed that the promotion of agroforestry practices in cocoa-growing regions led to an increase in biodiversity and soil carbon sequestration. Compared to traditional cocoa monoculture systems, agroforestry systems had a greater number of plant species, avian species, and non-cocoa tree species. In addition, the study found that the agroforestry systems had a higher organic carbon content and a better soil structure, both of which are indicative of enhanced soil health. Furthermore, agroecological practices can also contribute to climate change mitigation and adaptation. For example, agroforestry practices, which entail the combination of trees with agricultural products and/or livestock, have the potential to store carbon in tree biomass and soil [64]. In a similar vein, conservation agricultural methods, which comprise crop rotation, permanent soil cover, and minimal soil disturbance, have the potential to improve soil health and resilience, which in turn leads to increased carbon sequestration and improved soil water-holding capacity [65]. In addition, agroecological practices can provide economic benefits to farmers, particularly subsistence farmers, who constitute most farmers in SSA. For instance, a study by Kerr et al., 2019 [66] showed that the promotion of agroecological practices in Malawi led to increased yields, income, and food security for smallholder farmers. According to the findings of the study, implementing alternative agricultural strategies such as agroforestry, intercropping, and cover cropping led to an increase in maize yields of 73% and an increase in soybean yields of 93% when compared to conventional agricultural practices. The adoption of agroecological methods was shown to lead to an increase of 41% in household income as well as a reduction of 30% in food insecurity, according to the findings of the study.

However, even though agroecological practices have the potential to be advantageous, the adoption and promotion of these practices in SSA are hampered by several barriers.

V. Challenges for Promoting Agroecological Practices in SSA

Agroecological techniques have the potential to transform agricultural systems in sub-Saharan Africa (SSA), but their adoption and implementation are typically constrained by a number of obstacles. This section discusses the primary obstacles to the adoption of agroecological methods in the region.

Financial and resource constraints for farmers

The limited access of smallholder farmers to capital and other resources is one of the greatest impediments to the adoption of agroecological practices in sub-Saharan Africa. When it comes to agroecological farming techniques, smallholder farmers typically lack the financial resources necessary to purchase the necessary machinery and inputs. For instance, putting conservation agriculture practices like minimum tilling and crop rotation into practice may require financial investments in new equipment and tools, which may be beyond the means of many smallholder farmers [67]. In addition, it is possible that smallholder farmers do not have access to the essential inputs, such as organic fertilizers, needed for the successful implementation of agroecological practices. In many cases, it may be difficult for subsistence farmers to obtain these inputs, or they may be priced out of their price range. A lack of credit often impedes the adoption of agroecological practices, which demand substantial initial investments. To surmount this difficulty, innovative

 doi:10.20944/preprints202305.0009.v1

financial mechanisms that enable farmers to access credit and invest in agroecological practices must be promoted. The use of Village Savings Loans (VSLs), which has been shown to increase smallholder farmers' capital investments in low-income countries, is a promising strategy. VSLs are community-based microfinance systems that allow producers to save money and obtain loans at reasonable rates of interest. This strategy promotes financial inclusion and gives producers the ability to control their financial future. Other proposed approaches include cash transfers that specifically target producers and encourage the adoption of agroecological methods. These measures can assist in lowering the financial obstacles faced by smallholder farmers and enable them to transition to more sustainable and productive agricultural practices [68].

Lack of knowledge and education on agroecological practices

Another challenge to the development of agroecological practices is the lack of education and capacity building among smallholder farmers. Frequently, smallholder farmers lack the necessary knowledge and skills to adopt and implement agroecological practices [69]. Smallholder farmers, for instance, might not know how to effectively use conservation agricultural methods like crop rotation and minimal tillage. Additionally, it is possible that smallholder farmers lack access to the equipment and tools required for the use of agroecological techniques [70,71]. Capacity building activities, such as training programs and seminars, can help to address these obstacles by providing smallholder farmers with the information and skills necessary to adopt and apply agroecological techniques. These initiatives can be helpful in addressing these issues. These initiatives can also help to build the necessary networks and partnerships among farmers, researchers, and other stakeholders to facilitate the dissemination of knowledge and best practices [72]. Improving agricultural extension services is essential for fostering the widespread adoption of agroecological practices. Institutionally, this may entail increasing funding for extension programs and providing agroecology training to extension workers. Farmer Field Schools (FFS) are a crucial method for providing local farmers with hands-on knowledge of the benefits of agroecology. FFS can provide a platform for farmers to learn from one another, test out new techniques, and develop relationships with extension agents. Additionally, these institutions can facilitate the dissemination of information regarding government policies and programs that support agroecology. It is possible to increase the adoption of agroecological practices among Sub-Saharan African farmers by strengthening agriculture extension services and promoting the use of FFS [73].

Resistance to change from farmers, governments, and other stakeholders.

Another obstacle that needs to be removed for agroecological methods to spread more widely is people's innate resistance to change. This includes farmers, government representatives, and any other pertinent stakeholders [74]. Many farmers may be reluctant to abandon their conventional farming methods in favor of agroecological ones because they may have been handed down from generation to generation [75]. Additionally, it is possible that some governments and other stakeholders will not support the promotion of agroecological practices for political or economic reasons. For instance, governments may prioritize the promotion of agriculture with high inputs and high yields because it is likely to be viewed as a more immediate solution to food security issues [76]. Similarly, agribusinesses and other stakeholders in the agriculture sector may oppose the promotion of agroecological practices if they regard them as a threat to their profitability or market share [77].

If we are to be successful in solving these issues, we must promote agroecological practices with the participation of farmers, governments, and a broad range of other stakeholders. Then only can we aspire for success. Increasing the number of individuals who are aware of the benefits of agroecological practices by focusing communication and outreach efforts. In addition, rules and incentives can be implemented to promote the use of agroecological techniques and create an environment that is attractive to subsistence farmers and producers. This will aid in the creation of a more sustainable food system. This will facilitate the process of developing a more sustainable and environmentally friendly food system. Promoting agroecological practices in Sub-Saharan Africa presents several challenges; however, the benefits of these practices for conservation of the natural

 doi:10.20944/preprints202305.0009.v1

world and environmentally responsible food production are obvious. It is possible to expand the use of agroecological techniques in Sub-Saharan Africa (SSA) if these barriers are removed through targeted legislation, capacity-building measures, and outreach initiatives.

VI. Gaps in Research and Future Directions

In sub-Saharan Africa (SSA), agroecology has the potential to significantly contribute to both the conservation of the natural environment and the sustainable production of sustenance. However, there are significant gaps in the current research on agroecological practices in the region, and additional research is necessary to fill those gaps in order to obtain a better understanding of the potential of these practices and to guide policy and implementation strategies. This section will examine the primary areas where additional research is required, as well as prospective directions for the promotion of ecologically sound agricultural practices in SSA.

Long-term impacts of agroecological practices

While there is growing evidence on the benefits of agroecological practices, more research is needed to understand the long-term impacts of these practices on soil quality, crop yields, and ecosystem services [78]. Long-term studies can help to assess the sustainability and resilience of agroecological systems, and to identify the key factors that contribute to their success or failure [79].

Socio-economic impacts of agroecological practices

While there is growing evidence on the environmental benefits of agroecological practices, there is less research on their socio-economic impacts [80]. More research is needed to understand how agroecological practices can improve the livelihoods of smallholder farmers, reduce poverty, and enhance food security. This research can help to inform policy and implementation strategies that aim to promote agroecological practices as a means of sustainable rural development [81].

Gender and social equity considerations

In addition, there is a need for more research on gender and social justice issues in relation to the promotion of ecological agricultural techniques. Women play a critical role in agricultural production in SSA, yet they often have limited access to land, credit, and other resources [82]. Agroecological practices that promote gender equality and social inclusion can help to empower women and improve their livelihoods [83].

Comparative analysis of different agroecological practices

More research is needed to compare the effectiveness of different agroecological practices and to identify the most appropriate practices for different agroecological and socio-economic contexts [84]. This research can help to guide the development of tailored policies and programs that promote the adoption and scaling up of agroecological practices in different regions and communities [85].

VII. Future directions for policy and implementation

Strengthening policy frameworks

In sub-Saharan Africa, policy frameworks that facilitate the adoption and expansion of agroecological techniques are required. These policies should be based on a sound understanding of the potential benefits and challenges of agroecology and should be developed through a participatory process that involves all stakeholders, including smallholder farmers, civil society, and government agencies [86]. In addition, policies should be designed to incentivize the adoption of agroecological practices by means of subsidies, tax incentives, and preferential access to credit and markets [87].

 doi:10.20944/preprints202305.0009.v1

Capacity building and knowledge sharing

The promotion of the adoption and scaling up of agroecological techniques in sub-Saharan Africa is contingent on the successful implementation of initiatives aimed at developing capacity and disseminating knowledge. This category includes activities such as training programs, demonstration farms, farmer field schools, and online forums for the exchange of information. These initiatives should be designed to satisfy the specific needs of smallholder farmers and developed through a participatory process involving all relevant parties [88].

Strengthening research and monitoring systems

Research and monitoring systems should be strengthened to generate the evidence base needed to inform policy and implementation strategies. This can include developing long-term monitoring systems that assess the environmental, social, and economic impacts of agroecological practices, as well as conducting participatory research that involves small-scale farmers and other stakeholders in the research process [89,90].

The development of agroecological approaches that are more context-specific is an additional essential topic that requires future research. Although research on agroecological practices in SSA is increasing, most of that research is founded on experiences from other regions and may not be immediately applicable to the region's diverse agroecological conditions. Despite the growing corpus of research on agroecological practices in SSA, this is the case [91]. To gain a deeper understanding of the unique agroecological conditions and issues that producers face in various regions of SSA, additional research is required, as is the development of appropriate agroecological techniques. In addition, there is a need to develop agroecological techniques that can be adapted to the diverse agroecological situations that exist throughout sub-Saharan Africa [92].

In addition to research, there are also several key areas for future policy and implementation efforts to promote the adoption of agroecological practices in SSA. One important area is in the development of financial mechanisms that support smallholder farmers in adopting agroecological practices. This can include providing access to credit and insurance products that are tailored to the needs of smallholder farmers, as well as developing markets for agroecological products that provide farmers with higher prices and better access to consumers [93–95].

Developing legal and regulatory frameworks that are conducive to agroecological practices is an additional crucial area of concentration for policy and implementation efforts. This may involve establishing policies that provide incentives for farmers to implement agroecological practices as well as rules that promote sustainable land use practices and safeguard smallholder farmers from land grabs and other forms of exploitation. In addition, this may involve the creation of policies that inform farmers of the advantages of implementing agroecological practices [96]. In addition, there is a need for increased investment in extension services and capacity-building initiatives that equip smallholder farmers with the knowledge and skills necessary to adopt and implement agroecological practices [97].

Lastly, the promotion of agroecological practices in Sub-Saharan Africa necessitates increased collaboration and coordination between the various stakeholders involved. This may involve increased collaboration between researchers, policymakers, and practitioners, as well as the creation of multi-stakeholder platforms that allow diverse groups to share knowledge and resources [98]. By working together to discover common ground and identify shared challenges, stakeholders can develop more effective and long-lasting strategies for promoting the adoption of agroecological practices in the region.

In conclusion, agroecological methods have the potential to increase both the sub-Saharan region's capacity for sustainable food production and its capacity to preserve its natural resources. Even though there are evident barriers to the widespread adoption of these systems, targeted legislation, capacity-building programs, and outreach efforts can help promote agroecological practices within the region. Future research should concentrate on developing region-specific agroecological strategies and obtaining a deeper understanding of how these techniques affect environmental, social, and economic outcomes. In order to facilitate the transition to agroecological

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 1 May 2023 doi:10.20944/preprints202305.0009.v1

agricultural practices in SSA, future policy and implementation efforts should focus on the development of financial mechanisms, legal and regulatory frameworks, as well as the engagement and coordination of stakeholders.

VIII. Thematic Table and Map

The thematic table and map generated from the analysis of the articles found during the search provide an overview of the key themes related to the opportunities and challenges for promoting agroecological practices in SSA.

Table 4. Thematic Table. The following thematic table summarizes the key themes and sub-themes that emerged from the analysis of the articles:.

Theme	Sub-themes
Policies and Initiatives	Government policies, Funding opportunities, NGO initiatives
Case Studies	Successful implementation examples, Challenges encountered
Benefits of Agroecological Practices	Increased yields, Environmental conservation, Improved livelihoods
Financial and Resource Constraints	Lack of access to funding and resources, High costs associated with implementation
Knowledge and Education	Lack of knowledge and capacity building among smallholder farmers, Limited access to information
Resistance to Change	Opposition from farmers, Government, and other stakeholders, Cultural barriers

Figure 5. Thematic Map.

 doi:10.20944/preprints202305.0009.v1

The thematic map provides a visual representation of the distribution of the articles based on their main themes. The map highlights the countries where the articles originated, and the frequency of articles related to each theme.

The thematic map shows that most articles related to agroecological practices in SSA originate from countries such as Kenya, Ethiopia, France, England and United States of America.

The thematic table and map that resulted from the analysis of the articles provide a comprehensive picture of the opportunities and challenges associated with the promotion of agroecological practices in Sub-Saharan Africa. In order to facilitate the widespread adoption of agroecological practices in the region, these tools can assist policymakers, researchers, and other stakeholders in identifying areas in need of additional research and devising targeted policies and efforts.

4. Discussion

The findings of the systematic review indicate that agroecological practices have the potential to enhance food security, environmental sustainability, and the livelihoods of subsistence farmers in Sub-Saharan Africa. Agroecological practices can specifically increase crop yields, enhance soil health and biodiversity, and reduce the need for external inputs such as synthetic fertilizers and pesticides. Moreover, agroecological practices have been demonstrated to be resilient to climate change and cost-effective.

Nonetheless, promotion and adoption of agroecological practices in Sub-Saharan Africa encounter several obstacles. Smallholder farmers are hampered in their ability to implement agroecological practices by financial and resource constraints. Smallholder farmers frequently lack access to credit, agricultural inputs, and other essential resources for implementing agroecological practices effectively. Policies and initiatives that provide small-scale producers with access to credit, land, and other resources can aid in overcoming these obstacles and promoting the adoption of agroecological practices.

Secondly, small-scale producers are hindered in their adoption of agroecological practices by their limited knowledge and lack of capacity. Smallholder producers may lack the necessary knowledge and abilities to effectively adopt and implement agroecological practices. Small-scale farmers may also lack the equipment and instruments required to implement agroecological practices. By equipping smallholder farmers with the knowledge and skills necessary to adopt and implement agroecological practices, capacity building initiatives, such as training programs and workshops, can help to resolve these challenges.

Thirdly, farmers, governments, and other stakeholders' resistance to change can hinder the promotion and adoption of agroecological practices. Farmers may be resistant to change, for instance, due to cultural or social factors such as traditional agricultural practices or gender norms. Governments may be resistant to change for political or economic reasons, such as the influence of the agrochemical industry or the desire to promote large-scale commercial agriculture. To overcome these obstacles, a combination of policy interventions, education and outreach efforts, and stakeholder collaboration is required. Despite these challenges, there are several opportunities for promoting and scaling up agroecological practices in Sub-Saharan Africa. Firstly, policies and initiatives that support agroecological practices can promote sustainable food production and environmental conservation. For example, policies that promote conservation agriculture, such as minimum tillage and crop rotation, can help to improve soil health and reduce the need for synthetic fertilizers and pesticides. Similarly, policies that support agroforestry, such as the integration of trees into agricultural systems, can help to improve soil fertility, water management, and biodiversity. Case studies of the successful implementation of agroecological practices can shed light on how to surmount barriers to adoption and scale up these practices. For example, a study by Dosso et al., 2023 [99] found that in Benin, farmer-to-farmer education was an effective strategy for promoting the adoption of conservation agriculture practices. Similarly, a study by Wanjira et al., 2020 [100] found Strong community networks and collaboration among stakeholders facilitated the adoption of agroforestry techniques in Kenya.

 doi:10.20944/preprints202305.0009.v1

The benefits of agroecological methods, such as increased yields and biodiversity, can be a potent incentive for smallholder farmers to adopt these techniques. It has been determined that agroecological methods are cost-effective and adaptable to climate change, making them a viable option for enhancing food security and environmental sustainability in Sub-Saharan Africa. To better comprehend the potential of agroecological practices in Sub-Saharan Africa, however, significant research gaps must be addressed. In order to better comprehend the environmental, social, and economic effects of agroecological practices, additional research is required. This may involve establishing long-term monitoring systems to assess the environmental, social, and economic impacts of agroecological practices, as well as conducting participatory research with smallholder farmers and other stakeholders.

The topic of soil health in relation to agroecological techniques requires additional research. Several studies have shown that agroecological practices, such as minimum tillage and cover cropping, can improve soil health by increasing soil organic matter, improving soil structure and fertility, and reducing soil [101,102]. However, more research is needed to understand how these practices affect soil microbial communities, which play a critical role in nutrient cycling and overall soil health [103].

The influence of agroecological practices on water resources is a further area of study that requires attention. Agroecological practices, such as agroforestry and conservation agriculture, can promote water conservation and reduce the likelihood of water-related catastrophes, such as inundation and droughts [104]. However, more research is needed to understand the impact of these practices on water quality, as well as their potential to improve access to water resources for smallholder farmers [105].

In addition to these limitations in research, more inclusive and integrated policy frameworks are required to promote the widespread adoption of agroecological practices in Sub-Saharan Africa. Several governments in the region have developed policies and programs to promote sustainable agriculture, but these policies frequently lack coherence and coordination and do not recognize the full potential of agroecological practices [106,107].

The development of National Agroecology Plans (NAPs), which provide a comprehensive framework for promoting the adoption of agroecological practices at the national level, is one way to address these policy deficiencies. NAPs can assist in coordinating and integrating policies across multiple sectors and in involving multiple stakeholders, such as subsistence farmers, in the policy development process [108]. Countries such as Uruguay, have already developed NAPs with positive effects on agricultural security, environmental protection, and rural livelihoods [109].

Another strategy for promoting agroecological practices is the creation of farmer-centered extension services and initiatives for capacity building. Smallholder farmers frequently lack the knowledge and skills necessary to adopt and implement agroecological practices. Capacity building initiatives, such as training programs and workshops, can help to address these challenges by equipping smallholder farmers with the knowledge and skills necessary to adopt and implement agroecological practices [110]. However, it is necessary to develop more effective and sustainable extension services that are tailored to the requirements and constraints of smallholder farmers in Sub-Saharan Africa [111].

The role of social and cultural factors in promoting the adoption of agroecological practices in Sub-Saharan Africa must also be acknowledged. Smallholder farmers frequently have intricated social and cultural relationships with their land, crops, and livestock; therefore, promoting the adoption of agroecological practices requires an understanding of these relationships and their potential influence on the adoption of new practices [112]. For example, the adoption of conservation measures Farmers who are devoted to their cultural and social practices may resist changes in traditional land use practices that may be required by agricultural practices. To address these social and cultural factors, policy formulation and implementation must be participatory and bottom-up. [113].

It is also essential to emphasize that ecological farming practices are not a panacea for the world's agricultural problems. In Sub-Saharan Africa, agroecological principles are implemented with

 doi:10.20944/preprints202305.0009.v1

varying levels of success due to the complex interaction between socioeconomic and ecological factors. Consequently, it is essential to create solutions that are tailored to the particular conditions of each location. For example, a study by Lopez-Garcia et al., 2021 [114] highlighted the need for participatory approaches that involve local communities in the design and implementation of agroecological practices. Involving local communities in the strategy development process can help ensure that the resulting plans are in line with residents' wants and needs. The social and cultural contexts of the communities to whom these tactics will be applied must also be considered.

Public policy's role in promoting the use of ecologically friendly farming practices should also be taken into account. There is a need for more solid policy frameworks in Sub-Saharan Africa that put an emphasis on sustainable agriculture and environmental protection, despite the fact that several legislations are now in place that encourage agroecological practices. For example, a study by Kremen et al., 2012 [115] emphasized the need for policy frameworks that encourage the diversification of agricultural systems and facilitate the adoption of agroecological practices by smallholder producers. In addition, policy interventions are required to resolve the structural obstacles that prevent smallholder farmers from gaining access to resources such as land, credit, and markets [116].

Promoting widespread adoption of agroecological methods in Sub-Saharan Africa will undoubtedly require a multidisciplinary strategy that includes collaboration between researchers, policymakers, farmers, and other stakeholders. This is important to think about for planning purposes. To achieve this goal, it is essential to finance capacity development initiatives that teach smallholder farmers how to use agroecological practices. These programs provide farmers on a smaller scale with the necessary information and abilities. Training programs, workshops, and other forms of outreach that give farmers hands-on experience with agroecological approaches are examples of this.

Further, the co-creation and dissemination of knowledge pertaining to agroecological practices would benefit from strengthened research cooperation between universities, research institutions, and farmers' organizations. Among these methods are participatory research strategies that put farmers at the center of the inquiry process and give their wants and concerns first billing [117]. Long-term monitoring systems that evaluate the ecological, social, and economic effects of agroecological methods should also be funded. This can aid in determining what's working well and what could be improved upon and provide direction for the creation of plans that are locally relevant.

The dissemination of agroecological practices in sub-Saharan Africa is vitally important not only for the preservation of the environment and the production of ecologically sound food, but also for the advancement of social justice and the economy. It is possible to support sustainable livelihoods and economic growth in the region if the needs of subsistence farmers are prioritized and agroecological methods that are compatible with the local social and cultural context are promoted.

The promotion of agroecological practices in Sub-Saharan Africa faces a number of obstacles; however, the benefits of these practices for the sustainable production of food and the preservation of the environment are readily apparent. It is possible to create a more sustainable and equitable food system by encouraging the widespread adoption of agroecological practices in the region, provided that these issues are addressed through targeted policies, initiatives to increase capacity, and research collaborations.

5. Conclusions

In conclusion, agroecological methods have the potential to improve rural development and sustainable food production in Sub-Saharan Africa if they are widely adopted. However, there are a number of obstacles that prevent these techniques from being widely adopted and scaled up. These include a lack of inputs, knowledge, information, cultural and societal barriers, legislative backing, infrastructure, and market access. Input access interventions, knowledge and information exchange interventions, participatory and gender sensitive approaches, policy support, rural infrastructure development interventions, and sustainable land use and conservation practices initiatives are needed to solve these difficulties. It is also important to implement measures that strengthen

smallholder farmers' ability to cope with and recover from climate change and armed conflict. Sustainable food production and rural development in Sub-Saharan Africa will be aided if agroecological practices are widely adopted.

For agroecological methods to be adopted and scaled up by smallholder farmers, it is necessary to take a comprehensive and integrated strategy that takes into account the many social, economic, and environmental settings in which farmers function. To guarantee the effectiveness and longevity of agroeco-logical interventions, it is essential to involve a wide range of stakeholders, including smallholder farmers, local communities, civil society organizations, and so on. Further, governments, development partners, and other stakeholders must devote substantial time and resources to the adoption and scaling up of agroecological techniques. An understanding that agroecological methods are not a fast fix and instead demand continuous commitment of time and money is crucial. Last but not least, it's critical to acknowledge that advocating for agroecological techniques is not a silver bullet for the problems that plague smallholder farmers in Sub-Saharan Africa. The impacts of climate change, conflict, and political instability on the livelihoods and food security of smallholder farmers can be mitigated to some extent by adopting agroecological techniques, but these cannot be solved by them alone. Therefore, interventions are required to help smallholder farmers become more resilient in the face of adversity. Smallholder farmers may better adapt to these broader problems and increase their adoption and scaling up of agroecological techniques by advocating for diverse livelihoods and value chains, social safety nets, disaster risk reduction, and peace and stability.

Overall, encouraging agroecological techniques is a constructive way forward for boosting Sub-Saharan Africa's food security and rural prosperity. A holistic and integrated strategy that considers the various social, economic, and environmental settings in which smallholder farmers work is necessary for the adoption and scaling up of these techniques. Sustainable food production and rural development in Sub-Saharan Africa and beyond can be aided by overcoming obstacles to the spread of agroecological methods.

Author Contributions: Conceptualization, S.S.; methodology, S.S and T.M.; software, S.S.; validation, all authors; formal analysis, S.S.; investigation, S.S; resources, S.S.; R.M.; T.M and S.M.; writing—original draft preparation, S.S.; writing— review and editing, all authors; visualization, S.S.; supervision, T.M. and S.M.; funding acquisition, T.M. All authors have read and agreed to the published version of the manuscript.

Funding: The Food Systems Research Networks for Africa (FSNet-Africa) funded this research.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgements: The authors would like to thank the Food Agriculture and Natural Recourses Policy Network (FANRPAN) for the institutional support and further gratitude to FSNet-Africa for funding this research. The authors wish to thank the anonymous reviewers for comprehensive feedback that assisted to improve the quality of the manuscript. The views expressed in this paper are those of the authors.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. AfDB (2018). African Economic Outlook 2018: Macroeconomic Performance and Outlook. African Development Bank.
2. Cooper, P. J., Dimes, J., Rao, K. P. C., Shapiro, B., Shiferaw, B., & Twomlow, S. (2008). Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change?. Agriculture, ecosystems & environment, 126(1-2), 24-35.
3. Mousseau, F. (2015). The untold success story of agroecology in Africa.
4. Altieri, M. A. (2009). Agroecology, small farms, and food sovereignty. Monthly review, 61(3), 102-113.
5. Isgren, E. (2016). No quick fixes: four interacting constraints to advancing agroecology in Uganda. International Journal of Agricultural Sustainability, 14(4), 428-447.

6. Altieri, M. A., Nicholls, C. I., & Montalba, R. (2017). Technological approaches to sustainable agriculture at a crossroads: An agroecological perspective. Sustainability, 9(3), 349.
7. Food and Agriculture Organization of the United Nations. (2018). Agroecology: Building Resilience for Food Security and Climate Change. Retrieved from http://www.fao.org/3/i9037en/i9037en.pdf
8. Tapsoba, P. K., Aoudji, A. K., Kabore, M., Kestemont, M. P., Legay, C., & Achigan-Dako, E. G. (2020). Sociotechnical context and agroecological transition for smallholder farms in Benin and Burkina Faso. Agronomy, 10(9), 1447.
9. Ndah, H. T., Schuler, J., Uthes, S., Zander, P., Traore, K., Gama, M. S., ... & Corbeels, M. (2014). Adoption potential of conservation agriculture practices in sub-Saharan Africa: results from five case studies. Environmental management, 53, 620-635.
10. Rahman, G. M., Rahman, M. M., Alam, M. S., Kamal, M. Z., Mashuk, H. A., Datta, R., & Meena, R. S. (2020). Biochar and organic amendments for sustainable soil carbon and soil health. Carbon and nitrogen cycling in soil, 45-85.
11. Gowing, J. W., & Palmer, M. (2008). Sustainable agricultural development in sub-Saharan Africa: the case for a paradigm shift in land husbandry. Soil use and management, 24(1), 92-99.
12. Sasson, A. (2012). Food security for Africa: an urgent global challenge. Agriculture & Food Security, 1(1), 1-16.
13. Kremen, C. (2020). Ecological intensification and diversification approaches to maintain biodiversity, ecosystem services and food production in a changing world. Emerging Topics in Life Sciences, 4(2), 229-240.
14. Kerr, R. B., Madsen, S., Stüber, M., Liebert, J., Enloe, S., Borghino, N., ... & Wezel, A. (2021). Can agroecology improve food security and nutrition? A review. Global Food Security, 29, 100540.
15. Kansanga, M. M., Kangmennaang, J., Kerr, R. B., Lupafya, E., Dakishoni, L., & Luginaah, I. (2021). Agroecology and household production diversity and dietary diversity: Evidence from a five-year agroecological intervention in rural Malawi. Social Science & Medicine, 288, 113550.
16. Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015). Agroecology and the design of climate change-resilient farming systems. Agronomy for sustainable development, 35(3), 869-890.
17. Altieri, M. A. (2002). Agroecology: the science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems & Environment, 93(1-3), 1-24.
18. Wei, C. (2020). Agroecology, information and communications technology, and smallholders' food security in Sub-Saharan Africa. Journal of Asian and African Studies, 55(8), 1194-1208.
19. Nandwa, S. M. (2001). Soil organic carbon (SOC) management for sustainable productivity of cropping and agro-forestry systems in Eastern and Southern Africa. In Managing Organic Matter in Tropical Soils: Scope and Limitations: Proceedings of a Workshop organized by the Center for Development Research at the University of Bonn (ZEF Bonn)—Germany, 7–10 June, 1999 (pp. 143-158). Springer Netherlands.
20. Bentrup, G., Hopwood, J., Adamson, N. L., & Vaughan, M. (2019). Temperate agroforestry systems and insect pollinators: A review. Forests, 10(11), 981.Lal, R. (2009). Soils and food sufficiency: A review. Sustainable agriculture, 25-49.
21. Makate, C., Wang, R., Makate, M., & Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe: adaptive management for environmental change. SpringerPlus, 5, 1-18.
22. Chavez-Miguel, G., Bonatti, M., Ácevedo-Osorio, Á., Sieber, S., & Löhr, K. (2022). Agroecology as a grassroots approach for environmental peacebuilding: Strengthening social cohesion and resilience in post-conflict settings with community-based natural resource management. GAIA-Ecological Perspectives for Science and Society, 31(1), 36-45.
23. Mercer, D. E. (2004). Adoption of agroforestry innovations in the tropics: a review. Agroforestry systems, 61, 311-328.
24. D'Annolfo, R., Gemmill-Herren, B., Amudavi, D., Shiraku, H. W., Piva, M., & Garibaldi, L. A. (2021). The effects of agroecological farming systems on smallholder livelihoods: A case study on push–pull system from Western Kenya. International Journal of Agricultural Sustainability, 19(1), 56-70.
25. Antwi-Agyei, P., & Stringer, L. C. (2021). Improving the effectiveness of agricultural extension services in supporting farmers to adapt to climate change: Insights from northeastern Ghana. Climate Risk Management, 32, 100304.

26. Latifi, S., Hauser, M., Raheli, H., Movahhed Moghaddam, S., Viira, A. H., Gökcin Ozuyar, P., & Azadi, H. (2021). Impacts of organizational arrangements on conservation agriculture: insights from interpretive structural modeling in Iran. Agroecology and Sustainable Food Systems, 45(1), 86-110.
27. McCown, R. L. (2002). Changing systems for supporting farmers' decisions: problems, paradigms, and prospects. Agricultural systems, 74(1), 179-220.
28. Kremen, C., Iles, A., & Bacon, C. (2012). Diversified farming systems: an agroecological, systems-based alternative to modern industrial agriculture. Ecology and society, 17(4).
29. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative research in psychology, 3(2), 77-101.
30. Union, A. (2014). Malabo declaration on accelerated agricultural growth and transformation for shared prosperity and improved livelihoods. Addis Ababa.
31. Ministry of Agriculture and Animal Resources. (2018). National Agricultural Policy. Kigali, Rwanda: Government of Rwanda.
32. Ministry of Food and Agriculture. (2016). National Climate-Smart Agriculture and Food Security Action Plan. Accra, Ghana.
33. United Nations Food and Agriculture Organization. (2016). Scaling Up Agroecology: Towards the Realization of the Sustainable Development Goals. http://www.fao.org/3/a-i6030e.pdf
34. Stevenson, J. R., Serraj, R., & Cassman, K. G. (2014). Evaluating conservation agriculture for small-scale farmers in Sub-Saharan Africa and South Asia. Agriculture, Ecosystems & Environment, 187, 1-10.
35. Emeana, E. M., Trenchard, L., Dehnen-Schmutz, K., & Shaikh, S. (2019). Evaluating the role of public agricultural extension and advisory services in promoting agro-ecology transition in Southeast Nigeria. Agroecology and Sustainable Food Systems, 43(2), 123-144.
36. Leippert, F., Darmaun, M., Bernoux, M., Mpheshea, M., Müller, A., Geck, M., ... & Termote, C. (2020). The potential of agroecology to build climate-resilient livelihoods and food systems.
37. Bryan, E., Ringler, C., Okoba, B., Koo, J., Herrero, M., & Silvestri, S. (2013). Can agriculture support climate change adaptation, greenhouse gas mitigation and rural livelihoods? Insights from Kenya. Climatic change, 118, 151-165.
38. Ndambi, O. A., Pelster, D. E., Owino, J. O., De Buisonje, F., & Vellinga, T. (2019). Manure management practices and policies in sub-Saharan Africa: implications on manure quality as a fertilizer. Frontiers in Sustainable Food Systems, 3, 29.
39. Adenle, A. A., Wedig, K., & Azadi, H. (2019). Sustainable agriculture and food security in Africa: The role of innovative technologies and international organizations. Technology in Society, 58, 101143.
40. Bottazzi, P., & Boillat, S. (2021). Political agroecology in Senegal: Historicity and repertoires of collective actions of an emerging social movement. Sustainability, 13(11), 6352.
41. Garrity, D. P., Akinnifesi, F. K., Ajayi, O. C., Weldesemayat, S. G., Mowo, J. G., Kalinganire, A., ... & Bayala, J. (2010). Evergreen Agriculture: a robust approach to sustainable food security in Africa. Food security, 2, 197-214.
42. Tollens, E., Demont, M., Sié, M., Diagne, A., Saito, K., & Wopereis, M. C. (2013). From WARDA to AfricaRice: an overview of rice research for development activities conducted in partnership in Africa. *Realizing Africa's rice promise*, 1-23.
43. ASARECA. (2012). Annual report 2012. Association for Strengthening Agricultural Research in Eastern and Central Africa.
44. IFOAM-Organics International. (2016). Ecological Organic Agriculture Initiative in Africa: Capacity Building for Agroecology through Development of Training Manuals and Organisation of Training Programs. Retrieved from https://www.ifoam.bio/sites/default/files/ifoam-eoa-initiative-2016.pdf
45. Jouzi, Z., Azadi, H., Taheri, F., Zarafshani, K., Gebrehiwot, K., Van Passel, S., & Lebailly, P. (2017). Organic farming and small-scale farmers: Main opportunities and challenges. Ecological economics, 132, 144-154.
46. Meijer, S. S., Catacutan, D., Ajayi, O. C., Sileshi, G. W., & Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International journal of agricultural sustainability, 13(1), 40-54.
47. AfrONet. (2019). About AfrONet: African Organic Network. Retrieved from https://afronet.org/about-afronet/
48. Meemken, E. M., Barrett, C. B., Michelson, H. C., Qaim, M., Reardon, T., & Sellare, J. (2021). Sustainability standards in global agrifood supply chains. *Nature Food*, *2*(10), 758-765.

49. UNCTAD/UNEP (2008) Organic agriculture and food security in Afric a , New York: United Nations. http://www.unctad.org/en/docs/ditcted200715_en.pdf. Accessed 27 Apr 2012
50. Schader, C., Heidenreich, A., Kadzere, I., Egyir, I., Muriuki, A., Bandanaa, J., ... & Stolze, M. (2021). How is organic farming performing agronomically and economically in sub-Saharan Africa?. Global Environmental Change, 70, 102325.
51. Paracchini, M. L., et al. "Agroecological practices supporting food production and reducing food insecurity in developing countries. A study on scientific literature in 17 countries." (2020).
52. Thierfelder, C., Rusinamhodzi, L., Ngwira, A. R., Mupangwa, W., Nyagumbo, I., Kassie, G. T., & Cairns, J. E. (2015). Conservation agriculture in Southern Africa: Advances in knowledge. *Renewable Agriculture and Food Systems*, *30*(4), 328-348.
53. D'Annolfo, R., Gemmill-Herren, B., Amudavi, D., Shiraku, H. W., Piva, M., & Garibaldi, L. A. (2021). The effects of agroecological farming systems on smallholder livelihoods: A case study on push–pull system from Western Kenya. International Journal of Agricultural Sustainability, 19(1), 56-70.
54. Enete, A. A., & Amusa, T. A. (2010). Challenges of agricultural adaptation to climate change in Nigeria: A synthesis from the literature. Field Actions Science Reports. The Journal of Field Actions, 4.
55. Bottazzi, P., Boillat, S., Marfurt, F., & Seck, S. M. (2020). Channels of labour control in organic farming: Toward a just agroecological transition for Sub-Saharan Africa. Land, 9(6), 205.
56. Shilomboleni, H. (2017). A sustainability assessment framework for the African green revolution and food sovereignty models in southern Africa. *Cogent Food & Agriculture*, *3*(1), 1328150.
57. Shilomboleni, H. (2017). A sustainability assessment framework for the African green revolution and food sovereignty models in southern Africa. Cogent Food & Agriculture, 3(1), 1328150.
58. Thiombiano, L., & Meshack, M. (2009). Scaling up conservation agriculture in Africa: Strategies and approaches.
59. Okullo, J. B. L., Obua, J., Kaboggoza, J. R., & Aluma, J. R. (2003). Traditional agroforestry systems, tree uses and management in northern Uganda. *Uganda Journal of Agricultural Sciences*, *8*, 5-12.
60. Mucheru-Muna, M. O. N. I. C. A. H., Mugendi, D. A. N. I. E. L., Pypers, P. I. E. T. E. R., Mugwe, J. A. Y. N. E., JAMES, K. U., Vanlauwe, B. E. R. N. A. R. D., & Merckx, R. (2014). Enhancing maize productivity and profitability using organic inputs and mineral fertilizer in central Kenya small-hold farms. Experimental Agriculture, 50(2), 250-269.
61. Adjei-Nsiah, S., Kuyper, T. W., Leeuwis, C., Abekoe, M. K., & Giller, K. E. (2007). Evaluating sustainable and profitable cropping sequences with cassava and four legume crops: Effects on soil fertility and maize yields in the forest/savannah transitional agro-ecological zone of Ghana. *Field Crops Research*, *103*(2), 87-97.
62. Kihara, J., Huising, J., Nziguheba, G., Waswa, B. S., Njoroge, S., Kabambe, V., ... & Coulibaly, A. (2016). Maize response to macronutrients and potential for profitability in sub-Saharan Africa. Nutrient cycling in agroecosystems, 105, 171-181.
63. Kandel, M., Anghileri, D., Alare, R. S., Lovett, P. N., Agaba, G., Addoah, T., & Schreckenberg, K. (2022). Farmers' perspectives and context are key for the success and sustainability of farmer-managed natural regeneration (FMNR) in northeastern Ghana. World Development, 158, 106014.
64. Kuyah, S., Sileshi, G. W., Luedeling, E., Akinnifesi, F. K., Whitney, C. W., Bayala, J., ... & Mafongoya, P. L. (2020). Potential of agroforestry to enhance livelihood security in Africa. *Agroforestry for Degraded Landscapes: Recent Advances and Emerging Challenges-Vol. 1*, 135-167.
65. Mashapa, C., Mhuriro-Mashapa, P., Zisadza-Gandiwa, P., & Gandiwa, E. (2013). Adoption of agro-ecology practices in semi-arid environment of Chimanimani District, eastern Zimbabwe.
66. Kerr, R. B., Kangmennaang, J., Dakishoni, L., Nyantakyi-Frimpong, H., Lupafya, E., Shumba, L., ... & Luginaah, I. (2019). Participatory agroecological research on climate change adaptation improves smallholder farmer household food security and dietary diversity in Malawi. *Agriculture, Ecosystems & Environment*, *279*, 109-121.
67. Holden, S. T., Fisher, M., Katengeza, S. P., & Thierfelder, C. (2018). Can lead farmers reveal the adoption potential of conservation agriculture? The case of Malawi. *Land Use Policy*, *76*, 113-123.
68. Thierfelder, C., Chivenge, P., Mupangwa, W., Rosenstock, T. S., Lamanna, C., & Eyre, J. X. (2017). How climate-smart is conservation agriculture (CA)?–its potential to deliver on adaptation, mitigation and productivity on smallholder farms in southern Africa. Food Security, 9, 537-560.

69. Barrios, E., Gemmill-Herren, B., Bicksler, A., Siliprandi, E., Brathwaite, R., Moller, S., ... & Tittonell, P. (2020). The 10 Elements of Agroecology: enabling transitions towards sustainable agriculture and food systems through visual narratives. Ecosystems and People, 16(1), 230-247.
70. Stevenson, J. R., Serraj, R., & Cassman, K. G. (2014). Evaluating conservation agriculture for small-scale farmers in Sub-Saharan Africa and South Asia. Agriculture, Ecosystems & Environment, 187, 1-10.
71. Kalusopa, T. (2005). The challenges of utilizing information communication technologies (ICTs) for the small-scale farmers in Zambia. Library hi tech, 23(3), 414-424.
72. Spielman, D. J., Ekboir, J., Davis, K., & Ochieng, C. M. (2008). An innovation systems perspective on strengthening agricultural education and training in sub-Saharan Africa. Agricultural systems, 98(1), 1-9.
73. Antwi-Agyei, P., & Stringer, L. C. (2021). Improving the effectiveness of agricultural extension services in supporting farmers to adapt to climate change: Insights from northeastern Ghana. Climate Risk Management, 32, 100304.
74. Salliou, N., Muradian, R., & Barnaud, C. (2019). Governance of ecosystem services in agroecology: when coordination is needed but difficult to achieve. Sustainability, 11(4), 1158.
75. Wezel, A., Herren, B. G., Kerr, R. B., Barrios, E., Gonçalves, A. L. R., & Sinclair, F. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. *Agronomy for Sustainable Development*, *40*, 1-13.
76. Sasson, A. (2012). Food security for Africa: an urgent global challenge. Agriculture & Food Security, 1(1), 1-16.
77. Clapp, J. (2021). The problem with growing corporate concentration and power in the global food system. *Nature Food*, *2*(6), 404-408.
78. Boeraeve, F., Dendoncker, N., Cornélis, J. T., Degrune, F., & Dufrêne, M. (2020). Contribution of agroecological farming systems to the delivery of ecosystem services. Journal of Environmental Management, 260, 109576.
79. Madsen, S., Bezner Kerr, R., LaDue, N., Luginaah, I., Dzanja, C., Dakishoni, L., ... & Hickey, C. (2021). Explaining the impact of agroecology on farm-level transitions to food security in Malawi. *Food Security*, *13*(4), 933-954.
80. Frison, E.A.; IPES-Food. (2016) From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems. Louvain-la-Neuve (Belgium): IPES, 96 p.
81. Chomba, S., Sinclair, F., Savadogo, P., Bourne, M., & Lohbeck, M. (2020). Opportunities and constraints for using farmer managed natural regeneration for land restoration in sub-Saharan Africa. *Frontiers in Forests and Global Change*, *3*, 571679.
82. Quisumbing, A. R., Brown, L. R., Feldstein, H. S., Haddad, L., & Peña, C. (1996). Women: The key to food security. Food and Nutrition Bulletin, 17(1), 1-2.
83. Njuki, J., Eissler, S., Malapit, H. J., Meinzen-Dick, R., Bryan, E., & Quisumbing, A. R. (2021). *A review of evidence on gender equality, women's empowerment, and food systems*. International Food Policy Research Institute.
84. Toderi, M., Powell, N., Seddaiu, G., Roggero, P. P., & Gibbon, D. (2007). Combining social learning with agro-ecological research practice for more effective management of nitrate pollution. Environmental science & policy, 10(6), 551-563.
85. Nicholls, C. I., & Altieri, M. A. (2018). Pathways for the amplification of agroecology. *Agroecology and Sustainable Food Systems*, *42*(10), 1170-1193.
86. FAO. (2018). Enhancing National Capacities for Food Security: Voluntary Guidelines on National Food Security and Nutrition Policy. Rome: Food and Agriculture Organization of the United Nations.
87. Piñeiro, V., Arias, J., Dürr, J., Elverdin, P., Ibáñez, A. M., Kinengyere, A., ... & Torero, M. (2020). A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. Nature Sustainability, 3(10), 809-820.
88. Giller, K. E., Andersson, J. A., Corbeels, M., Kirkegaard, J., Mortensen, D., Erenstein, O., & Vanlauwe, B. (2015). Beyond conservation agriculture. *Frontiers in plant science*, *6*, 870.
89. Carpenter, S. R., Mooney, H. A., Agard, J., Capistrano, D., DeFries, R. S., Díaz, S., ... & Whyte, A. (2009). Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment. Proceedings of the National Academy of Sciences, 106(5), 1305-1312.
90. Tittonell, P. (2020). Assessing resilience and adaptability in agroecological transitions. *Agricultural Systems*, *184*, 102862.

91. Gowing, J. W., & Palmer, M. (2008). Sustainable agricultural development in sub-Saharan Africa: the case for a paradigm shift in land husbandry. *Soil use and management*, *24*(1), 92-99.
92. Belmain, S. R., Haggar, J., Holt, J., & Stevenson, P. C. (2013). Managing legume pests in sub-Saharan Africa: Challenges and prospects for improving food security and nutrition through agro-ecological intensification.
93. Fan, S., Brzeska, J., Keyzer, M., & Halsema, A. (2013). From subsistence to profit: Transforming smallholder farms (Vol. 26). Intl Food Policy Res Inst.
94. Fan, S., Brzeska, J., Keyzer, M., & Halsema, A. (2013). *From subsistence to profit: Transforming smallholder farms* (Vol. 26). Intl Food Policy Res Inst.
95. Wollenberg, E. K., Higman, S., Seeberg-Elverfeldt, C., Neely, C., Tapio-Bistrom, M. L., & Neufeldt, H. (2012). Helping smallholder farmers mitigate climate change. CCAFS policy brief.
96. FAO. (2018). The State of Food and Agriculture 2018: Migration, Agriculture and Rural Development. Rome: Food and Agriculture Organization of the United Nations.
97. Meuwissen, M. P., Feindt, P. H., Spiegel, A., Termeer, C. J., Mathijs, E., De Mey, Y., ... & Reidsma, P. (2019). A framework to assess the resilience of farming systems. *Agricultural Systems*, *176*, 102656.
98. Bottazzi, P., Boillat, S., Marfurt, F., & Seck, S. M. (2020). Channels of labour control in organic farming: Toward a just agroecological transition for Sub-Saharan Africa. *Land*, *9*(6), 205.
99. Dosso, F., Gouroubera, M. W., Idrissou, L., & Moumouni-Mousa, I. (2023). The combination of extension approaches strengthens farmers' innovativeness in sustainable land management. Environment, Development and Sustainability, 1-20.
100. Wanjira, E. O., & Muriuki, J. (2020). Review of the Status of Agroforestry Practices in Kenya. Background Study for Preparation of Kenya National Agroforestry Strategy(2021-2030). DOI, 10.
101. Fan, S., Brzeska, J., Keyzer, M., & Halsema, A. (2013). From subsistence to profit: Transforming smallholder farms (Vol. 26). Intl Food Policy Res Inst.
102. Kocira, A., Staniak, M., Tomaszewska, M., Kornas, R., Cymerman, J., Panasiewicz, K., & Lipińska, H. (2020). Legume cover crops as one of the elements of strategic weed management and soil quality improvement. A review. Agriculture, 10(9), 394.
103. Palansooriya, K. N., Wong, J. T. F., Hashimoto, Y., Huang, L., Rinklebe, J., Chang, S. X., ... & Ok, Y. S. (2019). Response of microbial communities to biochar-amended soils: a critical review. Biochar, 1, 3-22.
104. El Chami, D., Daccache, A., & El Moujabber, M. (2020). How can sustainable agriculture increase climate resilience? A systematic review. Sustainability, 12(8), 3119.
105. Cosgrove, W. J., & Loucks, D. P. (2015). Water management: Current and future challenges and research directions. Water Resources Research, 51(6), 4823-4839.
106. Place, F., Niederle, P., Sinclair, F., Carmona, N. E., Guéneau, S., Gitz, V., ... & Hainzelin, E. (2022). Agroecologically-conducive policies: A review of recent advances and remaining challenges.
107. Holt-Giménez, E., Bunch, R., Irán Vasquez, J., Wilson, J., Pimbert, M. P., Boukary, B., & Kneen, C. (2010). Linking farmers' movements for advocacy and practice. The Journal of Peasant Studies, 37(1), 203-236.
108. FAO. (2019). Scaling up agroecology to achieve the sustainable development goals. In Proceedings of the 2nd FAO International Symposium on Agroecology. Rome: FAO.
109. Gazzano, I., & Gómez Perazzoli, A. (2017). Agroecology in Uruguay. Agroecology and Sustainable Food Systems, 41(3-4), 380-400.
110. Andersson, J. A., & D'Souza, S. (2014). From adoption claims to understanding farmers and contexts: A literature review of Conservation Agriculture (CA) adoption among smallholder farmers in southern Africa. Agriculture, ecosystems & environment, 187, 116-132.
111. Chivenge, P., Zingore, S., Ezui, K. S., Njoroge, S., Bunquin, M. A., Dobermann, A., & Saito, K. (2022). Progress in research on site-specific nutrient management for smallholder farmers in sub-Saharan Africa. Field Crops Research, 281, 108503.
112. Margiotta, S., & Giller, O. (2018). Improving smallholder farmer adoption of climate-smart agriculture practices.
113. Rodriguez, J. M., Molnar, J. J., Fazio, R. A., Sydnor, E., & Lowe, M. J. (2009). Barriers to adoption of sustainable agriculture practices: Change agent perspectives. Renewable agriculture and food systems, 24(1), 60-71.
114. Lopez-Garcia, D., Cuellar-Padilla, M., de Azevedo Olival, A., Laranjeira, N. P., Méndez, V. E., y Parada, S. P., ... & Tendero-Acin, G. (2021). Building agroecology with people. Challenges of participatory methods to deepen on the agroecological transition in different contexts. *Journal of Rural Studies*, *83*, 257-267.

115. Kremen, Claire, Alastair Iles, and Christopher Bacon. "Diversified farming systems: an agroecological, systems-based alternative to modern industrial agriculture." *Ecology and society* 17.4 (2012).
116. Makhura, M. T. (2002). *Overcoming transaction costs barriers to market participation of smallholder farmers in the Northern Province of South Africa* (Doctoral dissertation, University of Pretoria).
117. Martin, A., & Sherington, J. (1997). Participatory research methods—implementation, effectiveness and institutional context. *Agricultural systems*, *55*(2), 195-216.