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REVIEW ARTICLE

Agroecology supports sustainable development in Africa. A review

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Abstract

In African countries with high levels of food insecurity, food system transitions are key avenues for sustainable development but could also lead to serious trade-offs, depending on factors such as climatic conditions and socio-economic context. Here we review evidence of agroecology's impact on economic, social, environmental, and food security outcomes in 17 African countries with high food insecurity to assess how agroecology might contribute to Sustainable Development Goals (SDGs). The major findings are as follows: (1) agroecological practices positively affected multiple SDGs across semi-arid, sub-humid and humid agro-climatic zones for 94% of outcomes measured; (2) agroecological practices positively influenced two or more SDGs at the same time in 79% of articles. Crop diversification and agroecosystem diversity, for example, simultaneously lowered production costs (SDG1) and boosted yields (SDG2) through better soil health or agroecosystem resilience to climate events (SDG13/15), while reducing agrochemical pollution (SDG6) and improving biodiversity (SDG15). (3) Trade-offs between SDGs were documented in 14% of papers, and a negative feedback was observed between SDG8 (economic growth) and SDG5 (gender equity), with women disproportionately affected by the labour requirements of agroecological practices. Results from the review suggest that practical implementation of agroecology has the potential to reinforce interdependencies between SDGs, recommending this approach as an integral component of food system transformations for sustainable development.

Keywords Agroecological practices · Sustainable food systems · Sustainable development goals (SDG) · Food security

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1 Introduction

Although African governments have made progress on Sustainable Development Goals (SDGs) and many have incorporated these goals into national strategies and development plans, most are still only halfway to achieving SDG targets by 2030 (United Nations Economic Commission for Africa 2022). The ripple effects of conflicts, the COVID-19 pandemic, and climate-related catastrophes have particularly affected SDG progress in low income, food insecure countries, many of which are in Africa. Food system transformations can support sustainable development in Africa, if the form they take produces synergistic effects on SDGs while minimizing trade-offs (Sachs et al. 2019; Herrero et al. 2021). Agroecology is one agricultural approach proposed (Wezel et al. 2020a) and, in this review, we assess the potential of agroecological practices to contribute to sustainable development based on evidence from 17 African countries with high levels of food insecurity.

Agroecology combines ecological principles with farmers' knowledge to enhance ecosystem services that support agricultural productivity. Agroecological practices are locally adapted to the bio-physical and socio-ecological context, and include crop diversification, intercropping, and agroforestry (Wezel et al. 2014; Wezel 2017) (Figure 1). Agroecology also encompasses socio-economic and political aspects of food systems, including fairness, co-creation of knowledge, social values and diets (HLPE 2019; Wezel et al. 2020b). Other reviews have shown that agroecological practices can address major issues affecting food and agricultural systems, such as food insecurity and climate change, across countries with a range of food security levels (Bezner Kerr et al. 2021; Snapp et al. 2023). Environmental benefits of agroecological practices include higher agrobiodiversity, reduced nutrient runoff, and improved soil health (Wezel et al. 2014; Wezel 2017).

Although food system and land-use transformation holds promise for operationalizing the SDGs, this pathway also exhibits the "highest potential for trade-offs" across possible interventions (Sachs et al. 2019; Mehrabi et al. 2020). While there is consensus that global agricultural practices must become more sustainable (HLPE 2019; Willett et al. 2019; Webb et al. 2020; Chang et al. 2021), there are doubts about whether agroecology can contribute to progress on SDGs without significant trade-offs of its own (Bernard and Lux 2017; Morais et al. 2021). Dialogue about crop diversification – a core component of agroecology - weighs

Fig. 1 **A** A Malawian farmer applies compost to her maize field (photo credit: Gertrude Chisi). **B** Another Malawian farmer explains how she has diversified her production with sorghum and legume crops (photo credit: Rachel Bezner Kerr). Both began to use these agroecological practices with the hope that they would deliver multiple benefits.

the economic benefits of specialization in higher value cash crops vs. the benefits of producing diverse food groups for dietary quality (Sibhatu and Qaim 2018). Another source of tension is found between environmental outcomes and economic goals: agricultural intensification can lead to better economic returns, but is also linked to water and air pollution, greenhouse-gas emissions, and overexploitation of natural resources (Rasmussen et al. 2018). On the other hand, farming approaches with higher environmental performance, such as organic agricultural practices, may reduce yield stability or revenue unless products are marketed with organic premiums (Smith et al. 2019). Understanding how these trade-offs might appear in African countries with high levels of food insecurity is paramount for progress on SDGs through transformation of agricultural systems. We explore this topic by analyzing evidence of synergies and trade-offs between agroecology's effects on different SDGs.

Trade-offs between SDGs arise differently, depending on the context of food- and farming systems and the approach to food system change. While many factors will affect the success of agricultural transformations (Béné et al. 2020; Gaupp et al. 2021), we focus on agro-climatic conditions in this paper. The climatic conditions of a particular agro-ecosystem, such as rainfall patterns and temperature ranges, influence the outcomes of a particular farming approach. Agroecology's potential to deliver sustainability outcomes will be partially determined by its adaptability to different biophysical contexts, especially those with more challenging conditions for rainfed agricultural production, such as the semi-arid regions of Africa. This paper synthesizes results according to agro-climatic zones to reveal which agroecological practices are most prevalent, their effects on farming livelihoods, and implications for SDG progress.

2 Methodology

2.1 Literature review

We reviewed relevant scientific research on the social, environmental, and economic outcomes of agroecological practices from 17 African countries (See specific search string, including country list, in Appendix 1). Although agroecology encompasses multiple dimensions (science, social movement, practice) and principles, our search string identified research on agroecological practices. There are metrics that assess agroecology more comprehensively (Mottet et al. 2020), however, they were recently developed and are not widely implemented. Our search strings' emphasis on the practical side of agroecology thus allowed us to identify a wider range of relevant research appropriate to the timeframe and geography selected for the review. Our selection criteria for countries were those with high rates of food insecurity and sufficient research on agroecology, with a minimum threshold of three research publications per country. A four-phase PRISMA literature review protocol (Stevens et al. 2018) was used to screen abstracts, assess full-text, and evaluate the final selection of literature (Figure 2). We created a dataset of agroecology literature published between 2000-2021 using this protocol, based on literature searches in Web of Science. We chose to use this database after testing for sufficient and relevant references. In a pre-test phase we also tested the search string in Scopus, but this database returned fewer hits and the search results overlapped considerably with those from Web of Science. A total of 421 papers were judged relevant through abstract screening of the 7874 articles identified. The research team then further reviewed these abstracts and selected 133 articles for a full-text assessment. The research team refined this list using the following inclusion criteria: a) peer-reviewed and/or empirically robust research design b) examined agroecological practices, c) collected empirical evidence on-farm, d) and assessed social, economic, and environmental outcomes of agroecological practices, with a particular focus on food security. We thus excluded those publications that did not meet these criteria. We assessed whether the practices examined in a study were agroecological by referring to Wezel et al. (2014) and Debray et al. (2019). In total, 104 documents were selected: 94 peer reviewed journal articles, 3

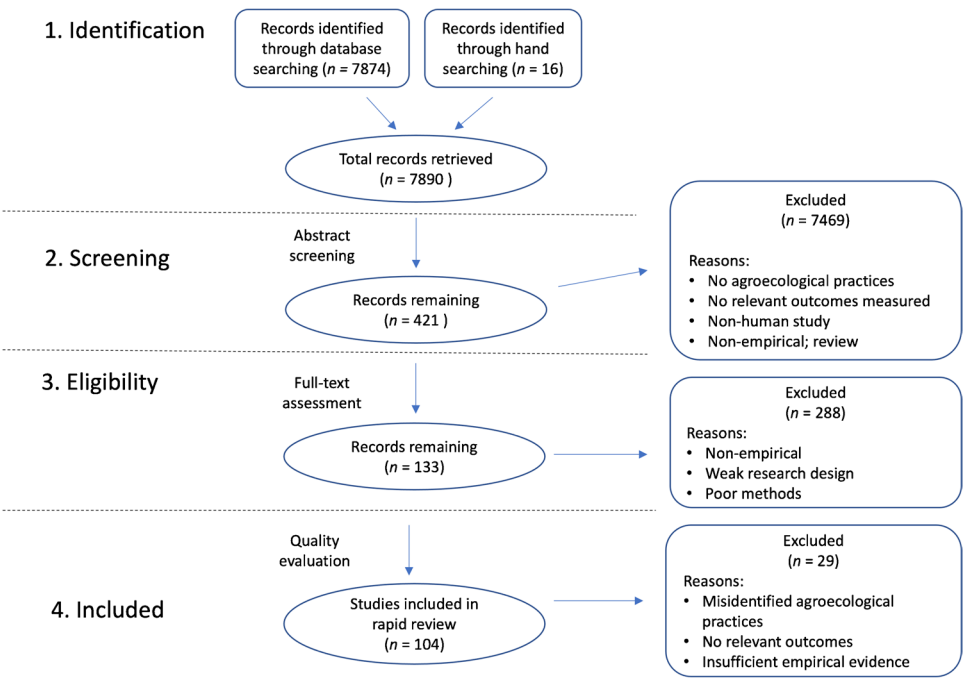

Fig. 2 PRISMA flow diagram depicting the steps of the literature review. The database search was performed in Web of Science Core Collection.

book chapters, 3 occasional papers/conference proceedings, 1 institutional report, and 3 doctoral dissertations.

2.2 Analysis

Key information about study site, methodology, agricultural practices, and social, environmental, and economic indicators was extracted from each publication and compiled in an Excel file. Team members analyzed results to identify specific sub-categories that represented different dimensions of the economic, environmental, and social outcomes reported in the literature. We clustered articles according to agro-climatic zones for analysis (Appendix 2). The agro-climatic zones were defined based on an agroecological zone surface map of Africa (Sebastian 2015). Zoning was delimited by locating the study site within agro-climatic regions found within each country. We calculated for each zone the number of articles reporting evidence of an outcome sub-category, as well as the average number of agroecological practices in use. In this paper, we summarize the common characteristics of each zone's agricultural systems and the impacts of agroecological practices on SDGs.

We analyzed the relationship between different sub-outcomes according to individual SDGs, but also between the following categories of SDGs: social, economic, environmental, and food security. This framework categorizes SDGs according to different dimensions of sustainable food systems (social, economic, environmental) that can pose trade-offs to each other (Barbier and Burgess 2017; Alemu 2022). We modified this framework to consider food security separately from economic goals, as food security is a key challenge in the selected African countries and a defining function of agricultural production, with unique possibilities for positive and negative feedbacks with other sustainability dimensions.

2.3 Sustainability outcomes

Twenty distinct sub-outcomes of agroecological practices were identified in the analysis and reported for each agro-climatic zone. These outcomes were then grouped according to eleven relevant SDGs (Appendix 3). Evaluations of agroecology's impact were based on longitudinal (e.g., contrasting use of agroecological practices with previous farming practices) and cross-sectional (e.g., contrasting agroecological practice with conventional practices) comparisons. Outcomes were classified as positive, negative, and neutral. One document could report multiple outcomes for each SDG, and a single paper might also indicate both positive and negative results. Those articles that contained "mixed" outcomes were counted twice- once as a negative outcome and once as a positive outcome. A neutral outcome indicated that agroecology had no impact on the SDG, whereas a positive outcome was assigned when agroecological practices had led to improvements in that SDG. For most sustainability sub-outcomes, the process of determining a "negative" outcome was self-evident, although not for all sub-outcomes. For example, an increase in agricultural working times may not lead to worse economic outcomes but we interpreted any increase in farming labour associated as a negative impact on SDG8.

3 Results

3.1 Agroecological practices reported in agro-climatic zones

The 104 reviewed studies were distributed across three agro-climatic zones: 20 in the (19%) humid tropical zone, 46 (44%) in the sub-humid tropical zone, and 38 (37%) in the semi-arid tropical zone. There were 11 studies located in both semi-arid and sub-humid tropical zones, but these were analysed with the sub-humid tropical papers because more study sites were located in that zone. Similarly, one paper that examined sites in both sub-humid and humid tropical zones was analysed with the humid tropical documents.

Nearly all studies in the included literature were conducted in rainfed smallholder farming systems, ranging from 0.5 - 6 hectares. Farms in both humid and sub-humid tropical climate sites were diversified, with households growing field crops, tending to smaller plots of vegetables and fruit trees, and rearing livestock. Literature from all agro-climatic zones studied cereal crops (e.g., maize, sorghum, rice, millet), tubers (e.g., yam, cassava, potato, sweet potato), and legumes (e.g., groundnuts, beans, and cowpeas). In semi-arid sites, more drought-tolerant cereals such as millet, sorghum, and barley were examined. In addition to field crops, many articles documented vegetable production. The most common cash crops grown were cotton and tobacco, although they were always grown in combination with food crops. Cattle, poultry and small ruminants were reared for livestock production, particularly in the semi-arid zone.

Studies examined a range of agroecological practices, which we grouped within larger sub-categories according to agroecological practice/system (Table 1). Some practices (e.g., crop rotation) could belong to several categories and, for these cases, we grouped the practices with the type to which they most often applied in the study's context. Field crop diversification was the most common type of agroecological practice (54%), followed by crop management practices for soil health (38%), compost and manure application (36%), and soil conservation practices (33%). Agroforestry was reported in 26 articles, while 23 papers studied crop-livestock integration. Research examined an average of 2.4 types of

Table 1 Description of types of agroecological practices examined in included literature.

Type of agroecological practice/system	Practices	Number of publications
Field crop diversification	Intercropping, companion cropping, strip cropping, and alley cropping	57
Crop management practices for soil health	Crop rotation, cover crops, and improved fallows	39
Soil conservation practices	Mulching, minimum soil disturbance (no/minimum tillage), soil conservation, and/or legume residue incorporation	34
Compost and manure	Application of animal manure or processed manure and other vegetative material	37
Physical landscape infrastructure for soil/water conservation	Soil bunds, vetiver grass plantings, terracing, contour ploughing, demi-lunes, and zai pits	14
Agroforestry	Field crop-tree integration and species diversification within tree plantations	26
Crop-livestock integration	Cultivation of field crops together livestock rearing	23
Biological pest control	Physical barriers or botanical sprays made from locally available plants and materials (e.g., neem oil)	12
Seed saving and selection	Farmer selection of seed according to desirable traits	3
Home garden diversification	Production of fruit and vegetable crops in small plots near the homestead	8

agroecological practices, with a maximum of 6 and minimum of 1 practices. Commonly combined practices included crop diversification and crop management for soil health (23%), crop diversification and compost/manure application (20%), and crop management and soil conservation (18%).

Disaggregated analysis of agroecological practices according to agro-climatic zone revealed similar patterns to those found across all zones (Figure 3). The average number of agroecological practices examined per document was highest for the humid zone (2.8), followed by the semi-arid zone (2.4) and the sub-humid zone (2.3). Field crop diversification was the most commonly studied type of practice for all three zones. Most papers from the sub-humid zone involved crop management and soil conservation practices, while compost/manure was most examined in the semi-arid zone. Half of the humid tropics publications studied agroforestry, especially cocoa agroforestry systems, reflecting the suitability of this zone for mixed tree-crop cultivation. Crop-livestock integration was most often found in the semi-arid zone, where grasslands for livestock grazing may be more accessible.

3.2 Agroecological practices and SDGs

All documents included in the review evaluated at least one SDG linked to agroecological practices. Most provided evidence relevant to more than one SDG, assessing two (21%), three (19%), four (23%), five (11%), six (13%), and seven

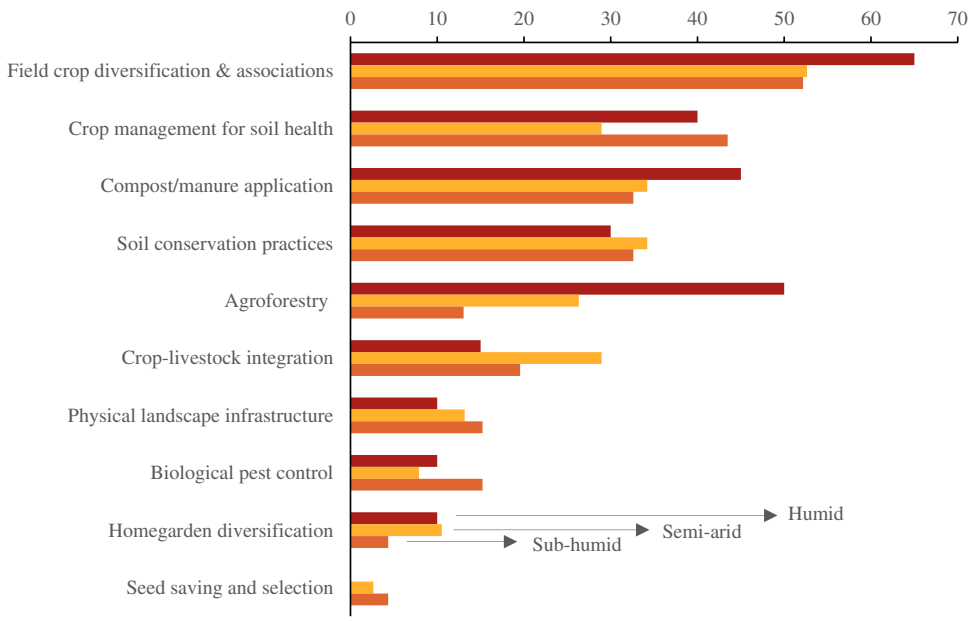

Fig. 3 Percentage of studies within each agro-climatic zone examining different types of agroecological practices.

(4%) SDGs. Only 9% of publications provided evidence relevant to just one SDG. Reflecting the study's focus on food security, evaluations of the impact of agroecology on SDG 2 (zero hunger) were the most common (Figure 4, Appendix 4), assessed in 84% of all studies. Indicators relevant to SDG 1 (no poverty) were the second most common, with 69% of the literature reporting relevant results. Finally, 56% of documents assessed the impact of agroecology on SDG 15 (life on land), with the majority focused on changes in soil quality and fertility.

Overwhelmingly positive outcomes associated with the use of agroecological practices were reported in the literature (Figure 4, Appendix 4) from all agro-climatic zones, with SDGs 1, 2, 8, and 13 most frequently assessed. Small differences between zones can be noted: more results relevant to SDG 8 were found within sub-humid agroecological studies, whereas a higher proportion of studies from humid zone sites assessed SDGs 13 and 6. In total, 15 papers (14%) provided evidence of a mixed, neutral, or negative effect for at least one SDG assessed. Only one of these studies found purely negative SDG outcomes; the remaining 14 reported a trade-off where agroecology also positively affected other SDGs.

3.3 Trade-offs between SDGs

Trade-offs were most commonly observed between yield (SDG 2) and other SDGs (6%), particularly those related to environmental (SDG 6, 13, 15) and economic (1, 8) goals (Ayoola and Adeniyan 2006; Binta and Barbier 2015). For example, although pigeon-pea maize intercropping and doubled-up legume systems generated the highest net income, sole maize with full fertilizer dosage produced higher maize yield (Snapp et al. 2018). A similar study in Ghana found that farmers preferred to rotate monoculture maize and groundnuts due to the negative effect that intercropping the two crops had on groundnut yields, while they favoured a different agroecological practice – compost application- for its benefits for soil health and weed pressure (Clottey et al. 2006).

Six studies, all located in semi-arid and sub-humid zones, found negative impacts on an economic SDG (1 or 8). All but one found that agroecological practices, such as legume intercropping, compost use, and agroforestry, positively impacted food security and at least one other social SDG but negatively affected SDG 8 by increasing labour demands (Bambara et al. 2008; Vidogbéna et al. 2016; Kpadonou et al. 2017; Daadi and Latacz-Lohmann 2021). Agroecological practices negatively affected gender equity in three studies, all located in the sub-humid zone. Two of these studies reported negative effects on gender equity despite improvements in economic, environmental and food security outcomes (Ebifa-Othieno et al. 2017; Maliki et al. 2017). The third study found that, although organic fertilizer and legume-intercropping positively impacted household food security, the increase in labour disproportionately affected women farmworkers (Daadi and Latacz-Lohmann 2021). This study also presented a trade-off between SDG 8 and 2: while increases in labour demands generated employment opportunities, they also increased production costs. No papers reported a negative outcome linked to an environmental SDG. While most studies reported trade-offs between SDGs, several also reported simultaneous negative impacts on other SDGs, indicating negative feedback loops (Appendix 5). Two of the studies, for example, that found that agroecological practices increased labour showed that this increase primarily impacted women (Maliki et al. 2017; Daadi and Latacz-Lohmann 2021), thereby negatively affecting SDGs 5 (gender equity) and 10 (reduced inequalities).

3.4 Synergies between SDGs

Most papers (79%) found that agroecological practices positively influenced two or more SDGs simultaneously

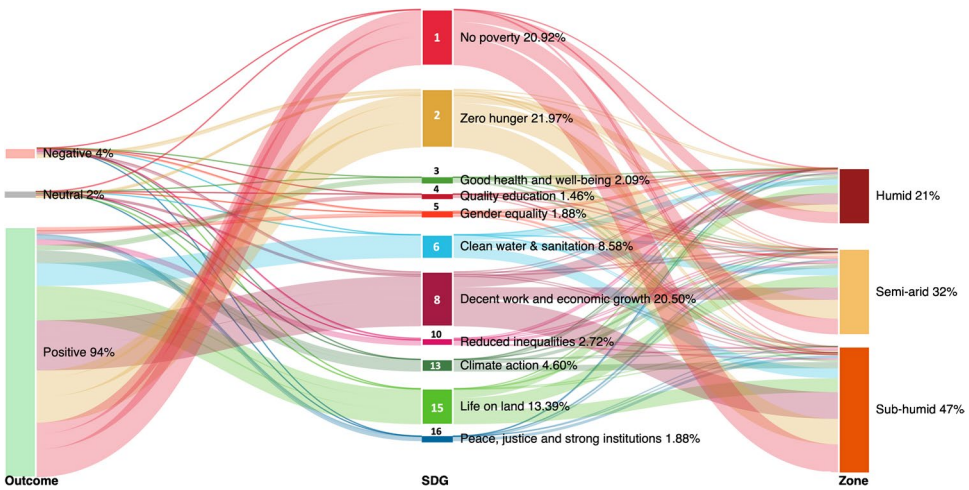

Fig. 4 Outcomes of agroecological practices for eleven SDGs assessed, distributed across agro-climatic zones. 94% of outcomes reported were positive.

(Figure 5). This was the case across literature from different agro-climatic zones, with humid and sub-humid zones reporting slightly higher average number of synergistic SDGs than the semi-arid zone.

Simultaneous improvements were frequently found in several combinations of SDGs. Some of these combinations were expected, given that these SDGs had overlapping sub-outcomes (Appendix 3). For example, SDG 1 and 8 (found together in 48 papers) were both assessed based on indicators of agricultural income, income diversification, and stability, although SDG 8 also included evaluations of changes in employment and labour requirements in agriculture. Other SDGs with overlapping sub-outcomes were: SDG5/10 and SDG 6/13/15. Of more consequence were the synergies our analysis revealed between SDGs without overlapping sub-outcomes, bridging SDGs in economic, social, environmental, and food security categories (Figure 6) (Barbier and Burgess 2017). Only 20% of included articles found evidence of only one SDG category, while 36% showed evidence of improvements in two SDG categories, 35% of three SDG categories, and 9% of all four SDG categories. The most common synergy was between food security and economic SDGs, with a total of 54 publications providing evidence that agroecological practices positively influenced both goals (Appendix 3). In the following sections, we describe other noteworthy combinations of SDGs.

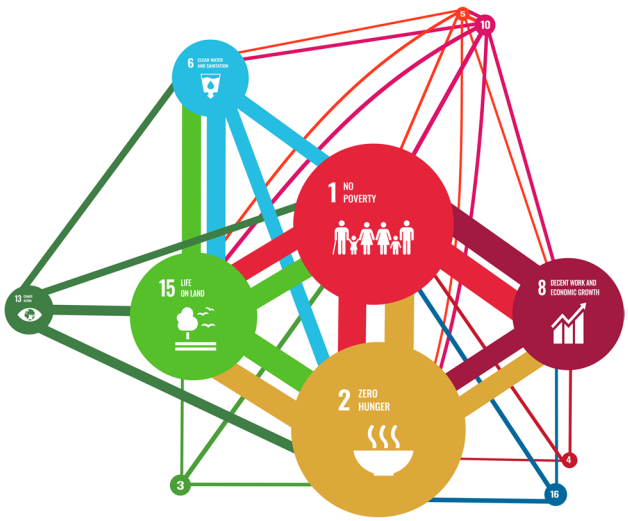

Fig. 5 Synergies within agroecological practices' positive effect on SDGs. Circle size represents the proportion of literature that reported a positive effect on the SDG. The link indicates the proportion of studies that found positive outcomes for both SDGs connected. Links are only pictured if 50% or more of papers that assessed the main SDG (link color) found a positive effect on both the main SDG and the connected SDG.

3.4.1 Building the economic and environmental foundations of smallholder livelihoods

Agroecological practices were associated with better household income and at least one other environmentally-oriented SDG (6, 13, 15) in 39 papers. Improvements in soil fertility and quality were the most frequently reported outcomes,

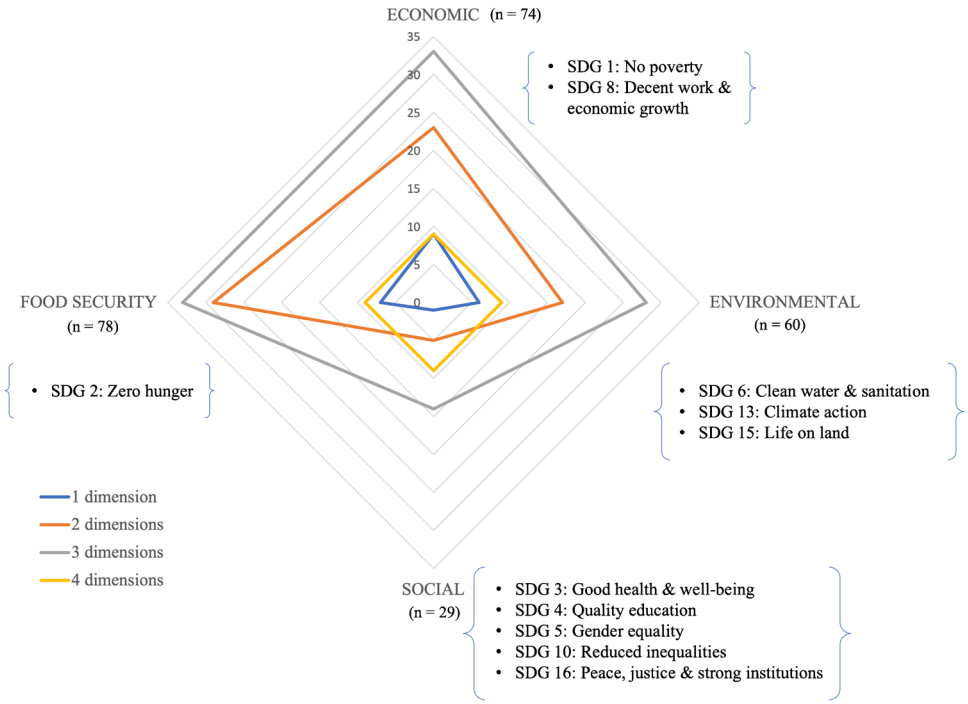

Fig. 6 No. of publications per SDG dimension (social, economic, environmental, food security) that reported improvements in one, two, three, or four SDG dimensions.

although 13 papers also found benefits for climate action (SDG 13), indicated by higher soil organic carbon, lower GHG emissions, and farmers' perceptions of greater agroecosystem resilience to extreme climatic conditions. Coffee-banana intercropping in Uganda, for example, led to higher agricultural income compared to pure stands of coffee while simultaneously improving coffee's resilience to drought (Jassogne et al. 2013). Economic benefits were combined with better soil and water erosion management (SDG 6) in 27 papers. Botanical sprays and biopesticides to control pests, for example, simultaneously reduced production costs while increasing the abundance of beneficial insects (Dassou et al. 2019), thereby supporting biodiversity while sustaining net income (Bisseleua et al. 2009).

3.4.2 Improving the environment while ensuring farmer food security

A total of 46 publications found improvements in both food security and environmental outcomes. Agroforestry was frequently found to deliver both benefits. Fields in closer proximity to the tree *Faiderhbia albida,* for example, had higher barley yields, organic matter and nitrogen content (Hadgu et al. 2009). In Burkina Faso, soil and water conservation practices, such as mulching, crop rotation, and reduced soil disturbance, increased sorghum yields, soil physical properties (Zida 2011), and soil macrofauna (Ouédraogo et al. 2001). Legume intercropping with cereal crops also boosted overall crop yields, while positively affecting soil nutrient balances (Myaka et al. 2006; Coulibaly et al. 2017). In Malawi, a mixed-methods longitudinal study found that legume residue incorporation and crop diversification were associated with significantly higher food security, with farmers attributing higher yields to improvements in soil fertility (Madsen et al. 2021).

3.4.3 Agricultural income for social benefits

A total of 23 papers reported that agroecological practices increased agricultural income (SDG 1) and at least one other SDG concerned with social outcomes. Several articles found that improvements in agricultural incomes translated into better access to education and health (Douxchamps et al. 2016; Nchanji et al. 2016; Quandt et al. 2017), with farmers more able to afford school tuition and hospital visits. In other studies, gender equity improved when diversification of agroforestry plots increased women's financial independence (Jassogne et al. 2013; Sanial and Ruf 2018). Socially marginalized HIV-affected farmers who began to use compost, crop diversification, legume rotation and crop residue incorporation experienced higher returns to labour, volumes of agricultural sales, and subsequent improvements in income and food security (Nyantakyi-Frimpong et al. 2016).

3.4.4 Diversified agroecosystems for better food security, income, and soil

SDGs 1, 2, 8, and 15 formed a nexus of closely related SDGs (Figure 5). Studies in the humid zone disproportionately reported this combination of SDGs, with half of papers from this zone finding improvements in economic, environmental and food security SDGs. In nearly one-third of all studies, agroecological practices improved food security, generated economic/financial growth, and also provided ecosystem services by building soil health (20 out of 31 studies), improving water and soil conservation (9/31), enhancing biodiversity conservation (3/31), and reducing agrochemical pollution (13/31). Twelve studies found simultaneous improvements in SDG13, indicated by increased soil carbon sequestration and higher resilience to climate events. A total of 17 of these studies directly measured food security while the remaining 14 used yield as a proxy measurement of food security. The agroecological practices most frequently linked to this combination of SDGs were plot-level diversification of field and forest crops. Indeed, one-third of agroforestry studies found improvements in social, economic, and food security outcomes associated with the practice. Half of the studies that reported benefits to this nexus of SDGs examined crop diversification, most commonly in the form of intercropping legumes within maize or tuber crops.

Agroecological practices, such as compost and manure application (Bezner Kerr et al. 2019), agroforestry (Beedy et al. 2013), and crop diversification and association (D'Annolfo et al. 2021), reduced agrochemical inputs in eight studies. Reducing these inputs benefited farmers financially and several studies reported that diversified systems lowered production costs because they required less labour for weeding (Fawole and Oladele 2007; Smith Dumont et al. 2014; Maliki et al. 2017). In addition to improving agricultural revenue, diversification practices increased overall yields and provided a higher quality diet (Fawole and Oladele 2007; Gnahoua et al. 2017; Maliki et al. 2017; Snapp et al. 2018). In nearly all cases, economic and food security outcomes were found together with improvements in soil health characteristics, such as soil organic matter, soil carbon, nitrogen balance and biomass. Diversified agroecosystems were more resilient to climate events, as greater vegetative cover maintained soil moisture while species diversity insured against total crop failure. Farmers observed that shade trees in agroforestry systems reduced the impact of climate change on their main crops' yield (Smith Dumont et al. 2014; Meaza and Demssie 2015; Okunlola et al. 2019) and diversified diets during months of food scarcity (Alao and Shuaibu 2011; Ebifa-Othieno et al. 2017).

3.4.5 Four categories of SDG improvements

A total of nine publications found improvements in economic, environmental, economic, social, and food security SDGs. These studies combined multiple agroecological practices to support multiple sustainability outcomes (Naudin et al. 2018; Payne et al. 2011; Vall et al. 2017) A cross-sectional study in Uganda, for example, found that mulching, manure application, and intercropping limited nematode populations and the crop damage they caused, reduced input costs associated with fertilizer and pesticides, and strengthened farmers' ability to diagnose and prepare organic treatments for crop diseases and pests (Karamura et al. 2013).

4 Discussion

Literature on sustainable development in Africa warns that some approaches to poverty and hunger reduction may worsen long-term climate change risks to food systems alongside other environmental and social SDGs (Nilsson et al. 2016; Barbier and Burgess 2017; Machingura and Lally 2017). In addition, short-term gains in SDG 1 and 2 may come at the cost of reducing long-term resilience and food systems stability with increased climate change impacts (Bezner Kerr et al. 2022). This review provides substantial evidence that agroecological practices can support progress towards multiple SDGs across agro-climatic zones in Africa without substantial trade-offs. Some of our findings corroborate existing scholarship on the topic, whereas others provide novel insights into both agroecology's potential for sustainable development and its possible risks.

4.1 Progress towards individual SDGs

Corroborating evidence from another global review on agroecology (Bezner Kerr et al. 2021), most included studies (84%) measured the relationship between agroecological practices and crop yields and/or food security, with the majority (75%) finding that this impact was positive. Food security benefits were evenly documented across all three agro-climatic zones, a finding highly relevant to SDG2 given that most studies were performed on smallholder farms in countries with high levels of food insecurity. "Life on land" (SDG 15) was another frequently assessed goal, and 58% of studies found improvements such as higher soil fertility/quality, biodiversity, reduced agro-chemical usage, or soil and water erosion. As agroecology aims to enhance ecosystem services such as nutrient cycling, biological pest control, and regulation of climate and water systems, this result is not entirely surprising. There can, however, be trade-offs between agriculture and other ecosystem services, especially in contexts without adequate institutional support (Power 2010). While several studies found that agroecological practices did not improve all environmental sub-outcomes, none reported a negative impact.

One limitation of the review was the lack of documents assessing social dimensions of agroecology, which composed fewer than one-third of the articles. On the one hand, this gap can be related to the search string not covering this dimension better, as it emphasized the practice of agroecology and its environmental principles more than its social principles. In its complete form, agroecology advances principles of co-creation of knowledge, social values and diets, fairness, connectivity, land and natural resource governance, and participation. This commitment to addressing social inequities in farming and food systems distinguishes agroecology from other sustainable agriculture approaches. On the other hand, the dearth of research on social dimensions of agroecology may also reflect a broader research gap. In a recent global review on the socio-economic performance of agroecology, it was also found that the social capital dimension was strongly 'under-investigated' in research (Mouratiadou et al. 2024). Indeed, most studies examined in this review omitted social principles integral to agroecology. Even so, purely positive effects were found on SDGs 3, 5, and 16, with improvements in agricultural income supporting better healthcare and education, while several studies reported stronger farmer networks.

4.2 Trade-offs and synergies

Although food system change could reinforce interdependencies between SDGs, thereby delivering benefits relevant to multiple SDGs, transformations could undermine progress on some SDGs for the attainment of others (Béné et al. 2019; Biggeri et al. 2019; Herrero et al. 2021). These trade-offs, which characterize dominant agri-food systems, have not been adequately explored for alternative, agroecological food production. This review suggests that, in some smallholder farming contexts, agroecological practices can support food security and environmental SDGs but at the risk of trade-offs for social and economic ones. A small segment of the literature that assessed these SDGs found that agroecology was linked to lower yields (7%) or higher labour requirements (11%). Importantly, one-third of studies that assessed gender equity found that agroecological practices negatively influenced this sustainability dimension, often because of a negative feedback with SDG 8 (Ericksen 2008). When agroecological practices increased on-farm labour, women became responsible for this additional work, thus exacerbating gender inequities (SDG 5). This finding highlights the importance of considering gender and other social inequities in agricultural interventions, a point emphasized in other systematic reviews of agrifood system transformation (Roy et al. 2022).

One-third of articles reported benefits to food security (SDG 2), incomes and economic growth (SDG 1, 8), and the environment (SDG 6, 13, 15). While agroecology's impact on SDG 2, 13 and 15 may be expected given the ecological science informing its practice, its effect on SDGs 1 or 8 is less predictable. As an approach that reduces the usage of fossil-fuel based technologies of agricultural intensification, agroecology has been critiqued for promoting environmental benefits at the cost of farm profitability (The Montpellier Panel 2013; Alliance for Science 2019). Yet of the 77 publications that assessed an economic sub-outcome of agroecology, 74 found a positive impact on at least one of these sub-outcomes, most commonly agricultural income or production costs. In particular, higher agrobiodiversity enhanced agricultural incomes alongside agroecosystem health and resilience while supporting better household food security. In addition, although the most negative sub-outcomes resulted from agroecological practices' impact on labour, two-thirds of studies (12/18) showed a reduction in agricultural labour time.

Economic improvements at the household level do not necessarily occur together with improvements in health and well-being, access to education, and broader community institutions. In these studies, however, improvements in income and food security interacted synergistically with each other, and also with socially-oriented SDGs, confirming other studies' results (Nilsson et al. 2016; Pradhan et al. 2017; Mainali et al. 2018; Sharma et al. 2022). Higher yields and crop diversity, for example, bolstered farmers' food security and agricultural income, allowing them to reallocate income towards healthcare and education.

5 Conclusion

Development of sustainable food systems is one among several major challenges faced by African countries. Food systems are coupled socio-ecological systems, fundamentally shaped by the interaction of food security, income, health, and environmental sustainability (Holling 2001). These interacting dimensions make food system transformation a complex challenge (Ericksen 2008), and debates over the future of agri-food systems hinge upon trade-offs between economic, social, environmental and food security dimensions. Agroecology is proposed as a transition pathway for reducing hunger, but questions remain as to whether agroecology can simultaneously support SDGs across sustainability dimensions.

This review provides robust evidence that agroecological practices can provide positive social, economic and environmental outcomes across three agro-climatic zones in Africa. While in a few studies agroecological practices created negative feedbacks, counterbalancing environmental benefits with economic and social losses, these feedbacks were positive in the vast majority of included literature, reinforcing gains in food security, agroecosystem health, income, and social dimensions of human well-being. This conclusion is based on evidence from 17 African countries with high levels of food insecurity where several studies of agroecology had been conducted at the time of the review. This selection criteria meant that Western and Eastern Africa regions were better represented in the included literature. Future studies assessing evidence of agroecology in Northern, Central and Southern Africa would complement these results. An additional limitation of the review was that it assessed a partial version of agroecology, identified through the use of one or more agroecological practices. Although principles of fairness, participation, connectivity, and social values and diets are fundamental to this approach to food production, few studies provided evidence related to the social outcomes of agroecological practices. The existing research generally found that agroecological practices positively impacted social outcomes, but future research should explore how more complete forms of agroecology appear and perform in African contexts.

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Declarations

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References

Alao J, Shuaibu R (2011) Agroforestry practices and preferential agroforestry trees among farmers in Lafia local government area, Nasarawa State, Nigeria. Waste Manag Bioresour Technol 1:12–20 (https://www.researchgate.net/publication/273945202_Agroforestry_Practices_And_Preferential_Agroforestry_Trees_Among_Farmers_In_Lafia_Local_Government_Area_Nasarawa_State_Nigeria August 4 2023)

Alemu R (2022) The race towards more sustainable food systems. Nat Food 3:679–680. https://doi.org/10.1038/s43016-022-00598-5

Alliance for Science (2019) Why traditional agricultural practices can't transform African agriculture. https://allianceforscience.cornell.edu/blog/2019/02/traditional-agricultur al-practices-cant-trans form-african-agriculture/. Accessed 1 Mar 2023

Ayoola OT, Adeniyan ON (2006) Influence of poultry manure and NPK fertilizer on yield and yield components of crops under different cropping systems in south west Nigeria. Afr J Biotechnol 5:1386–1392. https://doi.org/10.4314/ajb.v5i15.43121

Bambara D, Zoundi JS, Tiendrebeogo JP (2008) Sorghum Sorghum bicolor (L.) Moench and cowpea Vigna unguiculata (L.) Walp intercropping for crop-livestock integration in the Sudano-Sahelian are. Cah Agric 17:297–301. https://doi.org/10.1684/agr.2008.0203

Barbier E, Burgess J (2017) The sustainable development goals and the systems approach to sustainability. Economics: The Open-Access, Open-Assessment E-Journal 11:1–22. https://doi.org/10.5018/economics-ejournal.ja.2017-28

Beedy TL, Ajayi OC, Sileshi GW, et al (2013) Scaling up Agroforestry to Achieve Food Security and Environmental Protection among Smallholder Farmers in Malawi. Field Actions Sci Rep J Field Actions. https://hdl.handle.net/10568/34917

Béné C, Oosterveer P, Lamotte L et al (2019) When food systems meet sustainability – Current narratives and implications for actions. World Dev 113:116–130. https://doi.org/10.1016/j.worlddev.2018.08.011

Béné C, Fanzo J, Haddad L et al (2020) Five priorities to operationalize the EAT–Lancet Commission report. Nat Food 1:457–459. https://doi.org/10.1038/s43016-020-0136-4

Bernard B, Lux A (2017) How to feed the world sustainably: an overview of the discourse on agroecology and sustainable intensification. Reg Environ Change 17:1279–1290. https://doi.org/10.1007/s10113-016-1027-y

Bezner Kerr R, Kangmennaang J, Dakishoni L et al (2019) Participatory agroecological research on climate change adaptation improves smallholder farmer household food security and dietary diversity in Malawi. Agric Ecosyst Environ 279:109–121. https://doi.org/10.1016/j.agee.2019.04.004

Bezner Kerr R, Madsen S, Stüber M et al (2021) Can agroecology improve food security and nutrition? A Review. Glob Food Secur 29:100540. https://doi.org/10.1016/j.gfs.2021.100540

Bezner Kerr R, Hasegawa T, Lasco R et al (2022) Food, fibre, and other ecosystem products. Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, pp 713–906. https://doi.org/10.1017/9781009325844.007

Biggeri M, Clark DA, Ferrannini A, Mauro V (2019) Tracking the SDGs in an 'integrated' manner: A proposal for a new index to capture synergies and trade-offs between and within goals. World Dev 122:628–647. https://doi.org/10.1016/j.worlddev.2019.05.022

Binta BAA, Barbier B (2015) Economic and Environmental Performances of Organic Farming System Compared to Conventional Farming System: A Case Study of the Horticulture Sector in the Niayes Region of Senegal. Procedia Environ Sci 29:17–19. https://doi.org/10.1016/j.proenv.2015.07.132

Bisseleua DHB, Missoup AD, Vidal S (2009) Biodiversity conservation, ecosystem functioning, and economic incentives under cocoa agroforestry intensification. Conserv Biol J Soc Conserv Biol 23:1176–1184. https://doi.org/10.1111/j.1523-1739.2009.01220.x

Chang J, Havlík P, Leclère D et al (2021) Reconciling regional nitrogen boundaries with global food security. Nat Food 2:700–711. https://doi.org/10.1038/s43016-021-00366-x

Clottey VA, Agyare WA, Gyasi KO, et al (2006) Composting to ensure food security: Learning by doing. Livest Res Rural Dev 18. http://www.lrrd.org/lrrd18/10/clot18137.htm

Coulibaly JY, Chiputwa B, Nakelse T, Kundhlande G (2017) Adoption of agroforestry and the impact on household food security among farmers in Malawi. Agric Syst 155:52–69. https://doi.org/10.1016/j.agsy.2017.03.017

D'Annolfo R, Gemmill-Herren B, Amudavi D et al (2021) The effects of agroecological farming systems on smallholder livelihoods: a case study on push–pull system from Western Kenya. Int J Agric Sustain 19:56–70. https://doi.org/10.1080/14735903.2020.1822639

Daadi BE, Latacz-Lohmann U (2021) Organic Fertilizer Adoption, Household Food Access, and Gender-Based Farm Labor Use: Empirical Insights from Northern Ghana. J Agric Appl Econ 53:435–458. https://doi.org/10.1017/aae.2021.8

Dassou AG, Vodouhè SD, Bokonon-Ganta A et al (2019) Associated cultivated plants in tomato cropping systems structure arthropod communities and increase the Helicoverpa armigera regulation. Bull Entomol Res 109:733–740. https://doi.org/10.1017/S0007485319000117

Douxchamps S, Van Wijk MT, Silvestri S et al (2016) Linking agricultural adaptation strategies, food security and vulnerability: evidence from West Africa. Reg Environ Change 16:1305–1317. https://doi.org/10.1007/s10113-015-0838-6

Ebifa-Othieno E, Mugisha A, Nyeko P, Kabasa JD (2017) Knowledge, attitudes and practices in tamarind (Tamarindus indica L.) use and conservation in Eastern Uganda. J Ethnobiol Ethnomedicine 13:5. https://doi.org/10.1186/s13002-016-0133-8

Ericksen PJ (2008) Conceptualizing food systems for global environmental change research. Glob Environ Change 18:234–245. https://doi.org/10.1016/j.gloenvcha.2007.09.002

Fawole OP, Oladele OI (2007) Sustainable Food Crop Production Through Multiple Cropping Patterns among Farmers in South Western Nigeria. J Hum Ecol 21:245–249. https://doi.org/10.1080/09709274.2007.11905980

Gaupp F, Ruggeri Laderchi C, Lotze-Campen H et al (2021) Food system development pathways for healthy, nature-positive and inclusive food systems. Nat Food 2:928–934. https://doi.org/10.1038/s43016-021-00421-7

Gnahoua J-BG, Ettien DJB, N'zué B, et al (2017) Intensification pathway for improvement of smallholder cassava production systems in Southern Cote d'Ivoire. Exp Agric 53:44–58. https://doi.org/10.1017/S0014479716000041

Hadgu KM, Kooistra L, Rossing WAH, van Bruggen AHC (2009) Assessing the effect of Faidherbia albida based land use systems on barley yield at field and regional scale in the highlands of

Tigray, Northern Ethiopia. Food Secur 1:337–350. https://doi.org/10.1007/s12571-009-0030-2

Herrero M, Thornton PK, Mason-D'Croz D et al (2021) Articulating the effect of food systems innovation on the Sustainable Development Goals. Lancet Planet Health 5:e50–e62. https://doi.org/10.1016/S2542-5196(20)30277-1

HLPE (2019) Agroecological approaches and other innovations for sustainable agriculture and food systems that enhance food security and nutrition. Committee on World Food Security, High Level Panel of Experts on Food Security and Nutrition, FAO, Rome. link https://www.fao.org/cfs/cfs-hlpe/publications/hlpe-14

Holling CS (2001) Understanding the Complexity of Economic, Ecological, and Social Systems. Ecosystems 4:390–405. https://doi.org/10.1007/s10021-001-0101-5

Jassogne L, Nibasumba A, Wairegi L, Baret P, Deraeck J, Mukasa D, Van Asten P (2013). Coffee/Banana intercropping as an opportunity for smallholder coffee farmers in Uganda, Rwanda and Burundi. In: Blomme G, Van Asten P, Vanlauwe B. Banana systems in the humid highlands of sub-Saharan Africa. Wallingford: CABI, pp 144–149. https://doi.org/10.1079/9781780642314.0144

Karamura E, Jogo W, Rietveld A, Ochola D, Staver C, Tinzaara W, Karamura D, Kubiriba J, Weise S (2013) Effectiveness of agroecological intensification practices in managing pests in smallholder banana systems in East and Central Africa. Acta Hortic 986:119–126. https://doi.org/10.17660/ActaHortic.2013.986.10

Kpadonou RAB, Owiyo T, Barbier B et al (2017) Advancing climate-smart-agriculture in developing drylands: Joint analysis of the adoption of multiple on-farm soil and water conservation technologies in West African Sahel. Land Use Policy 61:196–207. https://doi.org/10.1016/j.landusepol.2016.10.050

Machingura F, Lally, Steven (2017) The Sustainable Development Goals and their trade-offs. Overseas Development Institute, London, UK. https://odi.org/en/publications/the-sustainable-development-goals-and-their-trade-offs/

Madsen S, Bezner Kerr R, LaDue N et al (2021) Explaining the impact of agroecology on farm-level transitions to food security in Malawi. Food Secur 13:933–954. https://doi.org/10.1007/s12571-021-01165-9

Mainali B, Luukkanen J, Silveira S, Kaivo-oja J (2018) Evaluating Synergies and Trade-Offs among Sustainable Development Goals (SDGs): Explorative Analyses of Development Paths in South Asia and Sub-Saharan Africa. Sustainability 10:815. https://doi.org/10.3390/su10030815

Maliki R, Sinsin B, Floquet A et al (2017) Sedentary yam-based cropping systems in West Africa: Benefits of the use of herbaceous cover-crop legumes and rotation—lessons and challenges. Agroecol Sustain Food Syst 41:450–486. https://doi.org/10.1080/21683565.2017.1279252

Meaza H, Demssie B (2015) Managing fragile homestead trees to improve livelihoods of land-poor farmers in the Northern Highlands of Ethiopia. Singap J Trop Geogr 36:57–66. https://doi.org/10.1111/sjtg.12098

Mehrabi Z, Gill M, van Wijk M et al (2020) Livestock policy for sustainable development. Nat Food 1:160–165. https://doi.org/10.1038/s43016-020-0042-9

Morais TG, Teixeira RFM, Lauk C et al (2021) Agroecological measures and circular economy strategies to ensure sufficient nitrogen for sustainable farming. Glob Environ Change 69:102313. https://doi.org/10.1016/j.gloenvcha.2021.102313

Mottet A, Bicksler A, Lucantoni D et al (2020) Assessing Transitions to Sustainable Agricultural and Food Systems: A Tool for Agroecology Performance Evaluation (TAPE). Front Sustain Food Syst 4:579154. https://doi.org/10.3389/fsufs.2020.579154

Mouratiadou I, Wezel A, Kamilia K, Marchetti A, Paracchini ML, Bàrberi P (2024) The socio-economic performance of agroecology. A Review. Agron Sustain Dev 44:19. https://doi.org/10.1007/s13593-024-00945-9

Myaka FM, Sakala WD, Adu-Gyamfi JJ et al (2006) Yields and accumulations of N and P in farmer-managed intercrops of maize–pigeonpea in semi-arid Africa. Plant Soil 285:207–220. https://doi.org/10.1007/s11104-006-9006-6

Naudin K, Autfray P, Dusserre J, Penot E, Raboin L-M., Raharison T, Rakotoarisoa J, Ramanantsoanirina A, Randrianjafizanaka MT, Rasolofo LI, Raveloson H, Razafimahatratra HM, Salgado P, Sester M, Vom Brocke K, Scopel E (2018) L'agro-écologie à Madagascar : de la plante au paysage. In: La transition agro-écologique des agricultures du Sud. Côte François-Xavier (ed.), Poirier-Magona Emmanuelle (ed.), Perret Sylvain (ed.), Roudier Philippe (ed.), Bruno Rapidel (ed.), Thirion Marie-Cécile (ed.). Ed. Quae, Versailles, pp 43–80. https://doi.org/10.35690/978-2-7592-2822-5

Nchanji YK, Nkongho RN, Mala WA, Levang P (2016) Efficacy of oil palm intercropping by smallholders. Case study in South-West Cameroon. Agrofor Syst 90:509–519. https://doi.org/10.1007/s10457-015-9873-z

Nilsson M, Griggs D, Visbeck M (2016) Policy: Map the interactions between Sustainable Development Goals. Nature 534:320–322. https://doi.org/10.1038/534320a

Nyantakyi-Frimpong H, Mambulu FN, Bezner Kerr R et al (1982) (2016) Agroecology and sustainable food systems: Participatory research to improve food security among HIV-affected households in northern Malawi. Soc Sci Med 164:89–99. https://doi.org/10.1016/j.socscimed.2016.07.020

Okunlola JO, Oke DO, Adekunle VAJ, Owolabi KE (2019) Effects of climate change and coping strategies among crop farmers in South West, Nigeria. Agrofor Syst 93:1399–1408. https://doi.org/10.1007/s10457-018-0263-1

Ouédraogo E, Mando A, Zombré NP (2001) Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa. Agric Ecosyst Environ 84:259–266. https://doi.org/10.1016/S0167-8809(00)00246-2

Payne W, Tapsoba H, Baoua IB et al (2011) On-farm biological control of the pearl millet head miner: realization of 35 years of unsteady progress in Mali, Burkina Faso and Niger. Int J Agric Sustain 9:186–193. https://doi.org/10.3763/ijas.2010.0560

Power AG (2010) Ecosystem services and agriculture: tradeoffs and synergies. Philos Trans R Soc B Biol Sci 365:2959–2971. https://doi.org/10.1098/rstb.2010.0143

Pradhan P, Costa L, Rybski D et al (2017) A Systematic Study of Sustainable Development Goal (SDG) Interactions. Earths Future 5:1169–1179. https://doi.org/10.1002/2017EF000632

Quandt A, Neufeldt H, McCabe JT (2017) The role of agroforestry in building livelihood resilience to floods and drought in semiarid Kenya. Ecol Soc 22:1–12. https://doi.org/10.5751/ES-09461-220310

Rasmussen LV, Coolsaet B, Martin A et al (2018) Social-ecological outcomes of agricultural intensification. Nat Sustain 1:275–282. https://doi.org/10.1038/s41893-018-0070-8

Roy J, Prakash A, Some S et al (2022) Synergies and trade-offs between climate change adaptation options and gender equality: a review of the global literature. Humanit Soc Sci Commun 9:1–13. https://doi.org/10.1057/s41599-022-01266-6

Sachs JD, Schmidt-Traub G, Mazzucato M et al (2019) Six Transformations to achieve the Sustainable Development Goals. Nat Sustain 2:805–814. https://doi.org/10.1038/s41893-019-0352-9

Sanial E, Ruf F (2018) Is kola Tree the Enemy of Cocoa? A Critical Analysis of Agroforestry Recommendations Made to Ivorian Cocoa Farmers. Hum Ecol 46:159–170. https://doi.org/10.1007/s10745-018-9975-0

Sebastian K (2015) Agro-ecological Zones of Africa. Harvard Dataverse. https://doi.org/10.7910/DVN/HJYYTI

Sharma R, Mina U, Kumar BM (2022) Homegarden agroforestry systems in achievement of Sustainable Development Goals. A Review. Agron Sustain Dev 42:44. https://doi.org/10.1007/s13593-022-00781-9

Sibhatu KT, Qaim M (2018) Review: Meta-analysis of the association between production diversity, diets, and nutrition in smallholder farm households. Food Policy 77:1–18. https://doi.org/10.1016/j.foodpol.2018.04.013

Smith Dumont E, Gnahoua GM, Ohouo L et al (2014) Farmers in Côte d'Ivoire value integrating tree diversity in cocoa for the provision of ecosystem services. Agrofor Syst 88:1047–1066. https://doi.org/10.1007/s10457-014-9679-4

Smith OM, Cohen AL, Rieser CJ, et al (2019) Organic farming provides reliable environmental benefits but increases variability in crop yields: A global meta-analysis. Front Sustain Food Syst 3:1–10. https://doi.org/10.3389/fsufs.2019.00082

Snapp SS, Grabowski P, Chikowo R et al (2018) Maize yield and profitability tradeoffs with social, human and environmental performance: Is sustainable intensification feasible? Agric Syst 162:77–88. https://doi.org/10.1016/j.agsy.2018.01.012

Snapp S, Kebede Y, Wollenberg E et al (2023) Delivering Climate Change Outcomes with Agroecology in Low- and Middle-Income Countries: Evidence and Actions Needed. In: von Braun J, Afsana K, Fresco LO, Hassan MHA (eds) Science and Innovations for Food Systems Transformation. Springer International Publishing, Cham, pp 531–544. https://doi.org/10.1007/978-3-031-15703-5_28

Stevens A, Garritty C, Hersi M, Moher D (2018) Developing PRISMA-RR, a reporting guideline for rapid reviews of primary studies (Protocol). http://www.equator-network.org/wp-content/uploads/2018/02/PRISMA-RR-protocol.pdf

The Montpellier Panel (2013) Sustainable intensification: a new paradigm for African agriculture. London. https://www.imperial.ac.uk/africanagriculturaldevelopment/themontpellierpanel/themontpellierpanelreport2013

United Nations Economic Commission for Africa (2022) 2020 Africa Sustainable Development Report: Accelerating Equitable and Sustainable Development in Africa. United Nations Development Programme, New York, NY. https://www.undp.org/africa/publications/2020-africa-sustainable-development-report

Vall E, Marre-Cast L, Kamgang HJ (2017) Intensification pathways and sustainability of crop-livestock systems in sub-Saharan Africa: crop-livestock interaction contribution. Cah Agric 26:2–12. https://doi.org/10.1051/cagri/2017011

Vidogbéna F, Adégbidi A, Tossou R et al (2016) Exploring factors that shape small-scale farmers' opinions on the adoption of eco-friendly nets for vegetable production. Environ Dev Sustain 18:1749–1770. https://doi.org/10.1007/s10668-015-9717-z

Webb P, Benton TG, Beddington J et al (2020) The urgency of food system transformation is now irrefutable. Nat Food 1:584–585. https://doi.org/10.1038/s43016-020-00161-0

Wezel A (2017) Agroecological Practices for Sustainable Agriculture: Principles, Applications, and Making the Transition. World Scientific Publishing Europe. https://doi.org/10.1142/q0088

Wezel A, Casagrande M, Celette F et al (2014) Agroecological practices for sustainable agriculture. A Review. Agron Sustain Dev 34:1–20. https://doi.org/10.1007/s13593-013-0180-7

Wezel A, Herren BG, Kerr RB et al (2020a) Agroecological principles and elements and their implications for transitioning to sustainable food systems. A Review. Agron Sustain Dev 40:1–13. https://doi.org/10.1007/s13593-020-00646-z

Wezel A, Herren BG, Kerr RB et al (2020b) Agroecological principles and elements and their implications for transitioning to sustainable food systems. A Review. Agron Sustain Dev 40:40. https://doi.org/10.1007/s13593-020-00646-z

Willett W, Rockström J, Loken B et al (2019) Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. Lancet Lond Engl 393:447–492. https://doi.org/10.1016/S0140-6736(18)31788-4

Zida Z (2011) Long-term effects of conservation soil management in Saria, Burkina Faso. Wageningen University, West Africa (9789085858362)