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Agroecological approaches to securing rural livelihoods: a critical analysis using the example of Tanzania

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Agrifood systems globally are confronted with mounting challenges, including hunger, rising food prices, and geopolitical tensions. Conventional agricultural models face criticism for causing environmental degradation and increasing poverty, which emphasizes the need for sustainable alternatives. Agroecology emerges as a promising solution that embodies a holistic, farmer-centric countermovement against corporate-led food systems. However, the practical implementation of agroecology as practice, science and social movement faces considerable barriers. Sceptics argue that agroecology is too complex, labor- and knowledge-intensive and cannot keep up with the production level of conventional agriculture. The case study was conducted in Tanzania's Southern Highlands, based on expert interviews and literature analysis. It finds 18 factors that potentially impede the implementation and dissemination of agroecological approaches. Impeding factors exist in all three agroecological approaches. Most obstacles were identified with agroecology as a practical approach. Agroecology as a social movement was only addressed to a limited extent. Main challenges within the approaches include the fear of high financial, time, and energy expenditures when implementing agroecology, difficulties in adopting agroecological practices, the desired and equal collaboration between farmers and researchers, diverging and different definitions and understandings of agroecology, gender relations in farming activities and market and price dependencies for generating income. The study emphasizes the need for collaborative efforts, awareness, and supportive policies to promote agroecology effectively. The research contributes to bridging the gap between theoretical debates and practical applications of agroecology and urges rethinking and revising its conceptualization.

KEYWORDS

Tanzania, agroecology, agrifood system transformation, hindering factors, rural livelihood, small-scale farming

Introduction

Hunger, despite a worldwide decline in relative and absolute levels in recent decades, is a persistent and serious problem, especially in parts of Asia and on the African continent. Significant parts of the world population suffer from undernutrition. Current statistics from the World Food Program (WFP, 2023) reveal that 738 million people face hunger, 333 million are affected by acute food insecurity, and approximately 45 million children below the age of five are projected to suffer from acute malnutrition. This global food crisis is attributed to a heightened frequency and severity of climate shocks, the aftermath of the COVID-19

pandemic, geopolitical tensions, rising food and fertilizer prices and unfair distribution of resources and power. This impacts global trade, raises food and transportation costs, and puts an immense pressure on agrifood systems. As the intervals between crises become shorter, agrifood systems have less time to recover, which requires increased adaptability and responsiveness (Hauser, 2023). Agroecological approaches are recognized for their potential to initiate significant changes by enhancing adaptability and reducing vulnerability to disasters (Poux and Aubert, 2018).

Widespread criticism is directed at dominant industrial and conventional agricultural models for their association with environmental destruction, their focus on monocultures and export orientation, a reduction in local food diversity and availability, the displacement of smallholder farmers by agribusinesses, unfair distribution of resources such as land, water and funding, precarious working conditions and low wages, price volatility and dependence on global markets. On the surface, productivity of agrifood systems worldwide has increased for a long time. Yet most agricultural production models drive a race for increased production, market penetration, and capital accumulation (Altieri, 1995). While allegedly serving the goal to “save people from hunger,” current modes of food production are primarily driven by capital interests, not humanitarian considerations. These models of agrifood production typically rely on the over-exploitation of nature and people, manifested in low wages and the externalization of environmental costs (HLPE, 2019; Wezel et al., 2009; Iderawumi, 2020).

In contrast to these conventional models, agroecology emerges as a promising practical approach. It addresses current challenges in agrifood systems and improve the shortcomings of other agricultural models. Agroecology as a political approach is deemed more sustainable and healthier for both the natural environment and people than the corporate food system (Altieri and Nicholls, 2020; FAO, 2020; Wezel et al., 2020; Oteros-Rozas et al., 2019). The ability to implement agroecological approaches is based on their holistic nature, which deviates from prefabricated, standardized agricultural practices. Instead, agroecology adapts to the site-specific context of the agricultural ecosystem and socio-cultural setting, incorporating ecological and normative principles (Sinclair et al., 2019; INKOTA-netzwerk e.V., 2019; FAO, 2018). Smallholder farmers are key actors who use their knowledge and skills in agricultural production systems. It is estimated that small-scale farms constitute about 80% of all farms worldwide. They play a significant role in addressing issues such as climate change, food insecurity, and market changes (Bezner Kerr et al., 2021; Monjane, 2018).

Agroecology, in theory, is a discipline that provides fundamental ecological principles on “how to study, design, and manage agroecosystems” (Altieri, 1995). An objective is to minimize the overt and hidden socio-ecological costs associated with agriculture and the overall agrifood systems, like soil degradation, water contamination, greenhouse gas emissions, and social inequalities (Bezner Kerr et al., 2021; Altieri, 1995). Agroecological approaches seek to redesign farming systems towards sustainability and climate resilience and thus take account of food security concerns.

In Africa, smallholder farmers face challenges due to the expansion of the global fertilizer industry, which see the continent as a crucial market. While synthetic fertilizer use is in decline in developed markets, it expands in Africa (Tups, 2022; Zinke, 2022). Smallholder farmers struggle with the affordability of industrial inputs, while at the same time lacking access to sufficient organic alternatives. Their dependence on fluctuating fertilizer prices and the

availability of products renders them vulnerable and underlines the need for sustainable solutions (Tups, 2022; Urhahn and Bassermann, 2020; Monjane, 2018).

The tripartite nature of agroecological approaches—technological application, knowledge production, and political vision—provides an analytical framework for current food production challenges (Wezel et al., 2009). Agroecological approaches can be addressed either individually or collectively, but they are considered to be more effective in the latter case (Méndez et al., 2017; Loconto and Fouilleux, 2019; Barrios et al., 2020). Advocates argue for agroecological transformation by citing its potential to combat resource and human exploitation and empower marginalized groups (Altieri, 1995; Monjane, 2018; Gliessman, 2018). Critics point to complex obstacles and question its ability to match conventional agriculture’s production levels (Bellamy and Ioris, 2017; Mugwanya, 2019; Kansanga et al., 2020).

The research interest in agroecological approaches arose from these global challenges and from disagreements about the potentials and difficulties of agroecological approaches. The state of research demonstrates that agroecology basically remains a theoretical approach and is rather marginally applied in practice compared to other agricultural models, raising the question why that is the case. There is a shortage of scientific studies that thoroughly examine practical problems of these approaches. The study therefore seeks to ascertain the factors for its marginal application by taking the Southern Highlands of Tanzania as case study. It addresses a critical gap in the scientific literature by examining and systematizing overlooked internal barriers to agroecological approaches and seeks to identify and understand the inherent limitations. The significance lies in establishing a robust scientific foundation to enhance the effectiveness of agroecological approaches as transformative approaches. The research object is the perspective of experts on such hampering factors of agroecology in order to understand local challenges and provide information for future research.

This paper addresses the research question: *Which factors impede the implementation of agroecological approaches in the Southern Highlands of Tanzania?* The research question posits agroecology as a viable political action approach. The Southern Highlands are chosen due to their susceptibility to climate change, recurrent droughts, and the prevalence of malnutrition, which reinforces high pressure on people and agricultural systems (Monjane, 2018). The agricultural landscape in Tanzania, predominantly shaped by subsistence farming, makes it an ideal setting for investigating the applicability and challenges of agroecological approaches. Additionally, the country faces a triple burden of malnutrition. Childhood undernutrition, high levels of micronutrients deficiencies among children and women, and increasingly high level of overweight and obesity are particularly high in the Southern Highlands (United Republic of Tanzania, 2019a).

Theoretical approach

Agroecological approaches serve as the theoretical framework for this study and form the theoretical basis on which the hindering factors were identified.

Agroecology as a practice applies ecological principles to agriculture (Lampkin et al., 2021; Wezel et al., 2009), which aim, i.e., for efficient resource use, reduced industrial inputs, crop diversification, soil health and fertility, and enhanced interactions between plants, animals, and the

environment (Sinclair et al., 2019; INKOTA-netzwerk e.V., 2019). Agroecosystems should mimic the functioning of local ecosystems and thus achieve a close nutrient cycling (Altieri, 2002). The main goal is a transformation of agricultural systems. However, there is no fix set of practices with which agroecology can succeed (Sinclair et al., 2019; Wezel et al., 2020).

Agroecology as a science is an academic discipline that integrates elements from agronomy, ecology, sociology and economics (Lampkin et al., 2021; Wezel et al., 2009). It is the study of ecological concepts and principles to the design and management of agroecosystems that are both productive and serve the conservation of natural resources, are culturally sensitive, socially just and economically viable (Wezel et al., 2009; Altieri, 1995, 2002). The transdisciplinary nature of the approach sets the goal to involve all stakeholders in knowledge generation and research (Sinclair et al., 2019).

To social movements and farmers' organizations, agroecology is a political framework in which they can defend their collective rights and advocate for the diversity of locally adapted farming and food systems (Méndez et al., 2017). A stronger link between agroecology, the right to food, environmental integrity and food sovereignty is key to the success of the approach in the political dimension. Social movements are engaged in a political struggle, explicitly addressing power imbalances and demanding change in policies and practices (Nyéléni Declaration, 2007).

The paper posits that the successful implementation of agroecology can potentially secure rural livelihoods at the individual, household and landscape level. However, the primary objective of the paper is not to assess the efficacy of agroecological approaches in securing rural livelihoods. Instead, the research aims to identify and explore factors that impede a successful implementation of agroecology.

Despite case studies showcasing successful agroecological implementations across various scales and regions, including Tanzania (e.g., Pant, 2016; Lampkin et al., 2021; Méndez et al., 2017; Diesel and Miná Dias, 2016; SwissAid et al., 2021; AFSA and TOAM, 2016), the existing body of research indicates that tensions within agroecological approaches often lead to implementation challenges. A distinction must be made between problems within the approach itself and external structural problems on the political and institutional level. This includes the need for a coherent transformation and requires changes aligning with national contexts and capacities, as emphasized by the Committee on World Food Security (CFS, 2021).¹

Structural challenges include political, social and economic aspects that influence each other and are accompanied by historically evolved power structures. They pervade society and institutions, regulate access to resources, influence and control over decisions and systematically disadvantage certain groups. For agroecological approaches to achieve efficiency and stability, power dynamics must be critically recognized, made visible and dismantled. Profound changes in the institutional

framework are therefore required (González de Molina, 2013; Oteros-Rozas et al., 2019; González de Molina et al., 2020). The establishment of market dynamics in local agrifood systems, driven by international actors such as the World Trade Organization (WTO) result in the global capitalist penetration of agrifood systems, mostly benefitting the interests of transnational corporations (TNC). Neoliberal globalization in trade also increases the profitability of TNC engagement in corporate food systems (Altieri, 2002). In addition, the public and private sectors can influence market development directly and indirectly through intervening in the market—through purchasing decisions, through regulation and provision of incentives such as fertilizer subsidies, through speculation and hoarding with agricultural products. This can negatively influence a (large-scale) implementation of agroecological practices (Foran et al., 2014).

Agroecology, though most prominent in smallholder farming, is equally needed for large-scale agriculture. However, practical and theoretical knowledge gaps hinder its broader adoption (Tittone et al., 2020). Key challenges identified by Valdivia-Díaz and Le Coq (2022) include: insufficient in-field support and sustainable innovation (knowledge dimension), limited access to native seeds and biological inputs (resource dimension), lack of loans and crop insurance (economic dimension), low consumer awareness and lack of formal sanitary authorizations adapted to agroecological production (market dimension), weak collaborations across sectors (alliance dimension), and insufficient public funding and lack of recognition of economic contributions (political dimension). Effective scaling requires active participation from consumers, citizens, and public authorities, though mobilizing such collective effort remains a major challenge (Gascuel-Oudoux et al., 2022).

Demographic changes, urbanization, land grabbing and limited infrastructure further hinder agroecological growth (Morton, 2007; Hall et al., 2017). The negative bias towards agroecological approaches within educational institutions, as well as narratives pessimistic about its productivity, contribute to challenges and necessitate comprehensive reforms to integrate agroecology into agricultural production (Petersen et al., 2012; Bellamy and Ioris, 2017; Bergius and Buseth, 2019). The above-mentioned narratives justify the continued and widespread application of industrial inputs in smallholder agriculture, allegedly to achieve the Sustainable Development Goals (SDGs). This can be referred to as the “green modernization-development discourse” (Bergius and Buseth, 2019).

Despite the diversity of external challenges to agroecology, this theoretical discussion reveals internal problems of the approaches, which can be summarized as follows: The *challenges of agroecological practices* are rooted in their varying applicability, which depends on local circumstances, existing farming systems, and ecological conditions. Agroecology's aim is to converse farming systems from high-input conventional management systems to low external input systems. The conversion process involves increased efficiency in the use of inputs through integrated pest or soil fertility management; the substitution of inputs or replacement with environmentally sound inputs; and a system redesign, including diversification with an optimal mix of crops and livestock that promotes synergy so that an agroecosystem can support its own soil fertility, natural pest regulation and crop productivity (Altieri, 2002; Altieri and Nicholls, 2004; Wezel et al., 2014). Agroecological transitions demand not just technological innovation but also farmer mobilization and cooperation (Oteros-Rozas et al., 2019). A diverse array of challenges, such as *high expenditures in time, energy and money, and labor*

¹ Key sources of the identification of factors are Altieri (2002), Wezel et al. (2014), Oteros-Rozas et al. (2019), Hatt et al. (2016), AFSA and TOAM (2016), Méndez et al. (2017), Gliessman (2016), Coolsaet (2016), Giménez Cacho et al. (2018), Kansanga et al. (2020), Bezner Kerr et al. (2021), Akram-Lodhi (2015), Altieri and Nicholls (2020, 2004), Lefèvre et al. (2020), Bellamy and Ioris (2017), González de Molina (2013), Sinclair et al. (2019), HLPE (2019), Utter et al. (2021), Altieri and Toledo (2011), Mockshell and Kamanda (2018), Mugwanya (2019), Mdee et al. (2019) and Tups (2022).

intensity complicates implementation, especially for smallholder farmers (Hatt et al., 2016; Richter and Tekülve, 2021; Mugwanya, 2019; Mdee et al., 2019; AFSA and TOAM, 2016). A *long-term perspective* is necessary for the conversion of an established agricultural and social behavioral system to one based on agroecological principles. A conversion process is time-consuming and also depends on external influences such as land rights and ownership. It involves trial and error, convincing farmers and requires customized agricultural practices (Hatt et al., 2016; Gliessman, 2016). *Convincing farmers* becomes a crucial factor in overcoming cultural barriers and gaining trust through practical evidence (AFSA and TOAM, 2016; Oteros-Rozas et al., 2019). *Providing incentives* to farmers can motivate them to participate in agroecological projects. Incentives provided from external actors include, for example, government subsidies; incentives that are realized internally refer, for example, to fair compensation for the time spent by farmers, and access to well-equipped land and markets (Altieri, 2002; AFSA and TOAM, 2016; Utter et al., 2021). Dependence on the *availability of organic inputs* is a challenge when it comes to ensuring a constant supply of high-quality inputs for productivity and food security while reducing dependence on industrial inputs (HLPE, 2019; Tups, 2022). *Farmer-to-farmer interaction* is central to agroecology as it promotes horizontal knowledge transfer and rejects top-down approaches. Farmer networks and cooperatives strengthen social cohesion, trust and food security and rely on the co-production of knowledge for effective transfer (Giménez Cacho et al., 2018; Kansanga et al., 2020; Petit et al., 2020; Bezner Kerr et al., 2021). In order to improve and disseminate agroecology, *more research* is still required (Altieri, 2002). This is coupled with a *lack of evidence* that agroecological approaches work in practice, which calls into question their feasibility and necessitates exploration through participatory research. It refers to evidence for farmers applying the practices as well as for policy makers, scientists, funders, the media, consumers or schools to support the dissemination of agroecology (AFSA and TOAM, 2016; Coolsaet, 2016). Critical to agroecological success is a *collaboration between research institutions and local communities* that involve farmers in the formulation of the research agenda and the process of technological innovation, even when different interests, logistical barriers and power imbalances present a challenge (Altieri, 2002; Méndez et al., 2017; Utter et al., 2021). Additionally, *multi-actor knowledge and exchange networks* and meetings are necessary to advance agroecological approaches. This is where different stakeholders with different types of knowledge come together so that new meanings and agricultural practices can be negotiated and institutionalized, either in their networks or at a higher policy level (Šūmane et al., 2018). At the same time, farmers often have to turn to *different institutions to resolve their concerns*. They rely on NGOs to represent their concerns in higher-level political decision-making processes, where they have limited direct influence. The *market imperative* demands that food producers sell their products at competitive market prices if they want to stay in business. This implies a constant effort to reduce production costs, which in turn requires to use revenues from sales to invest in techniques and technologies. However, not all producers can compete in this capitalist structure. Small producers and businesspersons in particular have to resort to wage labor and distress sales to meet their short-term cash needs and may even have to rely on asset sales later on (Akram-Lodhi, 2015). González de Molina (2013) emphasizes the importance of conscious consumers who are aware of the benefits of agroecology. A

successful transition requires *consumer responsibility* and a closer connection between producers and consumers at the local level. *Gender relations* are crucial, with men and women playing distinct roles in ensuring household and community food security. Women are increasingly dominating agricultural production due to demographic change and out-migration of men. They often face economic marginalization and a lack recognition. However, agroecological methods may impact women's workload if household gender relations are not transformed (Santoso et al., 2021; Waceke and Kimenju, 2007; FAO, 2019; HLPE, 2019). The concepts of *food security vs. food sovereignty* play a crucial role in the discourse of agrifood systems and how to defeat hunger and malnutrition. Both concepts are interconnected with agroecology, although this depends on how agroecology is understood (Schöneberg et al., 2022). The dynamic nature of agroecology additionally leads to *different definitions and understandings*, which raises concerns about the appropriation and loss of policy content.

Materials and methods

The research objective of the study is the perspectives of experts about agroecology which are investigated in the Southern Highlands of Tanzania. The logic of inquiry is based on the presupposition that the theory (agroecological approaches) only works to a limited extent in practice, whereby the aim is to ascertain what factors are responsible for this. Regarding the research question, it is effective to conduct a single case analysis. It serves to examine the complexity of a case and helps to understand and interpret the influencing factors and their interrelationships (Mayring, 2002). Individual case results can be embedded in larger social contexts. An individual case thus illuminates a characteristic of the social totality, which is an analytic generalisation rather than a statistical generalisation (Yin, 2014). While agroecology is expected to bring more equitable change, this expectation does not seem to match the reality in the Southern Highlands. By studying this case, we were able to explore specific challenges of implementing agroecology there. Although it was not possible to make broad conclusions, the challenges identified in existing research point to key areas where agroecological approaches face difficulties.

Data collection

This work follows Gläser and Laudel's (2010) definition according to which an expert is "[...] a source of specialised knowledge about the social facts being researched." Expert status is not understood as a personal characteristic or ability, but as an attribution. This attribution occurs when the interviewer addresses certain people as experts based on specific knowledge about the research interest (Bogner et al., 2014). A total of 35 experts were approached. We were able to conduct semi-structured interviews with 31 of them (Table A1). Our aim was to involve different stakeholders engaged in the study and implementation of agroecology in the Tanzanian Southern Highlands. We identified interviewees in three ways: through internet research, our own networks of relevant contacts and through the snowball system, where interviewees were asked to recommend other relevant experts. This process should ensure that counter-positions are included as well to avoid the risk to overlook important positions and

actors (Bogner et al., 2014). Despite the intention to work with a heterogenous sample of interview partners, it was not possible to conduct interviews with opponents or sceptics of agroecology, research institutes and further governmental representatives. This led to an NGO- and farmer-dominated view on the implementation of agroecological approaches (Table A2). To compensate for this, we complemented these perspectives through literature review.

The main objective of the interviews was to gain insights into the views of the different stakeholders regarding (a) the way agroecological approaches are applied, implemented and disseminated and the knowledge about them, and (b) factors that prevent a successful implementation of agroecology in the Southern Highlands and solutions for it. The interviews were carried out both through the video-conferencing software Zoom and in-person. Recordings were made with the interviewees' consent for documentation purposes. The interview sessions took place from May 11 to December 9, 2022, with durations ranging from 40 min to 2 hours. English was used as common language, as the participants speak different first languages. The interviewed farmers only spoke Swahili and other local dialects, wherefore the interview was translated into English by an interpreter.

Prior and informed consent was obtained from all study participants, and interviewees were anonymized thoroughly to protect their safety and privacy.

Data analysis

We used a Qualitative Text Analysis. The processing of data was guided by the category formation of Kuckartz (2019). We used a deductive development of analysis categories, whereby categories

based on the theoretical framework and state of research were developed. The ambition of the study was to investigate agroecological approaches in its holism. The main categories therefore reflect the three agroecological approaches—as a practice, science and social movement. Their purpose is to classify the subcategories and to show whether an approach dominates in the analysis. To fulfil an agroecological vision, we identified three main goals of agroecological approaches, which form the subcategories. First, the predominant goal and simultaneously a challenge of agroecology as a practice is to transform conventional to agroecological farming systems, which are more complex and demanding. Second, the incorporation of different knowledge systems is a basis in agroecology as a science. The inclusion of local expertise and farmers' knowledge is crucial to transform agrifood systems. Third, while a transformation of agrifood systems is the overarching goal of the agroecology-as-a-social-movement approach, it is also one of the most complex structural challenge.

The hindering factors form sub-subcategories. We identified them based on the state of research and theory. We looked for challenges that have been described in the literature as obstacles to agroecological implementation. We sorted these challenges thematically and used them to form factors. These factors were then assigned to the thematically appropriate subcategories, which cluster the hindering factors for a better overview. The interview questions were the tool to make the research question measurable. To trigger the perspectives on sub-subcategories, a key question was asked during the interviews. It was about factors that prevent a successful implementation of agroecology in the Southern Highlands. Challenges of agroecological approaches became tangible when statements from the expert interviews were assigned to the respective sub-subcategories based on the interview questions (see Table 1).

TABLE 1 Category system.

Supercategory	Subcategory	Sub-subcategory
Agroecology as a practice	Transformation of agricultural farming systems	Challenges of agroecological practices
		Long-term perspective
		Amount/availability of organic inputs
		Conviction of farmers
		Labour intensity
		Expenditure (monetary, time, energy)
		Incentive provision through agroecology
		Variety of institutions for different concerns
Agroecology as a science	Knowledge variety	Research necessity
		Collaboration between researchers and farmers
		Lack of evidence
		Different definitions and understandings
		Networking between agroecological partners
		Farmer-to-farmer interaction
Agroecology as a social movement	Transformation of agrifood systems	Gender relations
		Logic of the market imperative
		Consumer habits
		Food security vs. food sovereignty

The interview data was transcribed with the transcription software F4. The transcribed interviews were used to identify expert's views and experiences with the implementation of agroecological approaches and their opinion about the hindering factors identified from the state of research. We present our findings in a condensed format and maintain anonymity of the interviewees by not associating specific ideas or perspectives with individual respondents. Being able to identify them and assign them to statements could harm them.

The data analysis is category-based to analyze topical statements and realities of the experts, which enables an analysis of interrelationships between categories. This served to gain an overview of the respondents' views on agroecological approaches. The aim is to derive a trend as to what their views could mean for the implementation of agroecological approaches in the Southern Highlands.

The Results section is entirely derived from our interviews. In the Discussion section, we provide our own analysis of the findings and establish connections between these findings and the broader literature.

Case study: Southern Highlands

The field study took place in Tanzania's Southern Highlands (latitude 6°–12° S, longitude 29°–38° E). They encompass Iringa, Mbeya, Rukwa, and Ruvuma region (see Figure 1). The elevations from the sea level range from 400 to 3,000 meters, with a climate that varies from semi-arid conditions in Iringa to high rainfall in the highlands. The region's diverse topography includes hills, plateaus, volcanic mountains, and flat areas with swamps and ponds. Annual rainfall ranges from 823 to 2,850 mm, falling primarily from November to April, when soil moisture is essential for agricultural activities like plowing and sowing. The dry season spans from May to October. The study was conducted shortly after the rainfall season. The annual temperatures averages 22°C (Mbululo and Nyihirani, 2012).

Six main ethnic groups, primarily subsistence farmers and pastoralists, inhabit the highlands. The Safwa and Nyakyusa are traditionally farming communities who live in the mountains of Mbeya. The Wanda and Nyamwanga farm lowlands near Malawi and Zambia. In Njombe's Kipengere mountains, the Bena are predominant, and the Kinga reside around the Livingstone mountains, both practicing agriculture and livestock rearing. All groups are of Bantu origin and have similar dialects. The Southern Highlands are a major agricultural zone that contribute 46% of Tanzania's maize production. Over 80% of the maize is grown by smallholder farmers (Mfwango et al., 2018). Farming and livestock keeping are the main source of livelihood and economic activities. Main crops include maize, potatoes, wheat, millet, sunflower, cassava, coffee, and spices like cardamom and garlic. Climate change is seen as a key factor that alters agricultural practices, particularly due to reduced rainfall, delayed rainy seasons, increased drought, and rising temperatures. Unpredictable rains have pushed farming into wetland areas, causing deforestation, biodiversity loss, and wetland shrinkage. Farmers reported that climate change is massively harming agricultural practices and socioeconomic stability in the area (Kangalawe, 2016; Muganyizi et al., 2021). Furthermore, the level of malnutrition and stunting are particularly high in the Southern Highlands. The highest stunting prevalence ($\geq 40\%$) is in Njombe, Rukwa, Iringa, Songwe and three regions in the northwest of the country. Chronic malnutrition in children (0–59 months of age) is very high ($\geq 30\%$) and thus a public health concern (United Republic of Tanzania, 2019b).

The agricultural system in Tanzania is characterized by Green Revolution ideas—a set of technologies and agricultural practices transforming agriculture in developing countries (Patel, 2013). They include subsidizing synthetic fertilizers and hybrid seeds, as well as allocating land for large-scale agricultural intensification (Bezner Kerr et al., 2019). The Green Revolution is regarded as controversial due to negative impacts for (smallholder) farmers and the environment, like market- and supplier-dependencies, inequitable land distribution, insecure ownership, biodiversity loss, environmental pollution, and replacement of traditional nutrient-rich crops by higher-value cash crops (Skerritt, 2016; Pingali, 2012). The narrative of food scarcity is thereby still used as a humanitarian driver to continue to promote unsustainable investments in the style of the Green Revolution (Rasmussen, 1986). Tanzania's agricultural system is based on neoliberal principles and favors large-scale corporate investments. Two big state initiatives in the spirit of the Green Revolution in Tanzania are the Alliance for a Green Revolution in Africa and the Southern Agricultural Growth Corridor of Tanzania, which leads through the Southern Highlands. Even in the National Agriculture Policy (NAP), alternative models are barely represented. The NAP mentions organic farming mainly as an income opportunity without a strong commitment to sustainable practices (Ministry of Agriculture Food Security and Cooperatives, 2013). In 2015, Tanzania launched the 'National Ecological Organic Agriculture Strategy' (NEOAS) to enhance organic farming. However, NEOAS does not oppose conventional agriculture, but promotes benefits of organic farming and emphasizes consumer choice. Unfortunately, there is no reference to agroecology (FAO, 2023a; Desertif'actions, 2022).

Civil society organizations, on the other hand, are very active in advocating for agroecology, food sovereignty, and the right to food. NGOs like Sustainable Agriculture Tanzania (SAT) or Mtandao wa Vikundi vya Wakulima Tanzania (MVIWATA) implement agroecological projects for smallholder farmers. SAT (2016) reports a nationwide rising interest in organic food for its health benefits. The Arusha Collaborators for Agroecology Forum (ACAF) brings stakeholders like farmers, private sector and agricultural extension officers together quarterly to discuss about agriculture and policy. European NGOs like SwissAid and Biovision, and research institutes like the African Centre for Biodiversity and Sokoine University of Agriculture, aid local agroecology efforts. The Tanzania Agricultural Research Institute (TARI), under the Ministry of Agriculture, also supports agroecological research through its sub-centers in the Southern Highlands (TARI, 2024a).

Results

The scientific contribution of our research consists of providing a set of 18 hindering factors (Figure 2), inherent in agroecological approaches, extracted from the state of research and from expert interviews. These factors enable a critical examination of agroecological approaches and provide insights for potential re-evaluation and revision. While the analysis of hindering factors does not definitively answer the question whether agroecological approaches secure rural livelihoods due to data limitations specific to Tanzanian experts, it does shed light on how these experts perceive the approaches. Qualitative primary data could be collected through

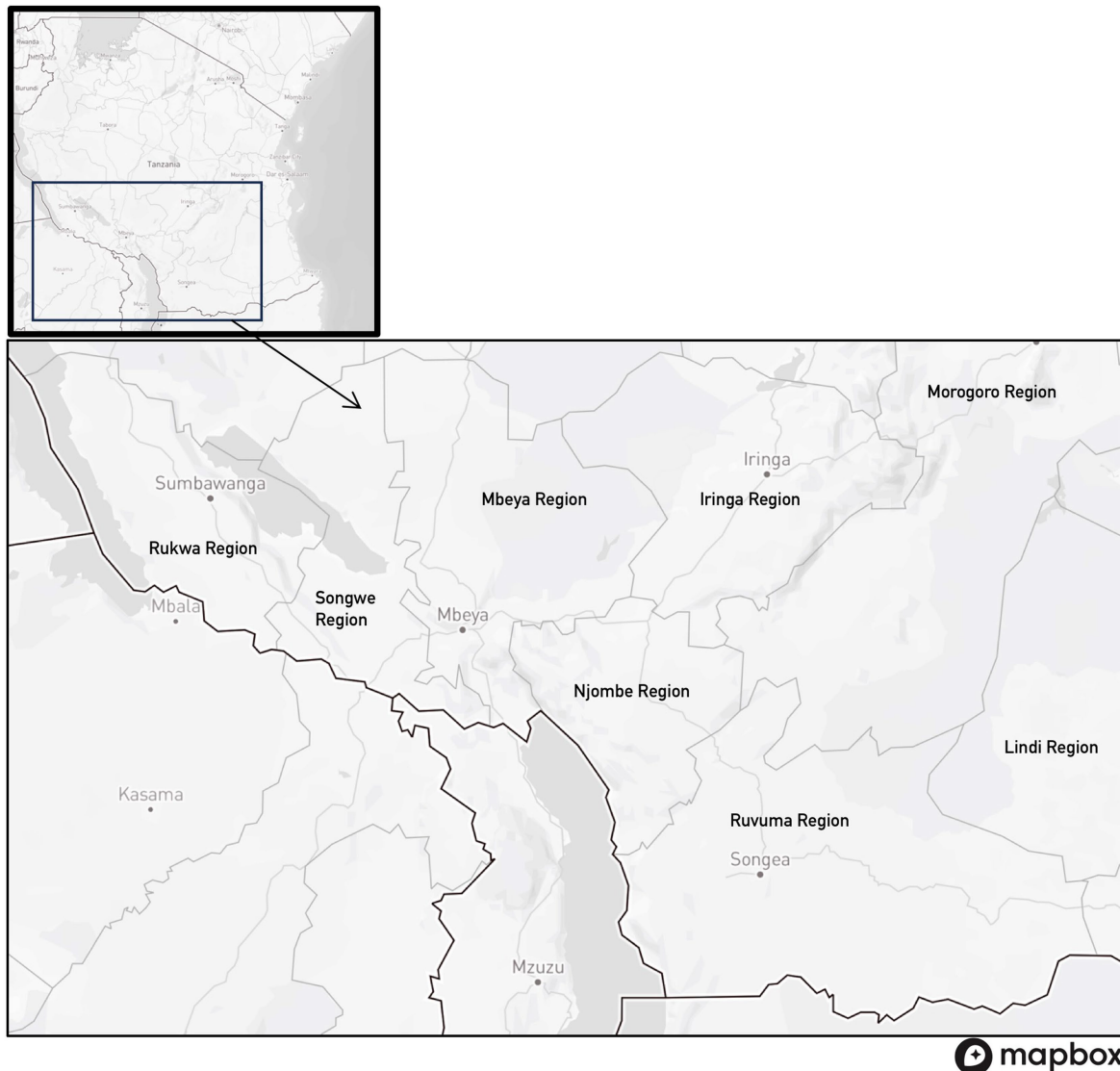


FIGURE 1
Tanzania, Southern Region, situation within Tanzania. Map source: Mapbox. © Mapbox, © OpenStreetMap.

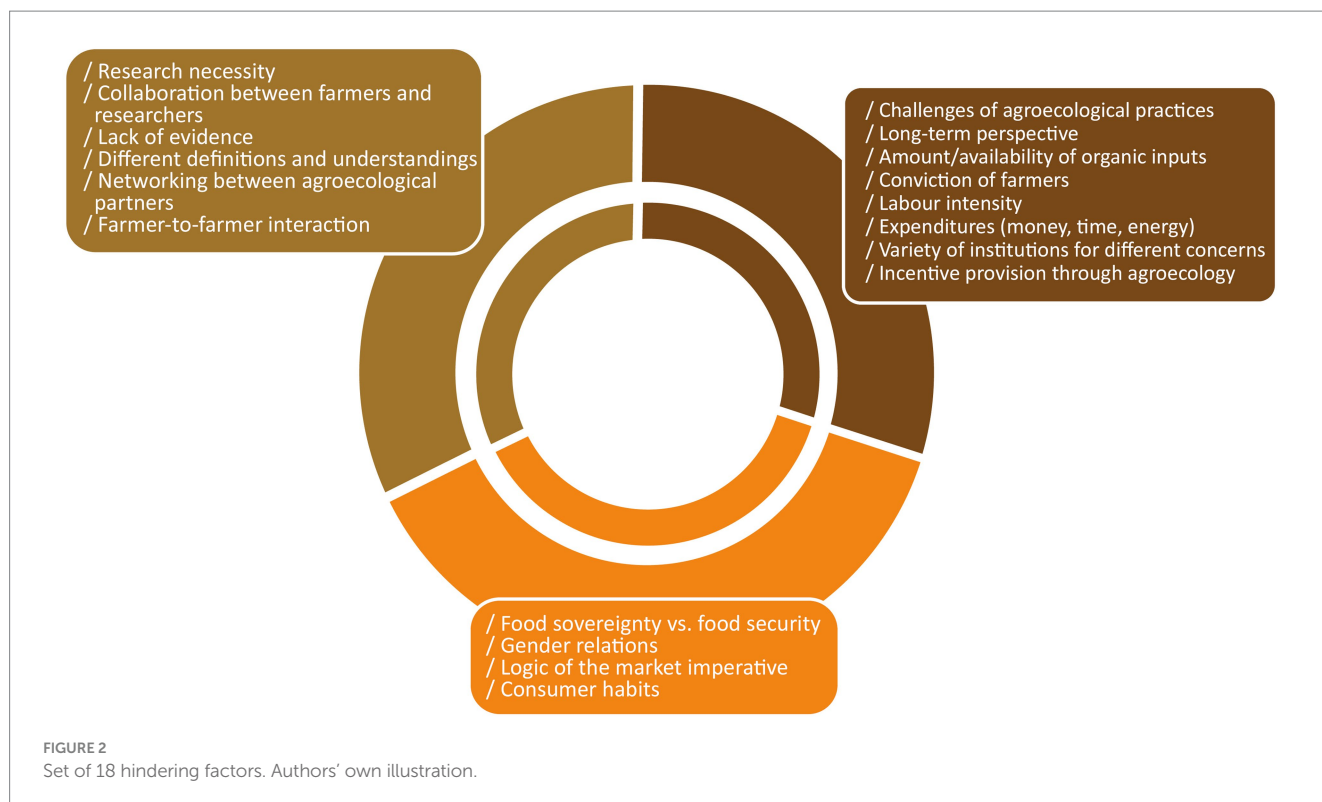
interviewing experts. They offered firsthand perspectives on experiences and realities in the research region. The experts' daily work in the field allowed them to identify core challenges of agroecological approaches, which are reflected in the hindering factors identified from literature. The findings confirm the existence of hindering factors in practice and indicate an implicit or explicit incorporation of agroecological approaches in their work orientation, projects or farm orientation, albeit to varying degrees.

To fulfill the agroecological vision, three main goals but simultaneously major challenges could be identified from theory for the respective approaches: transformation of agricultural farming systems (belongs to agroecology as practice), using knowledge variety (belongs to agroecology as science) and transformation of agrifood systems (belongs to agroecology as social movements). Recognizing these goals facilitates thematic classification and clustering of hindering factors for a comprehensive understanding and correlation establishment.

Transformation of agricultural farming systems

It is challenging for implementers and smallholder farmers to transform agricultural farming systems to agroecology. Even though farmers can be accompanied by researchers or organizations, it takes times to find methods fitting the local context. Even the soil must be adapted to a change of inputs, farming techniques, and crops. If the soil is adapted to frequent application of synthetic fertilizers, and may already be depleted, it will rarely respond positively to organic fertilizers straight away. Several factors can hamper a transformation, which will be analyzed in the following.

The interviewees highlighted *challenges in agroecological practices* by focusing on compost manure, pest control, farm implements, and soil conservation. Challenges with compost manure include production difficulties, especially in dry seasons, and the year-round availability or the labor-intensive pits-making. Farmers reported that “compost



manure is used in nearby fields, and chemical fertilizer [mostly available in a spray bottle] is used on farms far away from homes. It is difficult to transport compost manure to the distant fields” (R3, personal communication, May 11, 14–15, 2022). Pest management poses difficulties due to limited knowledge on how to produce natural pesticides. If farmers would see that natural pesticides or organic pest control are as efficient as synthetic ones and do not create extra workload, they would tend to use the natural or organic ones (R2, personal communication August 29, 2022; R8, personal communication, November 23, 2022). Soil conservation measures are received differently by farmers, indicating the complexity of implementing different agroecological practices (R3 and R4, personal communication, May 11, 14–15, 2022). Farmers, who are facing concerns of low crop production and frequent droughts, explore soil conservation measures as an alternative to irrigation agriculture. Unfortunately, this is hindered by the high cost of infrastructure and unreliable water resources. While some farmers receive training on soil conservation from implementing NGOs, the adoption of practices such as contour farming, crop rotation, agroforestry, and minimizing burning of plant residues varies among the farmers interviewed, reflecting a mixed response to these agroecological solutions (R3 and R4, personal communication, May 11, 14–15, 2022).

A challenge in promoting agroecology lies in the *long-term* versus *short-term perspective*. Industrial inputs may offer higher short-term yields when considering immediate outcomes, but result in long-term issues like soil degradation, acidification and erosion and loss of biodiversity. This short-time strategy of applying synthetic inputs inhibits the creation of soil nutrient cycles. Often, such negative outcomes are not considered when deciding for a farming model, practices and inputs. Soil depletion is among the costs that are invisible at first but evoke even higher costs in the long run. In agriculture, which is deeply rooted in tradition, change

requires persuasion and time. A gradual transformation, initiated through education, training, and practical demonstrations, is essential, as farmers are likely to resist abrupt changes imposed by organizations. R7 (personal communication, November 18, 2022) adds that “sometimes you just want to see what’s happening the following day. You do not care about what’s going to happen in ten years. Of course, conventional farming will bring more yield from season to season.” A lot of communication, convincing, evidence is necessary for a shift. Land ownership also impacts managerial practices and the adoption of new agricultural technologies if leases are short-term and incentives for investing time in improvements are low. R7 (personal communication, November 18, 2022) explains that this especially applies for agroecology:

“[...] because you need to have a long-term perspective. Agroecology is like ten years perspective typically, where you can really enrich the soil with organic matter and it’s only after two or three years that you will start receiving results.”

A central challenge in promoting agroecology lies in the *limited availability and affordability of organic inputs*. The non-availability of subsidized industrial inputs, however, could incentivize the adaption of organic alternatives. In the interviews, some farmers mentioned that they used self-produced organic fertilizers exclusively or in addition to synthetic fertilizers. According to farmers’ responses, some stick to synthetic fertilizers due to its perceived preferable performance, while others switch to organic inputs driven by concerns about rising synthetic fertilizer prices (R3, personal communication, May 11 and 14, 2022). R12 (personal communication, November 28, 2022) explains that “when the prices are good for [industrial] inputs, they [farmers] will go for external input and when it is difficult, they will go for

agroecological agriculture.” The interviewee clearly states that the use of fertilizers is highly dependent on external pricing, as well as on its practical application. When using organic fertilizers, farmers mainly use compost and animal manure. In some cases, it could be observed that farmers bought cattle to have access to additional organic material for the fertilization (R3, personal communication, May 11 and 14, 2022; R12, personal communication, November 28, 2022).

The *conviction of farmers* is a pivotal factor in adopting agroecological practices. It influences individual farming methods, crop varieties, and overall attitudes toward change. The acceptance of farmers is crucial for the long-term success of new practices. In development projects, NGOs frequently collaborate with intermediary farmers, who assume the roles of conducting training sessions, transmitting project data to NGOs, serving as local points of contact for queries and concerns, and ideally continuing to train new participants even after the project concludes. Convincing farmers requires a collaborative approach, with intermediary farmers serving as influential agents of change because they see eye-to-eye with the farmers. This is more convincing than an organization telling farmers top-down what they should change. This has to do with the balance of power and different hierarchical levels emanating from an external actor. However, challenges arise when key individuals are no longer present, which underlines the need for long-term commitment and evidence of positive outcomes. Farmers’ beliefs go beyond evidence and include mindset, perceived cost of change, income generation considerations and external constraints. Some organisations note that a lot of farmers are captured in an old mindset because “people have been trained on conventional agriculture all over, so education has to change” (R7, personal communication, November 18, 2022). Prevailing information contain conventional farming techniques due to the educational system’s focus, government programmes and subsidies. In addition, there is conflicting advice from different stakeholders and the perception that industrial inputs equate to higher productivity confuses farmers (R3, personal communication, May 11 and 14, 2022; R7, personal communication, November 18, 2022; R9, personal communication, November 24, 2022; R12, personal communication, November 28, 2022). R8 (personal communication, November 23, 2022) emphasizes that “those who are producing synthetic fertilizers and hybrid seeds, [...] were even giving them [farmers] free seeds or fertilizers, though they are inorganic, and they were telling them that if you apply this, you’ll get a higher yield.” This further complicates the adoption of agroecological practices.

The *intensity of human labor* required for agroecological farming was often mentioned in the expert interviews as a hindering factor if comparing with conventional farming. In “conventional agriculture, you buy packets of fertilizer and seeds,” which saves time and energy (R1, personal communication, August 23, 2022). Concerns include the complexity of practices, such as the manual production of compost and the collection of animal dung, which add to the already high workload in agricultural. This has to be done alongside other daily tasks such as cooking, livestock keeping, collecting firewood, producing charcoal, visiting markets or working on the fields. R1 (personal communication, August 22, 2022) identifies labor requirements in the beginning and a lack of technological innovations, such as tractors or oxcarts, as the only drawbacks of agroecology. The interviewee also recognized high workload as a major threat to gender equality because the workload often falls differently to men and women. While initial labor demands are acknowledged, proponents

argue that once established, agroecology can reduce labor requirements, allowing farmers to engage in additional income-generating activities. However, the transformation process requires time, knowledge, and commitment, with technological innovations seen as a potential solution to alleviate labor challenges (R4, personal communication, May 15 and 16, 2022; R10, personal communication, November 24, 2022).

Agroecological farming is associated with *expenditures* like *money, time, and energy*. Monetary costs involve expenses for technologies, land, and knowledge generation. If expenses accumulate, an approach such as agroecology appears less attractive, although expenses will be reduced in the long run. Farmers tend to shift towards self-produced organic manure when input prices rise, while lower prices for industrial inputs make them more likely to opt for the latter. The government’s input funding decisions play a significant role in influencing farmers’ choices, potentially creating dependency on subsidized products due to their cost-effectiveness and ease of application (R10, personal communication, November 24, 2022). Farmers fear a decline in prices and harvest loss when engaging in agroecology compared to the energy and financial investments required. The costliness extends to land issues, with long-term land renting posing challenges. However, land rent is a difficulty that is not specific to agroecology. Knowledge generation involves farmers contributing to costs, exemplified by trainings. The time and energy issue can be directly linked to the long-term perspective of agroecological approaches. It refers to both the time exposure of the transition of a farming system towards an agroecological one and the time spent for single practices (R1, personal communication, August 23, 2022; R9 and R10, personal communication, November 24, 2022; R11 and R12, personal communication, November 28, 2022). In Tanzania, training locations, typically at the village level, pose challenges for farmers. Intermediary farmers therefore suggested “putting training[s] on hamlet level, not on village level because a lot of people have to walk far to conduct the trainings” (R4, personal communication, May 15 and 16, 2022).

A further hindering factor is that farmers have to turn to *various institutions* to solve their concerns. Major concerns identified by smallholder farmers include seed and product certification, access to local contact persons, and the improvement of farming technologies. NGOs and umbrella organizations such as Participatory Ecological Land Use Management (PELUM) and Alliance for Food Sovereignty in Africa (AFSA) play a crucial role in advocating and lobbying at the regional or national level to strengthen agroecology and organic agriculture. As their members cover heterogenous stakeholders from the public and private sector and levels (farmers, consumers etc.), their bargaining power might be higher than that of single organizations representing—for example—smallholder farmers. Addressing these concerns involves connecting farmers with institutions like Tanzania Organic Agriculture Movement (TOAM) for product certification. They have to advocate for the certification of farm-saved seeds through organizations like Tanzania Official Seed Certification (TOSCI) and have to engage intermediaries for ongoing support beyond the project phase. This commitment requires sufficient resources, as well as bargaining and negotiating power. In most cases, NGOs represent farmers’ concerns at a higher level. However, these are often political decision-making processes over which farmers have only little direct influence but rely on the representation of their interests by institutions. These concerns are

fundamental and essential prerequisites for the dissemination of agroecology (R2, personal communication, August 29, 2022; R4, personal communication, May 15 and 16, 2022; R7, personal communication, November 18, 2022; R8, personal communication, November 23, 2022; R9 and R10, personal communication, November 24, 2022; R11 and R12, personal communication, November 28, 2022; R13, personal communication, December 9, 2022).

Incentive provision can be distinguished between two types: the first involves an incentive system for smallholder farmers to participate in low-input development projects, which emphasize the importance of convincing farmers of the long-term benefits of the project. A lack of farmer conviction in a project's methodology, due to a lack of incentives or unclear benefits, can lead to non-participation or dropout. Project staff must effectively communicate the long-term nature of changes and underline the delayed visibility of results. Organizations often provide training, knowledge, demonstration plots and trials to empower smallholder farmers to share their knowledge and act as 'multipliers'. The second type focuses on incentives for intermediaries, both during and after the project, to ensure their continued support and knowledge dissemination. Some organizations provide training, bicycles, and monetary rewards during the project, thereby creating a sustainable support system. When the project phases out, incentives are stopped being provided. For continuing supporting the community, R1 (personal communication, August 23, 2022) suggests that

"the group needs to recognize that this person has great knowledge to share but needs to be compensated or incentivized in order to give up his or her valuable time that they could be spending in their own farms, supporting their own family."

The sustainability of such a local support and knowledge distribution system without external NGO support would signify a crucial achievement in fostering farmers' self-sufficiency and dependency on further development projects (R4, personal communication, May 15 and 16, 2022; R9, personal communication, November 24, 2022).

Knowledge variety

Recognizing knowledge variety is a basis in agroecology, where the inclusion of local expertise and farmers' knowledge is crucial to transform agrifood systems into more socially just and ecologically sound ones. Agroecological methods are built around a plurality of knowledge systems, like traditional and indigenous knowledge, producers' and traders' practical knowledge, and scientific knowledge that needs to be considered and combined (Coolsaet, 2016; FAO, 2018).

Insufficient *investment in agroecological research* is a recognized obstacle that hinders progress and dissemination (Oteros-Rozas et al., 2019). While the focus when investigating this factors was initially on the need to invest more money, time, and effort in research on agroecology, the interviewees focused more on the need to connect farmers, researchers and NGOs as mediating actors. This is seen as one precondition to enhance agroecological research and generate more practical evidence of successful agroecological interventions (R1, personal communication, August 23, 2022; R2, personal

communication, August 29, 2022; R7, personal communication, November 18, 2022; R10, personal communication, November 24, 2022; R11, personal communication, November 28, 2022). Nevertheless, R7 (personal communication, November 18, 2022) emphasizes that agroecology "has to be better communicated, better researched, better tried and better contextualized," which urges in coordinated efforts among involved actors.

The interviewees see agroecology as a collaborative research process and as a community of practice in which *researchers and farmers work together*. This is intended to challenge the historical top-down approach where researchers impose their findings on farmers (R1, personal communication, August 23, 2022). All agricultural research conducted by the National Agricultural Research System (NARS) in Tanzania is overseen by the TARI (2024b). TARI Uyole in Mbeya is an important research institution for the Southern Highlands. While it has traditionally worked in isolation and concentrated solely on conventional farming, it has started engaging in agroecological research but to a limited extent (R10, personal communication, November 24, 2022; R11, personal communication, November 28, 2022). TARI Uyole's cooperation projects include the development of organic fertilizers, the improvement of bean seeds or the further development of traditional farming techniques and testing their sustainability. Sometimes research institutes provide plots with both conventional and agroecological farming inputs and technologies. Farmers can assess both models, and organizations provide a cost-benefit analysis, outlining the investments made in each model and their respective outcomes (R10, personal communication, November 24, 2022). However, some umbrella organizations express skepticism about the collaboration. On the one side, R2 (personal communication, August 29, 2022) fears that "once farmers' traditional seeds are improved, they will no longer belong to the farmer. They belong to the researcher and the researcher will be the one to decide how the farmer should use them." If the seeds are to be improved, this should happen through a participatory process, whereby farmers and researchers collaborate from problem drafting to concept creation. On the other side, R2 observes that farmers are only integrated after the breeding when testing the seeds on the fields but "farmers should not have to wait until they receive the researchers' end product." There are calls for farmers to be genuinely involved in the research process. A success story should be called into question if farmers are only involved in the test phase.

Agroecology faces skepticism regarding its effectiveness and scalability, wherefore robust evidence is required to counter such claims. R7 (personal communication, November 18, 2022) stated: "It is important to gather evidence and facts in order to present concrete figures. You are often challenged that agroecology does not work, but then the research results show: Yes, it does work." This *need for evidence* extends to policy making, as highlighted by R7 (personal communication, November 18, 2022), who emphasized the importance of field-level evidence for crafting national policies like the NEOAS. Accumulating evidence of the impact of agroecological practices on ecosystem functioning and livelihood strategies is a pivotal factor in facilitating agroecological transitions: Observing successful implementation by neighboring farmers trained in new techniques encourages others to adopt similar practices. R8 (personal communication, November 23, 2022) observed that "if we see the neighboring farmer is doing well with what has been trained, the others slowly start to change." This principle extends to demonstration

plots, where farmers can compare various farming methods, techniques, and crop varieties (R10, personal communication, November 24, 2022). Reports and visible outcomes particularly from peers, appear to play a crucial role in enhancing the attractiveness of agroecological practices. Moreover, evidence of success would not be limited to farming methods, since agroecology is a social, political, and economic approach. It would also encompass gender relations, marketing strategies, and income generation (R8, personal communication, November 23, 2022; R10, personal communication, November 24, 2022; R11, personal communication, November 28, 2022).

Agroecology lacks a unified *definition* among different actors with varied interpretations (Intriago et al., 2017; Bezner Kerr et al., 2019), which is reflected in the understanding the interviewed experts had of practices. Interviews revealed divergent understandings, with terms like agroecological, organic, and sustainable farming used interchangeably (R8-R13). When asking whether the organization works with the term ‘agroecology’ or with other terms, the answer was: “[...] we have like several agricultural projects and sometimes we are doing according to what we agreed with the donors, because sometimes we depend on the donors” (R9, personal communication, 24 November 2022). This leads to a dilution of the terminology. Despite the variations in terminology, there were similarities among interviewees. Most of the interviewees work with the term ‘organic farming’ and pursue common goals such as environmental protection, food security and market access for income generation. It can be assumed that they use this term because the NAP and the NEOAS have incorporated organic agriculture as leading term. Nevertheless, the impression arose that it was not clear that agroecology is based on three approaches and which components are to be understood as such.

Establishing *knowledge exchange platforms* is important to promote agroecology. They can foster collaboration and invite government officials to address concerns. These platforms facilitate discussions, collaboration and the sharing of experiences among diverse stakeholders. These networks, exemplified by ACAF, feature farmer testimonies and insights from enterprises involved in food system transformations. R2 (personal communication, August 29, 2022), as one participant of the ACAF, reported about the necessity of such network meetings to promote agroecology: “We have to know who is doing what, where are the supporters located and how can we strengthen the collaboration.” Interviewees also advocate for networking at both national and international levels, citing examples like ‘BIO-FACH’ in Germany and the ‘Andhra Pradesh Community Natural Farming’ project in India. While such initiatives, including international linkages, are seen as essential by R1 and R2, challenges remain that require increased efforts to link local and international agroecological actors more closely together in order to share experiences effectively. The emphasis on networking came primarily from umbrella organizations, which are capable to host national meetings due to their greater reach and resources.

Changes in agricultural practices are often driven by *horizontal interactions* and networking among farmers (Petit et al., 2020). For R1 (personal communication, August 23, 2022), “the holy grail is to find a method, find a methodology, a system of farmer training that at some point does not need external input or incentives of development organizations.” Two types of horizontal interactions are identified: *individual farmers* come into an exchange, also detached from

institutionalized structures. They ideally engage in agroecological farming practices whereby acting as trainers and multipliers and influence behavioral change. “Trained farmers can bring their knowledge and experiences back into their community, which gives non-participating farmers the opportunity to decide if they want to or are able to copy the practices” (R1, personal communication, August 23, 2022) and whether external conditions make a conversion possible for them at all. Often, there is a lack of structural, collective organization that leads to little bargaining power. *Farmer networks* can build trust between them, a support system when harvest fails, enhance collective bargaining power, and address challenges such as transportation of goods and market negotiations (R7, personal communication, November 18, 2022; R8, personal communication, November 23, 2022). According to observations by interviewees in the Southern Highlands, regular interactions between farmers on community level create a sense of group belonging and responsibility. It also promotes the development of local business or loan groups (R3, personal communication, May 11 and 14, 2022).

Transformation of agrifood systems

Food security, criticized for its insufficient consideration of social concerns, is contrasted with the broader and politically charged concept of *food sovereignty* (Edelman, 2014; Patel, 2009). The food sovereignty movement, like La Vía Campesina, does not reject the term ‘food security’. It contextualizes food sovereignty as logical precondition for genuine food security, wherefore it should not be a question of ‘either food security or food sovereignty’, but a question of how to achieve food security through food sovereignty (Patel, 2009; La Vía Campesina, 1996). Despite the conceptual linkage between agroecology and food sovereignty, the interviews with Tanzanian stakeholders reveal a predominant focus on achieving food security rather than food sovereignty. The experts interviewed see agroecology primarily as a practice rather than a political concept that challenges power structures and the international corporate food system. Awareness of food sovereignty is low among interviewees. Food sovereignty was used by four organizations only in the context of local/indigenous seeds (multiplication of own seeds for next season’s cultivation to be independent of buying hybrid seeds from a dealer to foreign-determined prices). By having an own distribution system with seeds, they multiply and could self-determine their seed management. However, it should not be concluded that interviewees do not support the goals of food sovereignty. The marginal awareness could be because the term is unknown, or it is unclear what project components it might encompass. They might already implement food sovereignty components but do not use the term.

Agroecology has a positive *gender dimension* because it creates “[...] more recognition of the role of women who are seen as guardians and as main source of agricultural labor.” (R1, personal communication, August 22, 2022). However, gender inequality is due to traditional roles and women bear the brunt of household tasks. A district officer (R6 personal communication, May 12, 2022) confirmed that “gender inequalities are deeply rooted at the family level. Men rather go out of the village to find more lucrative jobs while women stay at home.” Male outmigration tends to increase the number of female-headed households (Dastrup, 2015). Gender and agroecology influence each other, first regarding the gendered motivations for adopting

agroecological practices. This includes women's higher interest and active participation in trainings and small businesses. There is a chance through engagement to gain more means of control over the production system and commercial benefits out of business activities (R1, personal communication, August 22, 2022; R3, personal communication, May 11 and 14, 2022; R7, personal communication, November 18, 2022). Second, the link between gender and agroecology refer to the implications of the gendered division of labor inside and outside the household. Most interviewed farmers, both men and women, can see changes in the share of workload after gender sensitization trainings (R3, personal communication, May 11 and 14, 2022). Some even revealed that the relationship is more equal than before, although household activities—which are considered to be traditional female jobs—are still mainly carried out by women. This active participation and interest of women is a negative side effect because it could increase their workload. “Often the workload falls to men and women in different ways and it's often women who have to do the kind of repetitive jobs in farming.” (R1, personal communication, August 22, 2022) In addition, stigmatization of women, customary practices and limited access to assets and extension services persist, which makes inclusive approaches, involving both men and women, necessary (R9, personal communication, November 24, 2022; R1, personal communication, August 22, 2022; R3, personal communication, May 11 and 14, 2022; R11, personal communication, November 28, 2022).

Smallholder farmers often face existential fear due to an unpredictable food market. High crop yields often lead to high supply and consequently low prices, which mainly benefits trade intermediaries who buy from farmers at prices below production cost. One interviewee (R12, personal communication, November 28, 2022) told that “the government is at least trying to allow these middlemen [trade intermediaries] to operate in a kind of centralized system” to empower farmers with better prices. The ideal alternative food system, based on principles of solidarity, participation, and transparency, remains largely aspirational and is conceivable, if at all, in short value chains. The prevailing *market logic* often undermines agroecological approaches. Income generation is crucial for farmers, who often resort to market-friendly crops and industrial inputs (R11, personal communication, November 28, 2022). R8 (personal communication, November 23, 2022) explained that if “the government and international organizations would invest in agroecological practices and provide access to export markets so that farmers would gain a fair income from what they are producing from their agroecological crops, this would increase the speed of adopting agroecological practices.” Farmers and NGOs in the research context often adhere to the market imperative, supporting the prevailing system. This illustrates the contradiction: Most interviewed organizations want smallholder farmers to sell their produces and surplus to decent prices on local markets or even export markets. With this framework for action, there would still be a risk that farmers would earn an income but continue to live in dependency structures. However, the aim of agroecological approaches is to create independence from external influences and give smallholder farmers the capacity and self-determination to decide where to produce, what, when and where to sell for how much.

The food environment, encompassing physical, economic, political, and socio-cultural factors, significantly influences *consumer behavior*. A strong demand for agroecological products signals producers to increase their agroecological production. R8 (personal communication, November 23, 2022) highlights the *role of consumers*

in transforming the agricultural system, because “the one who can make the farmer change is the consumer. If a consumer would opt for organic products, the farmer would certainly change. But the consumers prefer crops with a good shape.” The interviewee points out that consumers often prioritize the appearance of agricultural products by favoring those cultivated with industrial inputs for their attractive look. Agroecological products, as R8 cited tomatoes as an example, are organic but may not be attractive to consumers due to their less appealing appearance. R8 suggests that raising awareness among consumers about the negative effects of industrial inputs and the benefits of sustainable farming, independent of product appearance, could promote agroecological practices.

Discussion

The research highlights challenges of implementing agroecological approaches with the aim of transforming agrifood systems. A transition is intricate and requires time and energy. Overall, the research underlines the multifaceted nature of promoting agroecology and emphasizes the need for joint efforts, awareness, and supportive policies. The claim for holistic approaches and complexity of the factors involved necessitates to practically address all three approaches of agroecology. If only single practices are introduced, the level of change is usually low (Altieri, 2002). This means that change is most successful when implementers follow coherent components (R5, personal communication, May 13 and 17, 2022). According to the interviewees, there are barriers that impede the implementation of coherent agroecological practices. This complexity and the difficult realities on the ground are in contrast with the positive image of agroecological approaches that is painted in the literature.

The most widely and intensively discussed hindering factor both in literature and the interviews are challenges of agroecological practices and the dealing with different forms of knowledge.

These refer to practical questions of the agroecological transition on the farm and community level, confirming findings from the literature. A study by Constantine et al. (2020) shows that smallholder farmers adopt agroecological practices only to a limited extent, due to short-term land leases and concerns about maintaining investments in soil fertility on non-owned land, a notion reiterated by the interviewed farmers. What is more, there are structural barriers regarding a widespread use of organic inputs, such as limited availability in local shops and commercial challenges for large-scale application (Tups, 2022). With rising fertilizer prices exacerbating the situation, smallholder farmers find it increasingly difficult to afford synthetic fertilizers. Proponents of organic inputs also face the challenge of countering the one-sided narrative, which is spread through public channels, that yield increases are primarily achieved through industrial inputs (Tups, 2022). This leads to a need for training on the benefits, variety, and the possibility of self-made production of organic inputs. These are examples of difficulties in the practice-knowledge-nexus. In agroecology, technical approaches or ‘one size fits all’ solutions, typical of conventional agriculture, are inappropriate, considering the heterogeneity of rural people and agroecosystems. Some agroecological practices require agreement, collective action among different stakeholders (Altieri, 2002); many different agroecological

practices exist that can be applied at different levels (Wezel et al., 2014).

From smallholder farmers' and implementers' perspective, it can be assumed that not all identified hindering factors represent an obstacle and have a direct impact on the implementation of agroecology, and thus, on farmers' livelihoods. This does not imply a lack of significance. Moreover, not all hindering factors always pose a problem or affect the implementation of agroecology in the same way.

The positive attitudes towards agroecology in theoretical literature contrasts with the critical views of implementers facing challenges on the ground. While most factors were derived deductively from theory and existing research, the literature exhibits an optimistic inclination. Those actively implementing agroecological practices on the ground expressed a critical stance towards the generally positive portrayal of agroecology. They identified obstacles in the introduction and implementation of agroecology among smallholder farmers and attributed these difficulties to factors inherent to the approaches themselves as well as external structural factors.

All interviewees apply components that fall under the three agroecological approaches. However, these components seem rather disconnected from agroecology as a holistic approach. This implies that the interviewees may not see agroecology as a coherent approach that needs to be applied holistically. One reason could be that the agroecology-as-a-practice approach seems to correspond more to the direct challenges and living realities of smallholder farmers and the corresponding development projects. Another reason could be that the interview questions rather set a focus themselves on agroecology as a practice or science, reflecting a weakness of the interview guides. A third reason could be the rather low awareness of agroecology as a holistic approach and the broad and complex definition of agroecological approaches and their principles. What counts is primarily achieving food security and the components that are part of a secured rural livelihood. If the only goal is food security rather than food sovereignty, the ambition of changing the food system may be lower and not strictly necessary. The term food security says little about unequally distributed power, and policies that threaten rural livelihoods and destroy the environment, thereby triggering food insecurity. It does not sufficiently address social control over the food system and therefore, neglects a critical examination with power relations (Akram-Lodhi, 2015; Edelman, 2014; Patel, 2009). Depending on hunger and malnutrition rates in the country, it may be more important for people to have a reliable food supply through increased productivity and income generation.

Despite its high relevance, the agroecology-as-a-social movement approach was addressed the least. As it is the most political and abstract approach, it appears to be the most difficult to capture. Farmer networks can encourage a common understanding of agroecology (Mockshell and Kamanda, 2018), and farmer-to-farmer interactions have the potential to build autonomy and independence (Giménez Cacho et al., 2018). Nevertheless, these political implications of collective actions are rarely addressed by the participants in this study.

In contrast, gender relations and market access were thereby frequently mentioned, without explicitly embedding these factors to agroecology as a social movement and in a systematic transformation structure. Gender equality is treated as a cross-cutting issue in development projects; many projects automatically include gender-specific activities to empower women and girls. Income generation is

a major interest of smallholder farmers and implementers for securing rural livelihoods. There are ideas for alternative market structures, such as short food supply chains, farmers' markets, sustainable local public procurement (Altieri and Nicholls, 2020). Consumer habits, influenced by advertising, pricing, and political interests, play a crucial role in shaping food choices (HLPE, 2019; González de Molina, 2013). While changing a food system requires political and institutional intervention, consumers can actively contribute by questioning their consumption patterns and demanding agroecological products (HLPE, 2019; González de Molina, 2013). Nevertheless, the approaches concerning gender equality and improved market access are still incorporated in capitalist market structures in which smallholder farmers are predominantly vulnerable and marginalized. It remains a major challenge to improve the economic viability of agroecological food systems from production to consumption, while the transformative potential of agroecology maintains its independence from large market players (Oteros-Rozas et al., 2019).

A transformation of existing farming and agrifood systems can be initiated at different levels. González de Molina (2013) and Sinclair et al. (2019) distinguish between five spatial levels: field, farm or livelihood, landscape or community, national, and global scales. Complementing this, Gliessman's (2016) model outlines five process-oriented levels, starting with field and on-farm transformations and extending to the broader food system and the societies in which they are embedded. The first three levels describe the steps that can be taken on farms and on an agroecosystem level for converting from conventional to agroecological farming systems. All five levels together can serve as a roadmap that gradually outlines a process to transform the global food system. The spatial levels correspond with Gliessman's solution approach of a step-by-step transformation and merge into a joint model. This model can be extended by FAO's and HLPE's elements of agroecology (FAO, 2023b; Wezel et al., 2020). What is more, the findings from this study emphasize the role of consumer behavior.

A transformation of existing farming and agrifood systems can be initiated in five steps and at five different spatial levels. As far as the research region is concerned, the interviewees only addressed the first two levels (field and farm), both spatially and in terms of process. The fact that experts focus less on agroecology as a social movement could be because it encompasses the last two levels of Gliessman's (2016) five-level model and the spatial levels of González de Molina (2013) and Sinclair et al. (2019)—the changing global agrifood systems. The national and global levels are the most difficult ones to change because certain interventions in an agroecosystem are beyond the capacity of farmers or other implementers with rather little bargaining and decision-making power. These interventions include the design of product prices, inputs used, subsidies and incentives (González de Molina, 2013). A farmer or an implementer may attempt to maintain or improve the biological stability of an agroecosystem at farm or landscape level by improving individual agroecological practices. Due to their territorial impact and economic costs, the above-mentioned interventions exceed the possibilities of the community and therefore fall more within the competence of the state or its regional planning bodies. The economic stability of farms and supply chains mostly depend on decision-making and regulatory areas that are often far removed from rural communities (González de Molina, 2013). Structural factors such the influence of powerful stakeholders such as agribusiness, the recognition and willingness to involve stakeholders

at different levels in decision-making processes, the orientation of national policies, the dependence of NGOs on donors in their orientation, etc. influence the possibilities for implementing agroecological approaches.

Nevertheless, this step-by-step solution approach could also be relevant for the Southern Highlands because it can facilitate agroecological transformation without overwhelming implementers or the environment. It considers personal resources available for the transformation and, at the same time, it pays attention to livelihood security. The study did not explicitly categorize the identified barriers to agroecological implementation into the different stages of transformation. However, such a categorization could help to examine the barriers at their specific levels, provide insights into the factors at each stage and identify the actors responsible. It is important to emphasize that the responsibility for overcoming structural challenges in implementing agroecological approaches should not lie solely with smallholder farmers. Given the prevailing power structures and decision-making dynamics, responsibility for structural barriers also extends to other actors involved in the process.

The research underscores the interconnectedness of hindering factors, yet some pose a particular barrier for the implementation by smallholder farmers and NGOs. It can be assumed that if these factors accumulate, the implementation of agroecology on the ground could be at risk. An essential observation is the existence of interdependencies between internal and structural factors, including the neoliberal global food system, as political, economic, institutional, and social framework conditions collectively influence the effectiveness of agroecological approaches.

Conclusion

The benefit of agroecology lies in its potential for transforming farming systems and agrifood systems through its holistic application of all three approaches—as practice, science and social movement. To achieve a transformation, agroecological approaches critically deal with and question central dimensions—gender inequalities, power structures and asymmetries, access to land, alternative market structures, control over means of production, property rights, discrimination based on origin, class, age and other societal discriminations, etc. Some of these dimensions were also addressed by the interviewed experts in the Southern Highlands of Tanzania.

In response to climate crises, rising hunger, and food system disruptions, the approaches have gained prominence. Agroecology is not only discussed in the context of smallholder farmers in the Global South, but also as an alternative agricultural model in the Global North. Organizations such as the FAO and the CFS underline the need to question current agricultural structures amid the global food crisis. Regarding the UN's Sustainable Development Goals, agroecology is even used as development narrative. There are many case studies of agroecological projects showing that the approaches can be successful—especially in the field of development cooperation. Nevertheless, the study does not go so far as to present agroecology as the only alternative. This would be problematic insofar as research and implementation in practice have not yet progressed to the point where the model could be applied on a broad basis and thus solve the current food crisis. Shifting to sustainable production and consumption requires changes in politics, economics, culture, and technology, which agroecology alone cannot address.

Additionally, differing interests and views on how to solve the food crisis, as well as prevailing power structures, slow down change.

In literature, agroecology is often idealized as the future of farming, while conventional agriculture is simplified to negative associations. This contrast supports arguments for agroecological transformation by emphasizing its positive framing. Against this background, the study focused on internal factors of agroecological approaches that impede their implementation and dissemination. The research identified 18 hindering factors. They comprise of practical implementation difficulties such as lacking organic inputs, high expected expenditures, gender inequalities, difficult market access and marketing options, lack of conviction due to a lack of evidence, no uniform definition, lacking collective organization power, etc. Tanzanian experts confirmed these challenges in their context, which validates the factor's significance in practical scenarios. The interviews' analysis shows an imbalance: in the Southern Highlands is a focus on agroecology as a practice and science and an underrepresentation of agroecology as a social movement. This means that agroecology is primarily being relevant at field and farm level to improve agricultural practices, such as adopting sustainable techniques and reducing dependencies on external forces. However, the broader social and political dimensions of agroecology to transform the entire agrifood system are less emphasized. The movement's potential to address systemic issues such as right to food, inequality and injustice within the agrifood system is not being fully realized. Although the study focused on internal factors, external factors were also identified such as low investment in research, policies undermining the right to food, neoliberal orientation in trade, lacking provision of infrastructure, climate crisis impacts, access to secure land rights, educational focus on conventional farming, etc. Both factors lead to an inhibition of agroecological implementation and must be dealt with to make agroecology successful.

Based on the hindering factors identified in the study, some policy recommendations can be proposed to address the challenges associated with agroecology. One key issue is the lack of robust evidence and practical experience in many regions, where best-practice examples for agroecology are scarce. To address this, NGOs, international organizations and governments could implement “flagship projects” to establish best-practice examples. These initiatives would provide evidence and serve as role models for others to follow, promoting wider adoption of agroecological methods. An inclusive presentation of best-practice examples would be necessary to reach different target groups. Another challenge stems from farmers' dependency on synthetic farm inputs, which have been used over time to ensure reliable harvests. Transitioning away from these inputs may jeopardize the income stability of farmers. While subsidies and other forms of financial assistance can create new dependencies, they may be necessary during the transition period to support farmers. Additionally, insurance programs could act as financial safeguards, incentivizing farmers to adopt new, sustainable farming practices. At a broader level, a significant barrier to agroecology is the concentration of power within the agribusiness sector. Companies that produce synthetic farm inputs often have little incentive to support smallholder farmers in becoming more self-sufficient, as this would reduce reliance on their products. These companies, due to their financial clout, exert considerable political influence. To counterbalance this, civil society organizations and international organizations must play an active role in advocating for policies and initiatives that promote agroecological approaches and reduce the dominance of agribusiness interests.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

NA: Conceptualization, Data curation, Investigation, Resources, Visualization, Writing – original draft, Writing – review & editing. SK: Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix

TABLE A1 Interview guides.

1. How did you get involved in an NGO that focuses on agriculture?
2. In which regions do you implement agricultural projects?
3. What are main challenges for smallholder farmers in the region?
4. What kind of inputs do farmers you work with mostly use?
5. What kind of differences in agricultural practices (use, choice of technology, handling and access to land) are there according to ethnicity or religion?
6. What do you understand by the term agroecology/organic agriculture?
7. What prevents a successful implementation of agroecology (in the Southern Highlands)? Is it due to political framework conditions (institutional, other interests, etc.) or the approach itself (too complex, too knowledge-intensive, too little yield etc.)?
8. What is your main goal when implementing an agroecological/agricultural project?
9. In what way have livelihoods strategies changed through the adoption of agroecology?

TABLE A2 Interviewees and their relevant expertise.

Sector	Thematic expertise
Non-profit	Challenges of agroecological implementation in Tanzania
Non-profit	Agroecology in politics and practice
10 Smallholder farmers	Farming practices and livelihood strategies
10 Intermediary farmers	Role of intermediaries in a food security project and agricultural performance of individual households
Non-profit	Agricultural situation for smallholder farmers in the Southern Highlands
Local government	Cooperation with agricultural NGOs and general information about agriculture in the Southern Highlands
Non-profit	Implementation of agroecology in Southern Highlands
Non-profit	Challenges of the implementation of agroecology
Non-profit	Challenges of the implementation of agroecology
Non-profit	Challenges of the implementation of agroecology
Non-profit	Challenges of the implementation of agroecology
Non-profit	Challenges of the implementation of agroecology
Non-profit	Land rights and their impact on smallholder farmers