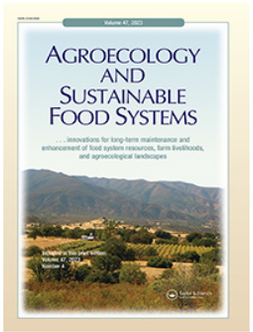

Agroecology and Sustainable Food Systems

ISSN: 2168-3565 (Print) 2168-3573 (Online) Journal homepage: www.tandfonline.com/journals/wjsa21

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**To cite this article:** Emma Johansson, Respikius Martin & Kenneth M. Mapunda (2023) Participatory future visions of collaborative agroecological farmer-pastoralist systems in Tanzania, Agroecology and Sustainable Food Systems, 47:4, 548-578, DOI: 10.1080/21683565.2023.2165592

**To link to this article:** https://doi.org/10.1080/21683565.2023.2165592



Published online: 09 Jan 2023.

AGROECOLOGY AND SUSTAINABLE FOOD SYSTEMS
2023, VOL. 47, NO. 4, 548–578
https://doi.org/10.1080/21683565.2023.2165592

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# Participatory future visions of collaborative agroecological farmer-pastoralist systems in Tanzania

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**ABSTRACT**

Agroecology is increasingly promoted as a way to create just and sustainable farm- and food systems. Although there are multiple initiatives to scale up agroecology, current socio-political structures often hinder its potential to transform food systems. This study uses participatory approaches to create paintings that envision agroecological futures in the context of increased farmer-pastoralist collaborations in Tanzania, how they would function, and what political action is needed to support such futures. The visions are based on focus group discussions with agroecological farmers and pastoralists, and a multi-stakeholder workshop with farmer and pastoralist representatives, innovative food system actors, and researchers. We find that the envisioned transformation of the food system would lead to positive effects on farmers' and pastoralists' income, autonomy, long-term planning, and producers' and consumers' health. We conclude that new policies and financial support systems are needed to enable the expansion of agroecological farming and food systems, by increasing the availability of organic markets, supporting domestic botanicals production, and by creating more inclusive and just food value chains.

**KEYWORDS**

Sustainable food systems; future visions; sustainable pastoralism; conflict mitigation; agroecological transformation; participatory art

## Introduction

Conflicts between farmers and pastoralists are common in Sub-Saharan Africa (Mabebe 2022), and can even result in violence and death (Benjaminsen, Maganga, and Abdallah 2009). Conflicts mainly result from cattle encroachment on farmers' crop fields before harvest in search for grazing areas and water points during the dry seasons. Conflicts also occur when farmland and farmers block animal paths to water points. Root causes for such conflicts are often described as an effect of resource scarcity due to population growth and decreased availability of land, but are also influenced by local histories, discourses, and national policies and legislations that tend to marginalize pastoralist groups (Benjaminsen, Maganga, and Abdallah 2009). Multiple pressures

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related to land use, food security, and population growth in a changing climate, are likely to increase conflicts over land and natural resources. For farming, the predominant solution has been mechanization and chemical use, but agroecology is gaining traction as a more sustainable alternative for agricultural intensification. Agroecology can also be a conflict mitigation strategy, where collaborations between farmers and pastoralist mainly build on the interdependent relationship of exchanging fodder with organic manure (Roba 2018).

In order to meet future needs for food, current agricultural policies in Tanzania aim to intensify crop production without further expanding farm areas, while searching for innovations to mitigate and adapt to the effects of climate change (NSCA 2021). However, increased food production in itself will not combat hunger and malnutrition if it does not generate higher incomes and improved livelihoods for the poorest – the smallholder farmers (De Schutter 2010). Since the 1990s, the dominant discourse for agricultural development has been to modernize and commercialize through initiatives like Kilimo Kwanza (Agriculture first), the "Southern Agricultural Growth Corridor of Tanzania" (SAGCOT) and the Agricultural Sector Development Program I and II. Such development strategies offer few solutions for small-scale farmers, local traders and service providers, since large agricultural estates offer few jobs and tend to invest their revenues in imported inputs and machinery (De Schutter 2010). Many large-scale agricultural projects have rather led to land dispossession and a (re)centralization of land control, than fulfilling policy expectations of land tenure security, employment, and poverty reduction for smallholder farmers (Engström, Bélair, and Blache 2022).

A wider transformation of food systems requires more than sustainable intensification of production systems, as it also requires the mobilization of farmers, their cooperation, and new governance structures (De Molina 2013). Agroecology is a powerful paradigm that entails a massive redesign of the economic structures that govern our food systems. Globally, agroecology is gaining traction, as it has been acknowledged as a solution to the food crisis by institutions like the FAO (2018). Also, recently agroecology is seen as a potential solution for reducing farmer-pastoralist conflict (Hauser et al. 2021; Mbih 2020). The Tanzanian government has shown interest in this by initiating discussions to create an agroecology department under the Ministry of Agriculture (Blog 2021). However, the incentives and policies to promote agroecological practices are lagging behind and most agroecological experiences are still bound to local initiatives (Swai, Sibuga, and Yusuph 2022).

As regional and national prospects to upscale agroecology in different social and political settings are poorly understood (De Molina 2013), the main aim of this research is to better understand how agroecological initiatives are to expand and challenge mainstream conventional food systems in Tanzania, and at the same time improve farmer-pastoralist relations. In particular, we

envision what such agroecological futures could look like, how they might function, and what type of political and financial support is needed to get there. In this way, we respond to the call for improved understanding of socio-political obstacles against transformations toward sustainability, and how to overcome them (Lahsen and Turnhout 2021). We explore this knowledge gap by focusing on three scaling strategies in sustainability transitions (Moore, Riddell, and Vocisano 2015). Specifically, how can agroecology *scale out* (i.e., expand by replication)? What policies need to be reformed to support agroecological food systems and *scale up* agroecology (i.e., change rules, norms, and legislation)? How can agroecological food systems be *scaled deep* (i.e., change values and minds) and create new types of markets and consumer demands? We explore these three aspects of scaling by co-creating future visions with farmers and pastoralists that are currently engaged in agroecological practices and sustainable livestock keeping through the "Morogoro farming-livestock integration" initiative led by Sustainable Agriculture Tanzania (SAT). Thereafter we discuss, and elaborate on these visions from a food systems perspective together with innovative food industry actors and researchers.

## Conceptual background

In Tanzania, the agricultural sector is at the core of the country's GDP (26.9%) and a major source of food, employment, material, and foreign exchange (NSCA 2021). Tanzania is experiencing a dramatic movement of labor out of agriculture, where the share of households engaged in agricultural activities have fallen from 82% to 66% between 2008 and 2020. This can partly be explained by rural-urban migration in search for employment, often leading to new vicious cycles of poverty and challenges in urban slums (Aikaeli, Mtui, and Tarp 2021; De Schutter 2010). Even though agricultural households have decreased in percentage, the total number has increased from 5.8 million to 7.8 million (NSCA 2021; Wineman et al. 2020). Pastoralist households have decreased from 3,917 to 1,465 (Figure A1), while the number of cattle has increased from 21.2 to 33.6 million. Even though Tanzania's agricultural output grew by 58% from 2008 to 2014, the increase was mainly an effect of farmland expansion and not of agricultural intensification (Wineman et al. 2020). An agricultural transformation is essential and urgent, but it is debated how agricultural development should happen. Here is a brief background to how ideas of agricultural modernization are reshaping agriculture in Tanzania, and how alternative ideas from agroecology might provide a more sustainable and just alternative for development.

### *Mainstream agricultural development through modernization*

Just like governments in many other countries across Sub-Saharan Africa, the Tanzanian government is pushing for a green revolution through agricultural

modernization based on market liberalization and privatization (Mdee et al. 2019). The modernization discourse builds on claims that the agricultural potential in Tanzania is underutilized, and that smallholder farms are characterized by low productivity, mainly as an effect of limited use and access to modern production technologies and techniques (Bergius, Benjaminsen, and Widgren 2018; West and Haug 2017). Mainstream development organizations aim to modernize, mechanize and commercialize African agriculture to "release the untapped potential" of underutilized land (Scoones et al. 2014). This type of agricultural transformation is driven by financial and institutional innovation, the use of new technologies (e.g., GMOs) and with heavy involvement from the private sector (Bellwood-Howard and Ripoll 2020).

Modernization builds on ideas that there are "progressive cores of modernity" and "lagging peripheries of tradition" (Bergius and Buseth 2019). Agricultural development is thereby seen as a progression from smallholder agriculture to industrialized agriculture linked to global markets. The stages of modernization aim to increase the scale of agriculture, while reducing the number of people that make a direct living from the land thus an increase in labor productivity (Bergius, Benjaminsen, and Widgren 2018). The goal is to gradually separate people from nature via the application of technology, with the ultimate aim to urbanize and "free" the rural population from their land and hard work via modern technology-intensive farms (Bergius, Benjaminsen, and Widgren 2018). However, there are few viable employment opportunities in the modern industry sector for those that are "released" from farming labor due to mechanization (Mdee et al. 2019). Hence, rural and urban industry can only absorb a fraction of the released labor.

### *Agroecology as an alternative pathway for sustainable food systems*

Agroecological intensification is a counter-narrative to conventional agricultural modernization, and proponents highlight that agricultural intensification through agroecology is a more inclusive and environmentally sustainable pathway for development (Mdee et al. 2019). Agroecology is a century-old concept that originated in the 1930s to describe the application of ecological methods in agriculture, and today agroecology can be seen as a scientific field, a set of agroecological practices, and a movement (Wezel et al. 2009). Recently, it has become increasingly integrated in mainstream agricultural development discourses (Silici 2014) through its promotion by the FAO (2018).

Agroecology builds on creating biodiverse agroecosystems that are able to "sponsor" their own functioning (Altieri 2002), e.g., to minimize the use of agrochemicals through using biological interactions and synergies for pest control and to enhance soil fertility. Aims are not only to solve challenges related to environmental degradation and productivity, but also rural poverty, and power imbalances in the food system. Key features of agroecological

production systems are that they should be appropriate for local human consumption, offer alternative markets, promote local and indigenous knowledge, campaign for land reforms, and promote peer-to-peer teaching and learning (Giraldo and Rosset 2018; Oteros-Rozas, Ravera, and García-Llorente 2019). Thus, agroecology contains a fundamental political dimension, that producers and citizens should have increased autonomy and agency to self-organize for sustainable food production and consumption (Anderson et al. 2019).

There is a growing Global dedication to create sustainable and climate resilient food systems, halt soil degradation and enable fair access to agricultural land (Global Forum for Food and Agriculture 2022). The efforts by the FAO to promote agroecology has however been opposed by some of its member states (Canada, Australia, Argentina and USA) as it does not represent their vision of agricultural development (Anderson and Maughan 2021). The main critique is that agroecology is unrealistic and unviable (Bellwood-Howard and Ripoll 2020), and rarely include modern agricultural innovations for sustainability (Anderson and Maughan 2021). Further, it is described as outdated, impractical, and even dangerous, since it undermines the focus on yields and profit as the main aim of agricultural development. Other claims are that agroecology denies African farmers the access to modern farming technologies and international markets (Bellwood-Howard and Ripoll 2020). A main reason for the critique of agroecology as aspirational, utopian, and not based on reality, is that social, cultural, political, and some ecological outcomes are difficult to "objectively quantify" (Anderson and Maughan 2021). Agroecology however articulates multiple socio-economic and environmental goals that are critical for sustainable and just food systems, and strives for that civil society actors have increased control over the food system, which requires radical changes in how food systems are understood and designed (Castillo 2014).

### *Alternative pathways for pastoralism and sustainable livestock keeping*

There are debates about the sustainability or un-sustainability of pastoralism. Pastoralism can be described as a low external-input agroecological system that uses patchy and variable resources on natural dryland rangelands to produce food and a range of other products and services (e.g. skins, hides). Degradation of the world's rangelands is poorly understood, but composed of multiple drivers like cropland expansion, over-exploitation of livestock, over-extraction of woody biomass, and increased aridity due to climate change and water extractions (Davies et al. 2016). Herd mobility can be crucial for sustainable management of rangelands, as under-grazing also can lead to land degradation, yet mobility has frequently been condemned as outdated and backwards. In this study, future pastoralists are described as more settled,

with smaller herds of improved breeds and pasture plantations. This is in line with the existing policy environment in Tanzania that promotes sedentarization. Roba (2018) questions sedentarization as a solution to pastoral production and governance, and claims that pastoral resilience and climate adaptation can only be enhanced by supporting their traditional and local production system. Another alternative to transhumance is rotational grazing through holistic planned grazing, which is a practice where livestock is concentrated at high densities to induce heavy grazing over a limited space and time, with planned recovery periods for the vegetation (Peel and Stalmans 2018). Although there are scientific debates about holistic management, multiple studies find that if practiced properly, it can improve ecosystem processes like water and mineral cycles, and restore degraded rangelands by enhancing their productivity and profitability (Gosnell, Grimm, and Goldstein 2020). Holistic planned grazing however requires organized herding and grazing plans, and a solid understanding of the water and mineral cycle, energy flows, and community dynamics.

### *Transformations, scaling and participatory future visions*

Conventional food value chains are fundamentally unsustainable, since their linear structure assumes that the Earth has limitless supplies of natural resources, and an endless capacity to absorb waste and pollution (Pimbert 2015). It is therefore crucial to transform, rather than reform the basic structures of the food system. An increasingly accepted alternative is to transform food systems into circular systems that mimic natural cycles. In circular production systems, specialized and centralized supply chains can be replaced with resilient and decentralized webs of food and energy systems that are integrated with sustainable water and waste management (Pimbert 2015). Such circular webs of systems can be designed across scales, for different contexts. Gliessman (2016) has identified five different levels for agroecological transitions. The first two levels focus on improving resource efficiency, and to substitute conventional inputs and practices with agroecological alternatives. The next three levels focus on redesigning agroecosystems, reconnecting consumers and producers through alternative food networks, and building a global food system based on participation, localness, fairness, and justice.

When agroecology meets the world of institutions, policies, and laws, it is important that it is not reduced to a set of practices, but that it is scaled up to also change institutions, policies, and laws (Giraldo and Rosset 2018). In order to guide policy and action, it is important to envision what such alternative futures could look like, how they would function, and what needs to change to get there (Johansson, Brogaard, and Brodin 2022). The future visions of sustainable food systems need to be based on the participation of actors who have an important role to play, especially those civil society actors who are

benefitting the least (Johansson 2021). Transdisciplinary research can aid the development of future visions, as such approaches seek to integrate scientific and nonscientific knowledge to produce new knowledge for solving complex problems, and communicate this new knowledge to spur action and change (McKee, Guimaraes, and Pinto-Correia 2015).

## Methods

This research builds on a qualitative approach including methods such as focus group discussions, field observations, and a multi-stakeholder workshop (Figure 1). In line with that, we arranged six focus group discussions in Mvomero district in Morogoro region, March and April 2022, with farmers and pastoralists (Maasai ethnic group) who are currently engaged in agroecology and farmer-pastoralist collaboration through the "Morogoro farming-livestock integration" program led by Sustainable Agriculture Tanzania (SAT). In May 2022, we arranged a two-day workshop in Morogoro town, where five focus group representatives (three farmers and two pastoralists) discussed future agroecological food systems with innovative food system stakeholders and researchers.

### *Demography, geography, and farming*

Morogoro region is the second biggest region in Tanzania, and has seven districts: Morogro, Mvomero, Gairo, Ulanga, Kilosa, Kilombero and Malinyi (Figure 2). In 2012, the total population was 2.2 million, where 71% resided in


**Figure 1.** Map showing the locations of the focus group discussions, field visits, and the origin of participants.

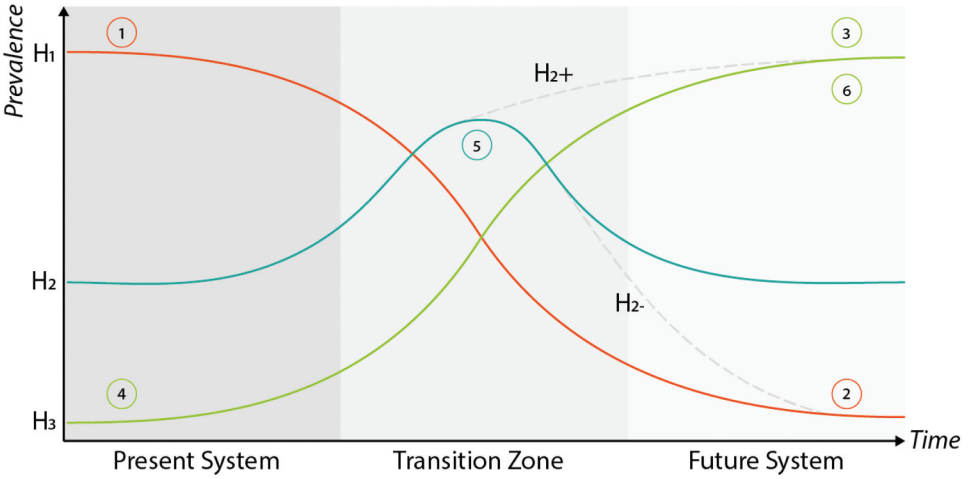


**Figure 2.** Conceptual figure of the three-horizons framework, adapted from Sharpe et al. (2016). Numbers indicate points where questions were asked during the workshop for creating future narratives, and how to get there.

rural areas, and 29% in urban areas. The majority of rural households were engaged in farming (79%), as opposed to in urban areas (21%). Urban centers experience an in-migration of youth from rural areas or other regions. In terms of education, 30% of the rural population had never been to school compared with 11% in urban areas. And the proportion of those who have completed school is higher in urban (52%) than rural areas (38%) (NBS 2016).

Morogoro region lies in a semi-arid agroecological zone, dominated by flat or undulating plains with rocky hills. The soils are moderately fertile with loams and clays, and receive about 600–800 mm of rain per year over two rainy seasons (NAPA 2007), the long rains with light showers from mid-February to May, and the short rains with more intense showers from October to December. The main growing season is traditionally between December and March, and harvesting is generally done between June and August (Kangile et al. 2020), although precipitation is experienced as increasingly erratic (Daninga 2015).

Many farming households produce and sell a mix of staple- and commercial crops (Kangile et al. 2020). Sunflower, coconut, sugarcane, and sisal are dominant commercial crops, while rice, maize, sorghum, cassava, and millet are the main staple crops. Products are usually sold to agents who collect products for local traders, either directly from households or from local markets (Kangile et al. 2020). Farming households are however diversifying their income sources, and between 2008 and 2014 the income shares from agriculture decreased while incomes from non-agricultural wages increased (Wineman et al. 2020).

### About sustainable agriculture tanzania

In Tanzania, an increasing number of NGOs and CSOs promote agroecology in different regional contexts (e.g. RECODA, PELUM, TOAM). One such NGO is Sustainable Agriculture Tanzania (SAT; www.kilimo.org) that is based in Morogoro Region, and supported by Austrian, German, and Swizz donors like the Austrian Development Agency, and Biovision Foundation among others. They operate a Farmer Training Centre for demonstrating and teaching farmers and extension officers agroecological practices, and also lead several projects for implementing agroecology and developing agroecological food systems, e.g., the Uluguru spice project; Farmers and pastoralists collaboration project; and Dodoma's women in agriculture and business initiative. Additionally, SAT have developed an innovation platform to facilitate communication among agroecological actors. They also run an organic shop for member farmer groups, and lead an initiative to grow the Tanzanian organic market (Organic now!). Their stated goal is to transform farming practices in Tanzania through knowledge dissemination; build capacity among farmers to participate in the value chain; collaborate with the public and private sector to strengthen their capacity in agroecology. They also aim to be a credible and transparent organization that have a cost-efficient approach to transform the agricultural sector to be environmentally friendly and economically viable.

### Participants of focus group discussions and field visits

We arranged six focus group discussions in three locations in Mvomero district to discuss farmer-pastoralist collaborations, agroecological practices, and improved livestock keeping (Figure 2). For that, we participated as discussion leaders, translators, and note takers. Focus group discussion is a frequently used qualitative method to gain in-depth understanding of a phenomenon or an issue, in this case of local concerns regarding socio-environmental dynamics. It is a participatory method that aims to obtain data from a purposely selected group of individuals, rather than a representative sample of a population (O. Nyumba et al. 2018). In total, 25 farmers and 32 pastoralists from 20 different villages, of different age (20–71, median 40) and gender (28 women, 29 men) participated in the focus group discussions. The selected participants have actively engaged in agroecological farming and improved livestock keeping between 1 to 6 years (median 4) through direct training by SAT (47), or by peer-to-peer learning (10). As the groups were mixed with farmers and pastoralists, we purposely divided the participants into groups of women and men, because according to social norms Maasai women are not allowed to speak in front of men. The questions were open-ended in order to co-create conditions for an empirically informed narrative about practices and relationships before and after the SAT intervention, how things have changed over time and space, and how participants want the future to develop (Appendix). We facilitated, synthesized, and analyzed the

focus group discussions, and also conducted ten field visits to participating farmers (5) and pastoralists (5).

### *Visualizing the future*

The focus group participants became the protagonists of this story when they laid the foundation for the future visions of collaborative agroecological farmer-pastoralist systems, that were depicted as paintings. A local artist was responsible to illustrate a synthesis of the narratives and features from the discussions as paintings. We use illustrations as they are an optimal tool to synthesize complex systems and narratives (Johansson and Isgren 2017; Johansson, Brogaard, and Brodin 2022), and can be used to facilitate the communication of key features of future visions as discussed by the participants. The use of illustrations also stimulated discussions and contributions from focus group participants, particularly those who could not read and write. As a principal investigator, Emma Johansson derived the key features of current practices and future aspirations from the focus group discussions and categorized these into a set of themes (e.g. infrastructure, education, collaboration, policy, markets, and environment). Thereafter, the artist made sketches that were cross-checked and approved by all authors of this article. The key features were illustrated as three paintings that represented future community-level collaborations, agroecological farm systems, and sustainable livestock keeping (Figures 3, 4 & 6). The paintings were thereafter shown to farmer- and pastoralist representatives from each focus group to provide feedback and suggest changes. The paintings were deemed to be complete when all elements of the participatory future visions were captured in the illustration (judged by the authors of this article). Finally, prints of the illustrations were shown and given to the participants who were invited to a final meeting, where they also provided comments and feedback on what was illustrated and how.

### *Participants of multi-stakeholder workshop*

The illustrated future visions were presented by five farmer and pastoralist representatives in a multi-stakeholder workshop at Sokoine University of Agriculture, in Morogoro. The main aim of the workshop was to discuss and elaborate on the aspired future visions, and to identify opportunities and barriers for their implementation and scaling. In addition to the farmer and pastoralist representatives, other innovative actors of the food system were represented by researchers (4), NGOs (3), food storage (1), botanicals manufacturer (1), and agricultural extension agents (3). In addition, one pastoralist, one dairy factory representative, and a livestock researcher were invited to the workshop, but could not attend.

### The three horizons framework

The focus-group and workshop discussions were guided by the qualitative approach called Three Horizons Framework (Sharpe et al. 2016), which is commonly used when working with complex and intractable problems and uncertain futures, and to identify key ideas and actions to enable a transformation of a system. The framework maps two main pathways over time (here defined as a decade), where the horizontal x-axis shows three stages of development (current system, a transition period, and future system), and the vertical y-axis represents the dominance of certain practices and systems (Figure 5). The first horizon $H_1$ (red line) represents the business-as-usual pathway, i.e., what currently dominates a particular system but needs to be phased out. The third horizon $H_3$ (green line) represents the emerging future we want to move toward. In the middle, there is a second horizon $H_2$ (blue line) that represents any disruptive innovations or activities that can help induce a shift to support the future vision ($H_{2+}$), but need to be designed to not be absorbed back to strengthen and maintain business as usual ($H_{2-}$). At the workshop, participants were guided through the framework by answering questions linked to numbers across the timeline (Figure 5, Table A1), inspired by Rana et al. (2020). Participants were also encouraged to add important aspects beyond the guiding questions that were brought up in the groups. At the end of the workshop, the working groups presented their key findings and action points for all workshop participants. This useful qualitative approach has also been applied to develop future visions with farmers and food system actors in Sweden (Johansson, Brogaard, and Brodin 2022).

### Reflections on the participatory research design

This research was purposely designed to facilitate discussions with innovative farmers, pastoralists, researchers and other food industry actors that aim to support agroecological farming and improved livestock keeping. The main reason was to create a clear vision based on farmers' and pastoralists' aspirations about what a sustainable food system could look like, and function, and what actions are needed to change the status quo on a larger scale. Even though the workshop was guided with questions that focused as much on agroecology as on livestock keeping (Table A1), pastoralists expressed that livestock keeping was somewhat underrepresented in the future food system. One reason for this might be that three key actors related to livestock did not attend the workshop, and that agroecological livestock keeping practices are not as clearly defined within agroecology as farming practices (Soussana et al. 2015).

### Analysis of the qualitative material

The analysis of the material is based on deriving themes from the focus group- and workshop questions, based the questions linked to the three-horizons framework. We followed a similar thematic categorization as Johansson,

Brogaard, and Brodin (2022), where the main themes for analysis were those uncovered by the participants within social, political, and environmental spheres, over a temporal scale from the present to the future. We highlight dominant narratives, as well as minor "outliers," and also look for tensions in the collected material in order to contrast conflicting ideas with each other. We distinguish between narratives obtained from the focus group discussions, and what was added through from the multi-stakeholder workshop. The synthesized thematic narratives are thereafter discussed and contextualized in relation to other research, and in relation to identified barriers for scaling up agroecology.

## Results

### *Challenges and solutions for farmers and pastoralists*

The farmers and pastoralists express that environmental degradation (e.g., soil erosion) and pollution (e.g., chemical residues in soils and water) from conventional and traditional production systems are key challenges related to food production, and there is inadequate knowledge at all levels about sustainable crop production, livestock keeping, processing and storage. The farmers further highlight that the heavy political and financial support for conventional farming has taken the agricultural identity away from many smallholder farmers, and created a culture of profit-based farming with high production costs and economic dependence on input suppliers. Many farmers express that the heavy use of agrochemicals for both food production and storage negatively affect the environment, and producers' and consumers' health. Farmers

**Figure 3.** Future vision focused on community-level collaboration between farmers and pastoralists. The illustration includes a milk factory, botanicals factory, shop for bio-inputs, organic markets, improved livestock market, Village Community Banks, farmer and pastoralist collaborations and integration in school, and for village meetings and leadership.

**Figure 4.** Future vision focused on farming systems. The illustration includes intercropping, agroforestry, mulching, livestock keeping, cash-crops (mushrooms), fish ponds, vegetable gardens, and new food distribution systems.

increasingly purchase and use annual certified seeds from agro-dealers that cannot be reused, as opposed to traditional seed varieties that can be stored and reused. Pastoralists explain that livestock keeping is practiced with little knowledge about the carrying capacity of available natural resources of the land. All groups raised that conflicts between pastoralists and farmers are common, mainly due to competing interests related to the use of land and water resources, and a lack of respect for each other. In terms of market access and profitability, most farmers and livestock keepers sell their products to middlemen at very low prices due to the lack of reliable markets and poor road infrastructure, and they further highlight that middlemen and traders benefit the most from selling and purchasing food products.

As participating farmers and pastoralists have been trained by SAT or peers, they have gained knowledge and increased awareness about agroecological practices and improved livestock keeping. In turn, the education has influenced their attitudes and practices in relation to conventional farming and traditional pastoralism. As a response, there is a growing level of peace and collaboration between the farmers and pastoralists that builds on awareness of

**Figure 5.** Future vision focused on livestock keeping. The illustration includes improved breeds, planted and natural pastures, fences, different livestock, farming, milk collection centers and collection, local dams, and storage of pastures.

mutual benefits, e.g., that cows can graze farmland after harvests, and that farmers can get manure from pastoralists. Although there are still occasional mishaps, those that have been trained mainly live in peace because they have been taught that they can live together in symbiosis. Table 1 summarizes mainstream practices and challenges as described by the participants, and how knowledge about alternative farming and livestock practices have solved some of these issues. Also, some persisting and new challenges are highlighted in italic in Table 1, and an extensive description of past and current challenges and solutions can be found in the Appendix.

## *Future visions of food, farm, and livestock systems*

### *The future food system*

All participants express a future where there is knowledge about agroecology at all societal levels (e.g. among producers, consumers, teachers, religious leaders, politicians). Workshop participants describe a future food system where food is locally and regionally sourced, and that most food products in

**Table 1.** Summary of past practices and challenges, current practices and solutions, as well as new and persisting challenges. The table is structured around themes that emerged from the focus group discussions with farmers and pastoralists.

| | Theme | Past practices | Past challenges | Current practices | Current state |
|---|---|---|---|---|---|
| **Farmers** | **Farm preparation** | • Prepare fields by burning plant residues after harvest<br>• Shifting cultivation<br>• Cut trees to produce charcoal as an alternative income source | • Environment not conserved<br>• Soil erosion | • Plant trees<br>• Biomass reused through mulching (i.e., spreading dry grass on the farm surface to prevent evaporation)<br>• Bury and integrate residues to fertilize soils | • Soil erosion prevention<br>• Enhanced soil organic matter, water retention, and organic life<br>• Fertile soils |
| | **Planting** | • Spread seeds haphazardly and put many seeds in one hole<br>• Poor knowledge about seed selection | • Poor planning<br>• Low yields | • Plant in rows with proper spacing<br>• Intercropping, cover cropping, agroforestry<br>• Vegetable garden near houses<br>• Use of improved local seed varieties<br>• Seed selection | • Plants benefit each other, leguminous plants cover soils and fix nitrogen<br>• Trees have fertilizing effects (e.g., Moringa and Gliricidia)<br>• Vegetables irrigated with kitchen water |
| | **Crop management** | • High use of inorganic inputs (agro-chemicals and synthetic fertilizers)<br>• Less knowledge how to avoid agro-chemicals | • High cost for inputs, low and short-term profits for yields<br>• Lifeless soils<br>• Resistant pests<br>• Killing plants due to overdose of chemicals<br>• Negative health impacts | • Make bio-inputs (i.e., "botanicals")<br>• Make "manure tea" | • Use locally available plants to make biological inputs<br>• Healthier farmers and soils<br>• No risk of killing plants due to overdosing<br>• No risk of killing plants due to overdosing<br>***New challenge:*** *botanicals take a long time to prepare and have a short shelf-life* |
| | **Harvests and crop preservation** | • Preserve and store harvests by adding chemicals | • Low yields (4–6 bags of maize) | • Use air-tight bags to store harvests without chemicals<br>• Mix harvested crops with dry neem leaves or ash from rice husks | • Doubling of yields (10–12 bags of maize)<br>• Healthy food free from chemicals<br>• Enough for household and the market<br>• Improved economy |
| | **Markets** | • Low access to reliable markets<br>• Lack of buyers that are reliable and give fair prices | • Need to sell for low price in times of urgent need for money | • Some new options as SAT has emerged as a new market | • Some new market opportunities<br>***Persisting challenge:*** *low access to reliable markets and buyers* |

(*Continued*)

**Table 1.** (Continued).

| | Theme | Past practices | Past challenges | Current practices | Current state |
|---|---|---|---|---|---|
| **Pastoralists** | **Improved breeds** | • Traditional migration to look for pastures and water during dry season<br>• Many cattle of low quality and market value<br>• No focus on productivity | • Conflicts with farmers<br>• Soil erosion resulting in gully formation<br>• Cows produce little milk (0.5 L/day)<br>• Difficult to access new breeds<br>• Cows sold for low prices (200 000 TZS) | • Strive to settle and have smaller herds<br>• Improved breed of cow and goat to cross-fertilize with traditional breeds | • Fewer but more productive cows<br>• More milk (4-10 L/day depending on season)<br>• Cows sold for higher prices (1–2 million TZS)<br>***New challenges:*** *new breed cannot walk far, hungrier and thirstier than the traditional breed*<br>***Persisting challenge:*** *water for livestock during dry season* |
| | **Livestock diseases** | • Cattle treated with medication from the agro-shop<br>• Chemical dips and sprays to control external parasites<br>• Not aware how to diagnose and treat sick cattle<br>• Traditional herbs to treat a few diseases | • No control if cow was injected before milking | ***New problem:*** *new breed has new diseases and are afraid of flies, which makes them difficult to control* | ***Persisting challenge:*** *No major solution to control livestock diseases*<br>***Persisting challenge:*** *No botanicals that can replace chemicals in dips* |
| | **Pastures** | • Migration to look for pastures for cattle | • Farmer conflicts<br>• Soil erosion | • Grow, preserve and store pastures<br>• Individual and group pastures<br>• Farmers can grow pastures to sell to livestock keepers<br>• Make hay bales<br>***New problem:*** *termites where fodder is stored* | • Fodder for livestock during dry season<br>• Reduced need for migration<br>• Additional income source by selling hay bales |
| | **Milk market** | • No reliable milk markets<br>• Few milk-collection centers | • Livestock keepers (particularly women) travel far, and sell at low prices | • Milk factory<br>***Persisting problem:*** *few milk-collection centers* | • Secure source of income<br>***Persisting challenge:*** *Poor road conditions and challenges to deliver milk* |
| | **Education and empowerment** | • Pastoral lifestyle based on family traditions<br>• Children and women take care of herds<br>• Pastoralists daughters married to other pastoralist families to obtain more cows<br>• Migration to take care of family graves | • Pastoralist children not sent to school<br>• Domestic violence if woman lose cows while grazing<br>• Early marriage for girls at the age of 12 | • Women responsible for milking and household (not grazing)<br>• Children sent to school<br>• Women aware of their rights<br>• Establishment of permanent settlements where Maasai move part of livestock, and some remain<br>• Family graves near settlement<br>• Workers are employed to graze cattle | • Less domestic violence<br>• Improved income for livestock keepers, others employed to take care of herds<br>• Girls married at the age of 18<br>• Women can sell livestock<br>• Women remain at house with few cattle<br>• Inter-marriage between farmers and pastoralists<br>***New challenge:*** *employed workers are not aware of new collaborations and peace between livestock keepers and farmers* |

(*Continued*)

**Table 1.** (Continued).

| | Theme | Past practices | Past challenges | Current practices | Current state |
|---|---|---|---|---|---|
| **Farmer and pastoralists** | **Collaboration between farmers and livestock keepers** | • No understanding or respect between farmers and pastoralists<br>• See each other as enemies<br>• Crops seen as food for cattle<br>• Some village government officials spur hate and conflict between farmers and pastoralists | • Land use conflicts<br>• Pastoralists graze farmland without permission<br>• Farmers harm livestock in cases of encroachment | • Agroecology has brought farmers and pastoralists together<br>• Exchange manure, milk, and meat with crop residues and vegetables.<br>• Livestock are allowed to graze farms after harvest in agreement with farmer<br>• Pastoralist settle and also engage in farming activities<br>• Government created committees for conflict resolution and fair compensation | • Farmers and pastoralists see how they benefit each other<br>• Peace<br>• Understanding that farming is also for profit.<br>• Maasai village chairman can represent both farmers and livestock keepers<br>***Persistent challenge:*** *Those who have not been trained in collaboration are still in conflict with each other* |
| | **Saving and lending** | • No saving and lending system | • Farmers sell for low prices in times of urgent need for money<br>• Pastoralists sell for low prices in times of urgent need for money<br>• Difficult to make investments | • Trained and mobilized to form groups for saving and lending money | • No need to sell livestock at low price in times of crisis<br>• No need to sell farm products at low prices in times of crisis<br>• Take sick people to the hospital<br>• Make investments<br>• Take children to school<br>• Construct houses<br>• Diversify incomes (e.g., building guesthouses and shops) |
| | **External challenges** | • Elephant threats<br>• Droughts and unreliable rainfall | • Elephants destroy farm fields and harm farmers<br>• Lower or failed yields due to drought | ***Persisting problem:*** *Elephants and droughts* | ***Persisting challenges:*** *Elephants and droughts* |

Tanzania come from within. Agroecological farm systems should be diverse but specialized in relation to local climates and conditions, which is likely to increase farm productivity. With improved incomes through higher yields, farmers can buy other locally or regionally sourced products from organic markets. Food production and storage should be chemical-free through increased access to cold rooms, air tight bags, and processing facilities. However, there is a need for specialized markets and sections in supermarkets where consumers can access organically certified products, which would enable agroecology to scale deep, as having accessibility of organic products might influence behavior and demand.

### *Future farming*

All participants describe future farms that are small-scale and productive, using agroecological methods like intercropping, mulching, cover cropping, crop rotation, and using biological inputs like manure, manure tea, and botanicals. Manure tea is a dilution of animal dung and water, fermented over 20 days, and further diluted with water and poured on plants for fertilization. Botanicals are biological pesticides made of locally available plants like chili, aloe vera, neem tree leaves and moringa. Participating farmers believe that such farming practices will improve soil fertility, and thereby reduce the need for shifting cultivation. Every future agricultural household should have an organic vegetable garden, and with improved yields and income, households will be food secure. Future farmers also have increased knowledge about seed selection, and save their own seeds for the next planting season. However, the farmers highlight a need for simple technological innovations and new industries to make agroecological farming easier (e.g., machines and industries that produce botanicals, oil processing factories), and organized markets for selling agroecological products, which would attract more farmers to join and scale out agroecology.

Workshop participants highlight that small-scale agroecological intensification is suitable in the Tanzanian context, as there are plenty of skilled and non-skilled smallholder farmers and workers. However, agroecological farmers need to be business minded and find ways to optimize their production by minimizing inputs and reducing costs through integrating water and feed in the production system. Another way to reduce costs and dependence on purchasing annual certified seeds is to use more perennial crops, or self-pollinating crops that can be harvested and re-planted. Waldman and Richardson (2018) highlight the overall economic benefits of growing perennials due to lower input and labor cost, even though yields are generally less than for hybrid seeds. One workshop group suggest block farming as a management strategy to make plowing and pest management more efficient through collective arrangements. This will require skills in communication,

collaboration, and that farmers organize themselves, which can be facilitated by strong local institutions.

### *Future livestock keeping*

The participating pastoralists would like to have smaller livestock herds containing a mix of cross-bred cattle for improved milk and meat production, and drought- and disease tolerant traditional breeds. They believe that smaller herds will minimize soil erosion and gully formation, which will conserve the environment. With smaller herds of increased productivity and profit, pastoralists will be able to settle and also cultivate some crops. Pastoralists also want to see water reservoirs near their settlements in order to have local water points for their livestock during the dry season, and irrigation systems for their crops. They also want to grow pastures for grazing and preservation (e.g. hay bales), and that some pastures are irrigated to increase plant growth in order to improve milk production. Some pastoralists also want fences that protect pastures and keep harmful animals away from livestock. The access to simple machines would make it easier to make hay bales, since the manual work is tedious, and grasses itch.

Workshop participants described the future as a "settled society" and added that livestock keeping should be done according to available resources and the carrying capacity of the land, e.g., through rotational grazing (see extended discussions and debates about pastoralism and sedentarization in the conceptual background). They further emphasized the need for water, disease control, pastures, improved breeds and record keeping. Future livestock keeping can be based on crop-livestock integration (i.e., residues for animals, manure for crops), and that manure can be used for biogas production to substitute fossil fuels. Workshop participants also highlighted that livestock keepers need to organize themselves and collaborate as entrepreneurs to innovate new production opportunities to meet societal demands.

### *Increased farmer and pastoralist collaboration*

In the future, farmers engage with livestock keeping and pastoralists in farming. They also share resources with each other, including new products like processed sunflower seed cake. Diversification will bring farmers and pastoralists even closer together, as they will turn to each other for advice, and gain better understanding and respect for each other's livelihoods. All participants emphasized the need for wells or dams, which would reduce the competition and conflicts over water. Many participants also emphasized the importance of inviting each other to social events like ceremonies and funerals, which will further strengthen relationships, understanding and peacebuilding.

### *Increased use of botanicals*

One of the farmers expressed that "industrial inputs give immediate results, as they kill pests and boosts harvests quickly. Organic inputs like botanicals work,

but not as quickly as inorganic inputs." However, with increased and more extensive use of botanicals, farmers are sure that their health will be improved, and that poisoning caused by chemicals will disappear. Pastoralists are currently not using botanicals for livestock treatment in dips and sprays, but if botanicals for such purposes were available, they would prefer to use them rather than chemicals. Farmers express that using agroecological practices and botanicals is complicated and requires more labor and planning than conventional farming, which is why many farmers choose to not engage. The participants express that technological innovations and factories that produce botanicals, and the availability of botanicals in agro-shops is crucial for agroecology to scale out. The establishment of many small- and medium-scale botanical factories will also generate job opportunities. However, the botanicals manufacturer representative expressed the need to systematically gather evidence about the quality of botanicals, and to develop standards that ensure their quality. In order to make the products efficient and available, botanical industries should be developed in collaboration with both researchers and the government. Also Riyaz et al. (2022) and Ngegba et al. (2022) highlight similar opportunities and limitations in using botanicals as the participants of this study, as well as the need to develop quality standards.

### *Consumer awareness, labeling, and markets for organic products*

All participants emphasized a future with increased awareness about healthy food and diets, both in terms of production and consumption. Agroecological products should be visible and available to meet consumer demand through organized markets. However, farmers highlight that consumers need to be well informed about how food has been produced through labeling and certification. Pastoralists further highlight the need for a quality indicator for milk and other dairy products to guarantee that cows have not been injected with chemicals before milking. Consumers should know how animals are treated, and with an increased use of botanicals, this concern can be reduced. Furthermore, farmers expressed the need to be recognized for producing food without chemicals, e.g. by having a higher price than conventional products. They also believe that higher prices will convince others to engage with agroecology, and think that consumers will be willing to pay more for high-quality and chemical-free products. Workshop participants also discussed the current lack of price difference between organic and conventional products, but as opposed to the farmers, they stress that organic markets need to meet the demand for availability and accessibility (that people can afford to buy) of healthy food. Hence, organic products should be made visible through labeling, but prices should be kept low through subsidizing biological inputs and reducing production costs. Jouzi et al. (2017) highlight that having access to organic markets, and opportunities to sell organic products for premium

prices are among the most important economic advantages for organic small-scale farmers.

### *Fair value-chains*

In order to empower both producers and consumers, some farmers suggested a new type of contract farming where consumers and producers agree on price and quantity upon order, and that farmers are paid a share in advance. Some livestock keepers emphasized the need for contracts between those who fatten cows for meat production, and those who slaughter. Additionally, middlemen should pay by weight rather than volume to better represent the value of what farmers sell. Pastoralists would like to see measuring scales for livestock at the market in order to get a fair price by weight. There is a need for more collection centers for both crops and milk, and common markets for such products. All participants highlighted the need for improved roads to access markets and processing factories. In terms of processing, there is a need for milk and meat processing factories, and factories for processing high-value products like sunflower oil. Workshop participants added that milk collection centers and factories should be established and owned by livestock keepers to process a variety of dairy products (e.g., cheese, yogurt, butter, gee). Processors should support sustainable food systems by demanding organic products, and when producers organize themselves, they can better negotiate prices with food processors. Clapp (2021) highlights the need for policy interventions that minimize growing corporate concentration and power in food systems, which instead motivate the public sector to support diverse food systems.

Workshop participants suggested that agroecological products should reach consumers through retailers like wholesalers (bulk quantities), and supermarkets (smaller quantities). In order to deliver high quantities of quality, farmers must be organized, and there should be fair contracts that indicate the standards that producers must meet. Opportunities and limitations of contract farming are complex, and Bellemare, Lee, and Novak (2021) found that contract farming can lower farmers' income variability, while Ragasa, Lambrecht, and Kufoalor (2018) highlighted that contract farmers do not benefit economically from higher yields due to higher input costs. Participants expressed that contracts are currently rarely sustained because of low productivity or small-scale producers, and that processors and supermarkets require large quantities that farmers cannot deliver. To solve this, they suggest retailers can contract agents to collect large quantities from multiple farmers, and such agents should be responsible for efficient distribution of agroecological products to markets, which can reduce transports and emissions. One workshop group also discussed the possibility of having "mobile shops" of agroeological products to cater for the needs of local buyers. Another workshop group discussed digital markets where consumers and producers

can place orders through e-marketing, which could further strengthen the producers' and consumers' power over the food value chain.

### *New income-generating activities, savings and loans*

All participants emphasized a future with modern concrete houses with metal roofs, and that "this success should come from the income generated from one's own farm." Farmers and pastoralists already experience that incomes have increased due to lower input costs and improved productivity, and that 'saving and lending groups' make it possible to acquire simple machines and to invest in other income-generating activities. Participants wish to invest in buildings to rent to shop-owners, beehives for beekeeping, or to establish tree plantations for botanicals. However, participants suggest that the payback time for loans should be adjusted in relation to the economic turnover of the investment. Banks should also provide loans for investments related to agroecology and improved livestock keeping, and not only support large-scale producers. Similar views on banks and loans have also been expressed by innovative farmers in the Swedish context (Johansson, Brogaard, and Brodin 2022).

### *Policies that support agroecology and improved livestock keeping*

The participanting farmers emphasize that there is a need to subsidize botanicals, and regulate or prohibit the sales and use of agrochemicals. Instead, the government should promote planting trees like neem and moringa, as these are important ingredients for botanicals. In terms of livestock keeping, the government should be at the forefront of providing pastoralists with improved breeds and education in improved livestock keeping, which is currently spearheaded by NGOs.

According to workshop participants, the Tanzanian government is currently developing a national strategy for "ecological" agriculture. Different ministries collaborate on agricultural issues, and these collaborations work well and should remain in the future, but the policies need to change and agroecology should scale up to guide policy development. More specifically, policies should favor domestic production of botanicals by many small- and medium-scale industries (as opposed to current prohibitive regulations for registering bio-inputs), which will create a new domestic market and generate many new employment opportunities. As conventional agro-inputs are currently cheaper than botanicals, there is a need to reduce taxes and subsidize botanicals. Farmers highlight that organic farms need larger quantities of bio-pesticides than inorganic chemicals, and that the costs are currently very high. Air-tight bags should also be subsidized to enable farmers to store seeds in chemical-free bags instead of adding chemicals for post-harvest preservation.

### *Agroecology in education, information systems, and research*

All participants emphasize the importance of education for scaling agroecology out, up and deep. Agroecology and farmer-pastoralist collaboration should be taught at all education levels (from primary school to university), and the government should work with leading organizations to develop curriculums for different levels of training. Agricultural extension agents should be trained in agroecology in order to become catalysts for change. Also (De Schutter 2010) emphasizes the need for a political environment that can enable agroecology to scale out through public policies that reinvest in agricultural education, research and extension systems. Currently, very few participants express that they benefit from any training from governmental extension services, as extension agents mainly come in case of conflict. The low level of engagement by extension agents is visible in the National Sample Census of Agriculture (NSCA 2021), where household services on crop production dropped from 67% to 7% between 2008 and 2020. The same pattern is also observed for extension services related to livestock keeping that decreased from 55% to 9%. Participants also highlight problems related to conventional advices, e.g., to use more or other chemicals to solve problems related to agriculture or livestock. As agricultural extension agents are generally not educated in sustainable farming, they can not advice or educate farmers to farm sustainably. Similar barriers related to knowledge and information systems have also been observed in the Ugandan and Swedish context (Isgren 2016; Johansson, Brogaard, and Brodin 2022).

In terms of information systems, farmers and pastoralists highlight that success stories should be communicated and promoted by influential people like religious leaders, chiefs, teachers, government institutions, agricultural extension agents, and shared via digital and non-digital platforms like television, radio, newspapers, and social media. They believe that when people see, hear, and learn about others' success, they will be inspired to do the same. There is also a need for more knowledge dissemination through peer-to-peer teaching and learning, as well as events that gather and unite farmers and pastoralists, like farm visits, seminars, workshops, and agricultural exhibitions, where they can explain their collaborations and practices. The research agenda should prioritize sustainable food systems, and all participants express a need for more collaborations between researchers, extension workers, farmers and livestock keepers. There is also a need to gather reliable information and evidence about agroecological practices and outcomes, and to communicate this information to politicians in order enable agroecology to become the new norm for agricultural development and sustainable food systems.

## Discussion

Profound transformations of food systems are needed to address the Sustainable Development Goals (United Nations 2015), and to reduce future

negative impacts of climate change (Zurek, Hebinck, and Selomane 2022). This transformation will affect what people eat, as well as how food is produced, processed, transported and sold. The Tanzanian population is projected to grow from 62 million to exceed 100 million in 2038, and agricultural output is currently mainly increasing through cropland expansion (Wineman et al. 2020). This stresses the need for improved food production through increased land productivity, while also conserving the environment and lifting people out of poverty. Similar visions for agroecological food systems have also been described by other researchers and advocacy organizations (Bellwood-Howard and Ripoll 2020; Braun, Bitsch, and Häring 2022; Johansson, Brogaard, and Brodin 2022; Uphoff 2013).

According to Pimbert (2018), four key changes are needed to bring about an agroecological transformation. Firstly, there is a need to invent new discourses about "modernity" by regenerating a diversity of autonomous food systems that nurture cultural diversity and enable many paths to realize self-defined aspirations. Also, linear food systems need to be by re-designed into circular systems by mimicking natural cycles, and re-localizing production and consumption. It is also important to re-think economics that exclude a high number of workers, and to link job creation and wealth creation with a fairer and more gender equitable distribution, and to deepen democracy and embrace food sovereignty by promoting locally autonomous and socially just food systems. This study showcase similar ideas and solutions for future food systems, but also highlight persisting barriers for a transformation toward agroecological food systems in Tanzania.

### *Barriers for agroecological food system transformations*

Wineman et al. (2020) emphasize that "Tanzania is transitioning to a more developed society," with increasing trends of urbanization and a smaller share of the population engaged in farming. The "modertization" discourse on agrarian development is a major barrier for agroecology to expand (Isgren 2016), as agroecological intensification of small-scale farms turns into a simplified debate about "modernity" versus "backwardness." Currently, the agricultural transformation in Tanzania is in line with agricultural modernization, signified by the establishment of mechanized medium- (5–100 ha) to large-scale (>100 ha) farms that are increasingly dependent on inorganic inputs and certified seeds (Wineman et al. 2020).

Furthermore, the Tanzanian government promote Climate Smart Agriculture (CSA) as a possible solution for agricultural intensification (NSCA 2021). CSA emphasizes the need to sustainably increase agricultural productivity and incomes by a sustainable use of natural resources, and makes use of some agroecological practices like intercropping and agroforestry (Global Alliance for Climate 2014). CSA is however fundamentally different

from agroecology as it also promotes herbicide-tolerant crops, toxic insecticides and fungicides, genetically modified seeds, energy-intensive livestock factory farming, large-scale industrial monocultures and biofuel plantations (Pimbert 2015). It also does not consider any wider changes of the food system in relation to producer's and consumer's power, or food sovereignty. The political and economic interest vested in this particular pathway of agricultural development is therefore another barrier for agroecology to scale out in Tanzania. Whether or not any form of sustainable intensification is part of an agroecological transformation depends on if other key agroecological principles like co-creation of knowledge, minimizing toxic inputs and maintaining agrobiodiversity, are included (HLPE 2019).

### *Potential to reduce agricultural constraints through agroecology, improved livestock keeping, and collaboration*

In this study, some farmers claim that they have doubled their yields through applying agroecological practices on their farms. Certainly, there is a need for more research that quantifies changes in yields, profitability, and labor demand, when farmers replace conventional with agroecological practices. One such study by Miyashita and Kayunze (2016) compared yields between organic and conventional production systems in Morogoro Region and show that organic farms had higher yields of maize (11% higher), cow peas (12%), and pumpkins (56%), and had mean net-income four times higher than conventional farmers. However, just like this study, they also highlight new and persisting challenges related to labor intense field preparations, poor access to markets, and the lack of premium pricing as major challenges and constraints for farmers that engage with organic agriculture.

Agricultural challenges and constraints are complex, which highlights the importance to not only focus on means to intensify agricultural production, but to also enhance farmers' and pastoralists' overall adaptive capacity. In the National Sample Census of Agriculture (NSCA 2021), the major agricultural constrains in 2021 related to droughts and floods; cost of inputs; access to land, credit and markets; low prices of agricultural products; pests and diseases; availability of inputs and quality seeds; soil fertility; destruction of wild animals; and conflicts between farmers and livestock keepers. As participants have expressed in this study, most of these challenges have improved or even been solved through agroecology, improved livestock keeping and collaboration. Costs and availability of inputs have improved by making and using botanicals; access to land has somehow been solved by intensifying production on existing land; chemical-free agricultural products can be sold at higher price because consumers appreciate high-quality products; pests and diseases are minimized by using traditional seeds, botanicals, planting crops in bags, and by using crop rotation strategies for controlling disease; farmers have

access to high quality seeds through seed selection, seed saving and sharing; they have access to credit through Saving and Lending Credit Associations and Village Community Banks; the access to markets have improved through the construction of a new milk factory, and the member-based organic shop initiated by SAT; conflicts between farmers and pastoralists have reduced due to increased awareness about interdependence and the formation of conflict resolving committees. Challenges related to droughts and floods are to some extent mitigated through intercropping, mulching, and planting cover crops, which preserves soil moisture. But farmers highlight that the effects from serious droughts cannot be resolved even with such soil water and nutrient retention, and more research is needed to assess how agroecology can lower the climate vulnerability of farmers. The destruction of farms by elephants is another major challenge for many farmers, but natural fences of beehives and crops like chili, sesame and sunflower might help solve some of these issues, as these crops are not eaten by elephants. There is some research that investigates if natural fences can mitigate elephant threats for crop production (Chang'a et al. 2016; King, Douglas-hamilton, and Vollrath 2011).

The Tanzanian government sees the low adoption of fertilizers as a main reason for low crop productivity in small-scale farms, and links this to the high cost of imported inorganic fertilizers. There is a relatively low use of fertilizers in crop production (20% of cultivated area) despite the government's efforts to promote inorganic fertilizers (Figure A2; NSCA (2021)). As a response, the government has identified policy implications to attract investments into domestic fertilizer production to lower prices and attract more farmers to use inorganic fertilizers. Here, we see an opportunity to instead develop domestic production systems for botanicals and biological fertilizers, which also aligns with the policy goal to explore niche markets that are willing to pay premium prices for organic foods. This also links to the participants' desires for recognition, and visibility for consumers related to chemical-free production. Participants boldly suggest that the government should develop policies that support agroecology, by prohibiting agrochemicals and incentivizing botanicals. Prohibiting agro-chemicals is a radical suggestion that may not be easily embraced by any government, but if there would be support for agroecology and botanicals, the demand for agro-chemicals might fade out naturally.

To sum up, this study shows that agroecology and sustainable livestock keeping can contribute to peace-keeping and collaboration, and reduce agricultural challenges and constraints in Tanzania, while also contributing to several SDGs. However, agroecology needs to be supported "from all ends" in order to scale out, up and deep. There is a need for strong political support to make agroecology easier for farmers, and a need for education and knowledge about sustainable food systems at all societal levels. When agroecology is supported politically (scaled up), more farmers might be willing to join

(scale out). When organic markets are in place for certified products, consumers will be able to make conscious decisions about what food they eat (scale deep), and it will be possible to consume food that is healthy for both people and the environment.

## Acknowledgements

We are grateful to the Swedish Research Council (Vetenskapsrådet) for financial support (grant number 2019-05474). Thank you to the Agroecology Hub in Tanzania for academic and financial support, specifically to prof. Mwaseba for advice when planning, conducting and finalizing this study. We are also grateful to Sustainable Agriculture Tanzania (SAT), who helped us organize field visits and to establish contacts with farmers and pastoralists that they have trained in agroecology. Thank you to all farmers and pastoralists who participated in the focus groups that formed the foundation of this research. Also, many thanks to everyone who participated in the workshop.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## Funding

The work was supported by the Vetenskapsrådet [2019-05474].

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