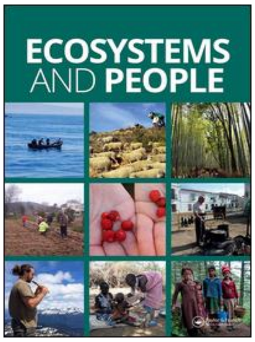


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REVIEW

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# The 10 Elements of Agroecology: enabling transitions towards sustainable agriculture and food systems through visual narratives

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**ABSTRACT**

The magnitude and urgency of the challenges facing agriculture and food systems demand profound modifications in different aspects of human activity to achieve real transformative change and sustainability. Recognizing that the inherent complexity of achieving sustainability is commonly seen as a deterrent to decision-making, the Food and Agriculture Organization of the United Nations (FAO) has approved the 10 Elements of Agroecology as an analytical framework to support the design of differentiated paths for agriculture and food systems transformation, hence facilitating improved decision-making by policymakers, practitioners and other stakeholders in differing contexts at a range of levels on a number of scales. Biodiversity, consumers, education and governance are identified as promising entry points to build a structured process using visual narratives that rely on the 10 Elements of Agroecology to graphically dissect prospective social-ecological transition trajectories. We illustrate such applications with examples from agroforestry worldwide, public food procurement in Brazil and the United States of America, and agroecology education vis-à-vis secure access to land in Senegal. Nexus approaches are used to highlight and examine salient interactions among different sectors and entry points, and to develop visual narratives describing plausible theories of transformative change towards sustainable agriculture and food systems.

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## 1. Introduction

The world's agriculture and food systems are not presently delivering desirable outcomes on food security and nutrition (FAO 2019a). In 2015, the Sustainable Development Goals (SDGs) were adopted, with SDG2 committing to 'end hunger, achieve food security and improved nutrition, and promote sustainable agriculture' by 2030 (UN 2015). The SDGs recognized, well beyond previous global goals, the strong interconnectivity among development goals. Thus, issues of hunger and malnutrition are linked to issues of equity, justice and employment, along with environmental sustainability – hence the need for holistic approaches. In order to meet SDG2, there is an urgent need for transformative change, understood here as a profound transformation of human activity across multiple dimensions and at multiple scales (Caron et al. 2018; Vermeulen et al. 2018; Díaz et al. 2019). The consensus call for transformative change has been further emphasized in several recent Global Assessment Reports (UNCCD 2017; IPBES 2018, 2019; IPCC 2019) and triggered the ongoing IPBES Transformative Change Assessment (IPBES 2020). Despite the growing consensus on the need for transformative change, however, there has been less agreement on how this could be accomplished (Foran et al. 2014; Veldhuizen et al. 2020). A recent large-scale quantitative textual analysis of the scientific literature on 'how to feed the world' highlights a disproportionate emphasis on increasing food production via technology, and the need for holistic approaches that consider three fundamental levers, namely, population, diet and food production in an integrated way (Tamburino et al. 2020). This is consistent with earlier studies recommending greater attention to multidimensional performance rather than to the prevalent focus on the productivity metric (Tittonell 2014; Gliessman 2016; Caron et al. 2018; Pretty 2018; Rasmussen et al. 2018; Tomich et al. 2018). Successful transitions towards sustainable agriculture and food systems would likely benefit from holistic and people-centred approaches

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that embrace a long-term vision, such as agroecology, which is increasingly acknowledged for its potential to bring about transformative changes required to meet the SDGs (FAO 2018a; HLPE 2019).

Agroecology has moved from being an ecology-based discipline, defined by five principles (i.e. efficiency, diversity, synergies, natural regulation and recycling), to being a broader, multidimensional concept that required additional principles to be defined, such as those in the realm of social, political and economic disciplines and dimensions (Altieri 1995; Wezel et al. 2014; Gliessman 2015; Dumont et al. 2016; Anderson et al. 2019a). Three major steps – increasing eco-efficiency, input substitution, system re-design – have been identified in the transition towards more sustainable agriculture and food systems (Tittonell 2014; Pretty 2018), based on the early descriptions of agroecological transitions put forward by Gliessman (1998) and others in the last century. While much has been written about increasing the efficiency of agricultural systems and the role of substitution processes in supporting such efficiency gains (Keating et al. 2009; Tittonell and Giller 2013; van Ittersum et al. 2013), significantly less explicit attention has been devoted to the re-design of agroecosystems resulting from the interaction of multiple forces through time.

Re-design processes as a means to achieve agricultural sustainability are inherently complex because they need to optimize the economic, social and ecological dimensions simultaneously, including poverty eradication and climate change adaptation and mitigation (Caron et al. 2018; Teixeira et al. 2018; Springmann et al. 2018). The transition towards sustainable agriculture and food systems remains often intractable because of the failure to deal with the issue in a sufficiently holistic way and to recognize the critical importance of pervasive interactions of a wide range of biological, socio-economic, cultural and political variables over time (Foran et al. 2014; IPES-Food 2016; Gosnell et al. 2019; Tamburino et al. 2020). It is not just a problem of poor choice of germplasm and cropping system design, but also of limitations in soil nutrient availability, often related to incidence of pests and diseases; of the linkage between land degradation and poverty; of unconducive national and global policies with respect to incentives; and of institutional failures (Tittonell et al. 2016). However, the re-design of agricultural systems to transition towards sustainability should require a comprehensive, yet broadly applicable monitoring and evaluation framework. Continuous evaluation is central to re-design (Groot et al. 2016; Kanter et al. 2018; Tittonell 2019), and in the case of social-ecological transitions guided by the 10 Elements of Agroecology, hereafter referred to as 'agroecological transitions' for brevity, monitoring and evaluation should require integrative frameworks that consider the ecological as well as the socio-economic, cultural and political dimensions of agroecology.

FAO's Common Vision for Sustainable Food and Agriculture (FAO 2014) consists of five general principles: (i) improving efficiency in the use of resources; (ii) conserving, protecting and enhancing natural ecosystems; (iii) protecting and improving rural livelihoods, equity and social well-being; (iv) enhancing resilience of people, communities and ecosystems; and (v) promoting good governance of both natural and human systems. To enhance the sustainability of food and agriculture, FAO has developed different frameworks, approaches, policies, tools and techniques to operationalize this Common Vision (e.g. climate-smart agriculture; ecosystem approach to fisheries/aquaculture; Save and Grow; Sustainable Land Management). As calls have increased for a more holistic approach across sectors, embracing social equity along with environmental safeguards, FAO proposes the 10 Elements of Agroecology as a framework to structure, describe and explore the realm of agroecology as another possible pathway to operationalize the Common Vision for Sustainable Food and Agriculture, recognizing both diversity of approaches while maintaining a holistic focus. This framework builds on existing analyses that have advanced agroecology as a science, a practice and a social movement (Altieri 1995; Tomich et al. 2011; Tittonell 2014; Wezel et al. 2014; Gliessman 2015) as well as efforts to address global sustainability challenges (Steffen et al. 2015; Springmann et al. 2018).

The objective of this paper is to present the 10 Elements of Agroecology framework (c.f. FAO 2018b) as a tool to facilitate the design of differentiated paths for the transformation of agriculture and food systems. Building on the four common recommendations derived from the regional seminars on agroecological transitions (FAO 2018c)[i], and on Caron et al.'s (2018)[ii] four part transformation of food systems, we identify four promising entry points – biodiversity, consumers, education and governance – to build an argument for future

i1. Strengthen the central role of producers and their organizations in safeguarding, utilizing and accessing natural resources; 2. Foster experience and knowledge sharing, collaborative research and innovations; 3. Promote markets for agroecology-based products and services; 4. Review institutional policy, legal and financial frameworks to promote agroecological transitions for sustainable food systems.

ii1. Food systems should enable all people to benefit from nutritious and healthy food; 2. Food systems should reflect sustainable agricultural production and food value chain; 3. Food systems should mitigate climate change and build resilience; 4. Food systems should encourage a renaissance of rural territories.

practice and provide a structured process that succinctly links the 10 Elements of Agroecology to the design of prospective agroecological transitions. Nexus approaches (Liu et al. 2018) are also proposed here to highlight and examine salient interactions among different sectors and entry points, and develop visual narratives using the 10 Elements of Agroecology icons to describe plausible theories of transformative change towards sustainable agriculture and food systems.

## 2. The 10 Elements of Agroecology framework

### 2.1 Development process

During the First FAO International Symposium on Agroecology for Food Security and Nutrition organized in 2014, a key recommendation made was the development of an Agroecology Knowledge Hub (AKH) hosted by FAO to collect and disseminate information on agroecology and to enhance global awareness about its potential to guide transitions towards sustainable agriculture and food systems (FAO 2015). A consultation and reflection process was initiated with agroecology experts on the best way to structure the newly created AKH. In view of the fact that agroecology has a long history and many articulations of principles, FAO chose not to structure its further work on the subject around any one uniform set of agroecological principles, but rather to extract a set of elements that describe essential components, key interactions, emergent properties and desired enabling environment in agroecological transitions.

The 10 Elements of Agroecology resulted from a multi-stakeholder process intended to generate a system and process re-design framework to be optimized and adapted to local contexts. It was developed between 2015 and 2019 through a process involving three main phases:

i) Information gathering: This phase was based on review of the scientific literature and an extensive multi-actor consultation process targeted at agroecology practitioners from different world regions. Seminal texts on agroecology (i.e. Altieri 1995; Gliessman 2015) were analyzed, and published and grey literature reviewed focusing on definitions of agroecology applied by different actors from different regions. The review of peer-reviewed scientific literature on agroecology was complemented by further sources of information, including the presentation material, discussion and results of the First International Symposium on Agroecology for Food Security and Nutrition (FAO 2015), and seven FAO multi-stakeholder regional and international meetings on agroecology conducted between 2015 and 2017, which incorporated perspectives on agroecology from governments, civil society, academics and the private sector (see FAO 2018c for a summary of the meetings held in Brasilia, Dakar, Bangkok, Kunming, La Paz, Budapest and Tunis). In total, these meetings involved more than 1,400 participants representing 170 Member Countries and nearly 500 organizations working at local, national, regional and international levels. Gender, country, and stakeholder balance and diversity were all factors considered by meeting organizers in selecting funded meeting participants and speakers.

ii) Synthesis: This process was led by FAO experts from diverse disciplinary backgrounds with contributions from invited external agroecology experts, and included workshop exercises, email discussion threads, and several rounds of drafting and comments. This phase aimed at recognizing common elements identified in the information gathering phase that clustered different articulations of principles in alignment with FAO's Common Vision for Sustainable Food and Agriculture (FAO 2014). Prominent themes from presentations delivered during the First International Symposium on Agroecology for Food Security and Nutrition (FAO 2015) provided an initial coherent structure: recycling, efficiency, diversity, resilience and synergies as central ecological features of agroecology (Tittonell 2015). The contextual analysis of recommendations emanating from the regional consultations (FAO 2018c) identified where stakeholders felt the emphasis should lie in further work on agroecology, and areas of correspondence with the initial five elements were noted to be strong. Nevertheless, calls in regional meetings for reinforcing social and political aspects of agroecology were also strong. Thus, these aspects emerging from regional consultations were clustered under an additional five elements: co-creation of knowledge, human and social values, culture and food traditions, responsible governance, and circular and solidarity economy. Following refinement of Element names, content, and the development of a consistent storyline highlighting the wholeness, interconnectedness and interdependence of agroecology and its 10 Elements, the framework was finalized after several rounds of review by international and FAO experts. The evolving concept of visual narratives was presented to the global scientific community in 2019. First, at the 4th World Congress on Agroforestry Congress held in Montpellier – France, which was attended by more than 1,200 delegates from 97 countries, as an invited keynote presentation in a session entitled 'Agroforestry and agroecology: opportunities and challenges', and also as part of FAO side-event entitled 'Agroforestry and the tenure barrier' during the same congress. Later in the year, it was presented at the 10th Ecosystem Services Partnership World Conference held in Hannover – Germany, which was attended by more than 750 participants, opening a Sectoral Working Group day session entitled 'Agroecology: managing biodiversity and soil health for the sustained provision of ecosystem services in agriculture' co-organized and co-hosted by FAO, the Helmholtz Centre for Environmental Research (UFZ), and the Institute of Environmental Planning of the University of Hannover.

iii) Approval by FAO: The 10 Elements of Agroecology framework (FAO 2018b) was launched at the Second FAO International Symposium on Agroecology held in April 2018 (FAO 2019b). In October 2018, the 10 Elements of Agroecology were supported by the Committee on Agriculture (COAG) at its 26th Session as a guide to one of the ways to promote sustainable agriculture and food systems (FAO 2018d). Following the review, revision, and clearance process through FAO's governing bodies (i.e. COAG, Programme Committee, Conference, Council), detailed in the report of the 163rd FAO Council that took place in December 2019, the 10 Elements of Agroecology were approved by the 197 Members of the Food and Agriculture Organization of the United Nations to guide FAO's vision on Agroecology (FAO 2019c).

## 2.2 Purpose of the 10 Elements of Agroecology

FAO's regional meetings on agroecology revealed a diversity of perspectives, experiences, geographies, cultures, and transition pathways. This diversity provides a richness that constitutes the base of agroecology that FAO can build upon in efforts to scale up agroecology. However, through these participatory multi-stakeholder meetings, it also became apparent that there is no unique definition and no single way to apply agroecology. Agroecological transitions, therefore, should be designed in an inclusive manner that embodies the local contexts and constraints.

The 10 Elements help to frame agroecology in an inclusive way, without privileging one definition, stakeholder group, or region, and they provide a structure for other entities contributing to advancing the uptake of agroecology. The 10 Elements can be used as an analytical tool or mental model to help policymakers, practitioners, and other stakeholders in planning, managing, and evaluating agroecological transitions. In doing so, the 10 Elements can help facilitate the identification of entry points for the exploration, analysis and dissection of plausible theories of transformative change towards sustainable agriculture and food systems.

## 2.3 The 10 Elements of Agroecology

The 10 Elements are interlinked and interdependent (Figure 1). Each element is essential, reflecting the holistic and integrated nature of agroecology.

### Diversity

The 10 Elements of Agroecology emphasizes the importance of *Diversity*, be it diversity of species or ecological functions or knowledge held by different actors within an agricultural system (Altieri 1999; Cash et al. 2003; Doré et al. 2011; Teixeira et al. 2018), or diversity of activities and livelihood options within food systems (Vermeulen et al., 2012; Béné et al. 2019), as a fundamental precondition and adaptive trait, particularly in the context of global change. Biodiversity provides a buffering effect or 'insurance' against environmental variation because different species respond differently to these variations, and thus collectively contribute to a more stable provision of ecosystem services (Zhang et al. 2007; Power 2010; Kremen and Miles 2012; Renard and Tilman 2019). While numerous species performing a similar function in an agroecosystem could be considered redundant at a given time, they are unlikely to be redundant when taking a longer-term perspective

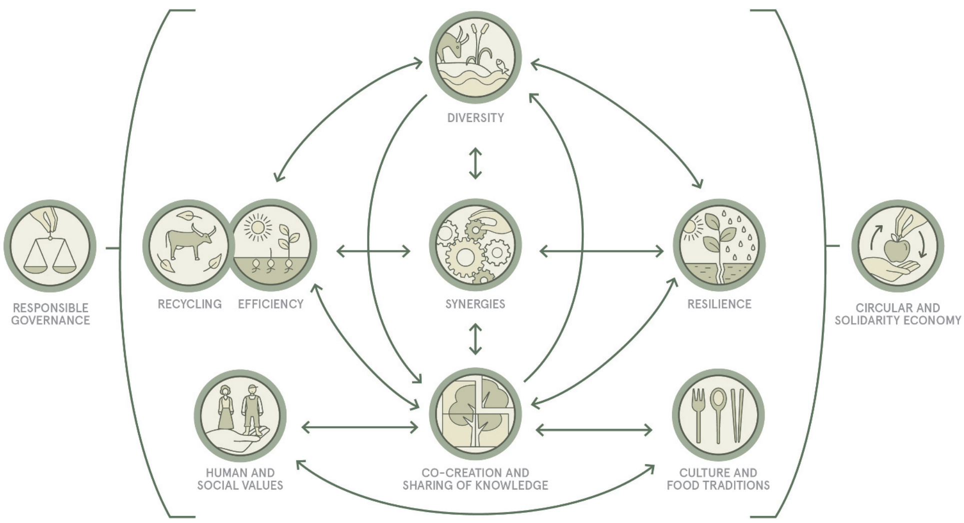


Figure 1. System components, key interactions, emergent properties and desired enabling environment in agroecology as defined by the 10 Elements of Agroecology framework (FAO 2018b).

and particularly under an increasingly changing climate. For instance, several studies have highlighted the positive contribution of crop diversity to the mean and variance in agricultural yields (Lin 2011; Gaudin et al. 2015; Bowles et al. 2020) and in farm income (D'Annolfo et al. 2017; van der Ploeg et al. 2019). Furthermore, recent global research shows that countries with higher crop diversity generally support more agricultural employment (Garibaldi and Perez-Mendez 2019). A similar relationship applies to food systems where an increase in the diversity of activities, products or services can help to evade risks generated by uncertain markets or policy environments (Ellis 2000; Reilly and Willenbockel 2010). By planning and managing biodiversity, agroecology can enhance the sustained provision of ecosystem services that are critical to agricultural production, including pollination and biological regulation of pests and diseases (Landis et al. 2000; Kremen and Miles 2012; Dumont et al. 2013; Midega et al. 2018). Diversification can also contribute to soil health by fostering soil management that minimizes soil erosion, enhances soil carbon storage, promotes soil nutrient balance and cycles, and preserves and enhances biodiversity, including soil biodiversity (Six et al. 2002; Barrios 2007; Fonte et al. 2010; Wagg et al. 2014). Diversity is thus an umbrella element that covers concepts such as diversification of activities and diversity of knowledge systems, but also biological diversity reflected by genetic, taxonomic and functional diversity in the different components of the agroecosystem (Pauli et al. 2012; Félix et al. 2018; El Mujtar et al. 2019). Furthermore, it also recognizes the importance of ecosystem services resulting from above-ground/below-ground biodiversity interactions in supporting agroecological transitions (i.e. social-ecological transitions based on the 10 Elements of Agroecology) (Bommarco et al. 2013; Veen et al. 2019).

### *Co-creation and sharing of knowledge*

The components and management of agricultural and food systems are primarily the result of human decisions. The *Co-creation and sharing of knowledge and practices, science and innovation* is a central element that drives decision-making in agroecology. Through the co-creation process, agroecology can encourage transdisciplinary engagement that may facilitate the blending of knowledge from different actors, including traditional and indigenous knowledge on agricultural biodiversity and management experience for specific contexts held by men and women, practical knowledge of producers and traders related to markets, and global scientific knowledge and practices (Méndez et al. 2013, 2015; Bendito and Barrios 2016; Nobre et al. 2017). Transdisciplinary engagement is considered here 'a facilitated process of mutual learning between science and society that relates a targeted multidisciplinary or interdisciplinary research process and a multi-stakeholder discourse for developing socially robust orientations about a specific real-world issue or challenge' (Scholz and Steiner 2015). Agroecology avoids prescriptive approaches and should encourage practices that are adapted to the local context and realities. Hence, fostering co-creation processes that build relevance, credibility and legitimacy is integral to the crafting of knowledge that is useful for sustainable development (Cash et al. 2003; Warner 2007; Barrios et al. 2012a; Clark et al. 2016; Lemos et al. 2018). Furthermore, formal and non-formal education play a fundamental role in sharing agroecological innovations resulting from co-creation processes while contributing to inclusive capacity building processes involving various local actors, especially women and youth (Holt-Giménez 2006; Ostergaard et al. 2010; Anderson et al. 2019b).

### *Synergies*

The increasing recognition of the multidimensional nature of many agricultural and food system challenges, and the limited success of sectoral approaches to face them, highlights the need for integrated holistic approaches that can address multiple dimensions simultaneously (Caron et al. 2018; Springmann et al. 2018). There is need to capitalize on the positive, greater-than-additive interactions, or *Synergies*, found between components in managed ecosystems. This include, for example, synergies manifested at the field level (i.e. nutritional benefits of cereal-legume intercropping), at the farm level (i.e. concurrent positive impacts of organic matter management on soil structure, reduced soil erosion and C storage), and at the landscape level (i.e. system diversification concurrent impacts on biological control of pest and diseases, and on pollination) (Power 2010; Pumariño et al. 2015; Barrios et al. 2018). Nevertheless, it is also necessary to recognize from the onset the cost of compromises (i.e. trade-offs) that need to be made when land is managed with multiple objectives, and that also manifest at multiple scales from the crop level (i.e. grain yield vs. crop residue production), to the field (i.e. crop yield vs. nitrogen fertilizer losses to the environment), to the farm (i.e. land for crop vs for animal production), to the landscape level (i.e. land for agricultural production vs. for nature conservation) (Tittonell et al. 2009; Power 2010; Klapwijk et al. 2014). Agroecology should pay careful attention to the design of diversified and synergistic systems, including the combination of annual, perennial and cover crops, livestock, aquatic animals, and trees. Aiming at synergies in the re-design of agricultural and food systems embraces the need to strategically use biological diversity (Midega et al. 2018;

Rosenstock et al. 2019a), and that of market linkages (Vermeulen et al., 2012; Schipanski et al. 2016) to harness multiple concurrent benefits from component interactions. In many instances, traditional agricultural systems are built around synergies – such as the integration of livestock with crops – that have been lost due to intensification, and merit reconsideration (Tittonell et al. 2009; Bonaudo et al. 2014). This emphasis, however, does not disregard the importance and pervasive presence of interactions that lead to trade-offs and the need to manage and minimize their impacts (Zhang et al. 2007; Bennet et al. 2009; Reed et al. 2013; Blaser et al. 2018; Kanter et al. 2018). To promote synergies within food systems, and best manage trade-offs, agroecological transitions should emphasize the importance of partnerships, cooperation and responsible governance, involving different actors at multiple scales, including multi-stakeholder partnerships.

### *Efficiency*

Re-designing agricultural and food systems, with synergies in mind, inherently aims to increase resource-use *Efficiency*. Innovative transitions towards enhanced sustainability outcomes should be able to move from input-intensive systems to information and knowledge-based systems of agricultural and food production aiming at further increasing productivity while optimizing the use of external inputs. Increased resource-use efficiency can be an emergent property of agroecological systems that carefully manage diversity to create synergies between different system components. Agroecological transitions should promote agricultural and food systems with the necessary biological, socio-economic and institutional diversity and alignment in time and space to support greater efficiency, and in such sense, it may contribute to attaining related intensions, such as so-called ecological or sustainable intensification or climate smart agriculture (cf. Tittonell 2014). While these efficiency gains should contribute to increased net incomes over time (Altieri et al. 2012; Gliessman 2015; van der Ploeg et al. 2019) as corroborated by true-cost accounting (TEEB 2018), returns to labour may not necessarily increase in the short term (Ajayi et al. 2009). Efficiency, in the broadest term, encompasses the classical notion of outputs per unit inputs, being these natural or human resources. But it also includes the notion of eco-efficiencies (Keating et al. 2009) meaning more output per unit of (environmental or social) impact, often referred to as 'more with less' (FAO 2011a). Agroecological approaches rarely assess efficiency at the level of an individual component (e.g. nitrogen use efficiency by a crop) but at the level of the whole farm, or ecological network efficiency (Alvarez et al. 2014; Alomia-Hinojosa et al. 2020).

### *Recycling*

By enhancing biological processes and recycling biomass, nutrients and water, producers can increase profitability by using fewer external resources while maintaining or increasing production, thus reducing costs and negative environmental impacts. *Recycling* can take place at both farm-scale and within landscapes, through diversification and building of synergies between different components and activities. Recycling is central to circular agriculture and food systems, which encompass not only the farm scale but also the flows of matter and energy at territorial and regional scale as well as between sectors of the food system (e.g. food waste or processing by-products as biochar recycled back onto agricultural soils to support plant production, fed to animals or used for biogas production – Woolf et al. 2010; de Boer and van Ittersum 2018). When true-cost are accounted for (TEEB 2018), recycling can more likely lead to agricultural production with lower economic and environmental costs (FAO 2014) and greater systems efficiency (Rufino et al. 2007). Recycling should deliver multiple benefits by closing nutrient and energy cycles and reducing waste that translates into lower dependency on external resources, increasing the autonomy of producers and regions, and reducing their vulnerability to market and climate shocks.

### *Resilience*

Enhanced *Resilience* of people, communities and ecosystems are key to sustainable agricultural and food systems (FAO 2014; Tendall et al. 2015). Resilience is considered here as 'the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks' (Walker et al. 2004; Folke et al. 2010). Agroecological practices aim to work with the biological complexity of agricultural systems promoting a diverse community of interacting organisms to allow the ecosystem to self-regulate when facing pest and disease outbreaks (Landis et al. 2000; Tscharntke et al. 2005; Midega et al. 2018). Diversified agroecological systems are usually more resilient – they have a greater capacity to recover from disturbances including extreme weather events such as drought, floods or hurricanes (Holt-Giménez 2002; Altieri et al. 2015) and boost soil health (Muchane et al. 2020). Diversified agricultural landscapes commonly show greater potential to contribute to pollination and pest and disease control ecosystem services (Bonaudo et al. 2014; Barrios et al. 2018; Kebede et al. 2018) and are able to better maintain such services when faced with climatic shocks. Agroecological transitions should equally enhance socio-economic resilience. Through diversification and integration, producers reduce their vulnerability should a single crop, livestock species or other commodity fail (Dumont et al. 2013; Bellon et al. 2020; Bowles et al. 2020). By reducing dependence on external inputs through enhanced reliance on biological processes underpinning soil health and the regulation of pests and diseases (Tscharntke et al. 2005; Barrios et al. 2012b; Dumont et al. 2013), agroecology can reduce producers' vulnerability to economic risk (Schipanski et al. 2016; Feliciano 2019). Enhancing ecological and socio-economic resilience go hand in hand; after all, humans are an integral part of ecosystems hence culture and environment exhibit strong influence on each other (Tomich et al. 2011; Ratner et al. 2013).

### Human and social values

Agroecology depends on context-specific knowledge. It should not offer fixed prescriptions – rather, agroecological practices should be tailored to fit the environmental, social, economic, cultural and political context. Agroecology should place a strong emphasis on *Human and social values*, such as dignity, equity, inclusion and justice, associated with gender and intergenerational equality and access to decent jobs, all contributing to the improved livelihoods dimension of the SDGs. It should put the aspirations and needs of those who produce, distribute and consume food at the heart of food systems. Empowering women is central to addressing gender inequity that persists despite the prominent role played by women in agriculture and food systems (FAO 2011b). Agroecological transitions can be effective to reduce gender inequity if they are designed to address underlying power imbalances women face, such as norms, relationships and institutional structures that perpetuate discrimination and imbalance (Siliprandi and Cintrão 2013; Bezner Kerr et al. 2019a). By building autonomy and adaptive capacities to manage agricultural and food systems, agroecology can strengthen the capacity of people and communities to overcome poverty, hunger and malnutrition (Altieri and Toledo 2011; Lemos et al. 2018). As a bottom-up, grass-roots paradigm for sustainable rural development, agroecology can empower people to become their own agents of change (Holt-Giménez 2006; Tomich et al. 2018).

### Culture and food traditions

Agriculture and food should be considered core components of human heritage. *Culture and food traditions*, developed as a result of long-term human-environment interaction, have played a central role in society and in shaping human behaviour underpinning agroecological transitions (Gosnell et al. 2019). However, while rural women are central to food security and nutrition as important holders of knowledge about production, processing and provision of food in most contexts, they commonly lack equitable access to land and natural resources, as well as control over their decisions (Siliprandi and Cintrão 2013; Doss et al. 2018). This discrepancy contributes to food systems with a disconnection between food habits and culture, the occurrence of food systems where hunger and obesity exist side by side (FAO 2019d; Willet et al. 2019)), and where traditional genetic resources for food and agriculture are under threat (Díaz et al. 2019; FAO 2019e). By empowering women and supporting diversified diets, agroecology can contribute to food and nutrition security while maintaining the health of ecosystems and their agrobiodiversity (Jones et al. 2014; Lachat et al. 2018). The co-creation and sharing of knowledge processes, including all the actors involved in the food system, should play a pivotal role in supporting the internalization of human and social values, and culture and food traditions, as key system context features.

### Responsible governance

Agroecological transitions towards sustainable agriculture and food systems demand the development of effective and innovative policies, institutions and markets that enable and support transformative change (Caron et al. 2018). *Responsible governance*, from communities to nations, should embody transparent, accountable and inclusive governance mechanisms that support producers, particularly during food and agricultural system re-design processes associated with transformative change. For instance, equitable access to land and natural resources (FAO 2012) is both key to social justice and a strong incentive for long-term investments necessary to protect soil, biodiversity and ecosystem services (Ratner et al. 2013; Anderson et al. 2019a). Responsible governance mechanisms at different scales can simultaneously support niche/territorial markets, by branding of agroecological produce (Wezel et al. 2009; IPES-Food 2019) and thus rewarding agricultural management that enhances regenerative production through the protection and enhancement of biodiversity and ecosystem services (van Noordwijk et al. 2012).

### Circular and solidarity economy

The *Circular and solidarity economy* reconnects producers and consumers while providing innovative solutions for achieving the SDGs (de Boer and van Ittersum 2018; Schroeder et al. 2018). Agroecological transitions should encourage recycling, shorter food circuits, and prioritizing local markets and economic development, strengthen the resilience of the rural fabric and have been shown to increase and sustain incomes of food producers while encouraging fair prices for consumers (Schipanski et al. 2016; Feliciano 2019). Despite recycling being described earlier as a separate Element, for farm- and community-scale emphasis, it is clearly part of circular economy. Moreover, short food circuits and local markets usually facilitate the involvement of women, and hence constitute an important way of increasing their personal and family incomes (Siliprandi and Cintrão 2013; IPES-Food 2019). Re-designing food systems based on the principles of the circular economy can also contribute to face the global food loss and waste challenge by enhancing recycling, making food value chains shorter and more resource-use efficient (Ghisellini et al. 2015; FAO 2019d). Strengthening responsible governance and circular and solidarity economy should be crucial ambitions of agroecological transitions to create an enabling environment that simultaneously promotes social, economic and environmental sustainability.

## 3. Visual narratives facilitating transformative change in agroecological transitions

The difficulty of designing differentiated paths for agriculture and food systems transformation, which responds to both local and national expectations and desires, has been identified as a major constraint to transformative change (Caron et al. 2018). More recently, Veldhuizen et al. (2020) identified the disconnection between food production and consumption, and between local practices and global commitments (i.e. the 'Missing Middle'), as an important restriction to the implementation of SDG2 by limiting the capacity for alignment of single actors and collective action towards positive economic, environmental or social impacts. As a contribution to facing both challenges, we propose the following process for the promotion of agroecological transitions. First, we use the 10 Elements of Agroecology (FAO 2018b) to highlight promising entry points illustrated hereby: biodiversity (i.e. Element: Diversity), consumers (i.e. Element: Circular and solidarity economy), education (i.e. Element: Co-creation and sharing of knowledge) and governance (i.e. Element: Responsible governance). Then, for each entry point, we identify a promising nexus that highlights salient interactions with multiple sectors, and where icons depicting each Element build a visual narrative to dissect and describe a plausible theory of transformative change towards sustainable agriculture and food systems, later validated with tangible examples.

### 3.1 Biodiversity–nutrition–climate change nexus

Biodiversity, nutrition and climate change are intimately linked because differences in the way plant and animal diversity are used and managed by men or women in agriculture can have important implications in the nutritional quality of food consumed and the adaptive capacity of agricultural systems to climate change (Snapp et al. 2010; Waha et al. 2018; Bezner Kerr et al. 2019b).

In Figure 2, we use the 10 Elements to graphically dissect a plausible theory of transformative change for the biodiversity entry point to an agroecological transition. A stepwise visual narrative is developed using the biodiversity–nutrition–climate change nexus, as follows:

(i) Values, culture and food traditions have contributed for centuries to define which native components (e.g. crops, livestock, trees) are included in production systems. Differences in availability, taste, ease of cooking, nutritional quality or intended use are part of the local knowledge and experience, particularly of women, and can strongly influence producer decisions on components to be selected in the system or bred for the system. The blending of

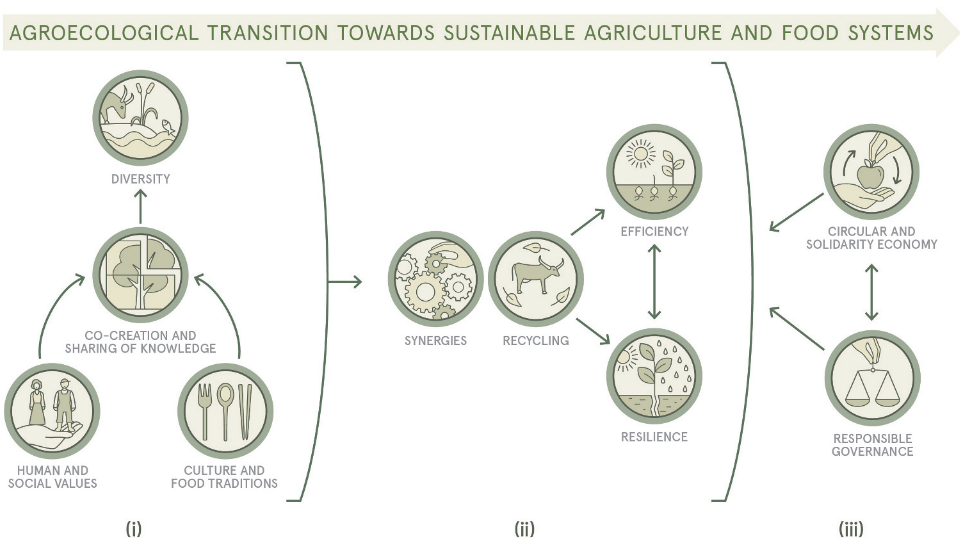


Figure 2. Dissecting a plausible theory of transformative change and agroecological transition trajectory in the biodiversity–nutrition–climate change nexus through visual narratives based on the 10 Elements of Agroecology.

local and scientific knowledge through participatory and inclusive methods should constitute a powerful approach to guide the selection of relevant system components aiming at building synergies;

(ii) Experience developed locally and globally on useful combinations of plant and/or animal types or species that encourage synergies can contribute to more diversified and nutritious diets and/or to increase the potential to adapt to an increasingly changing climate; and

(iii) Minimizing trade-offs is also considered when including plants and animals amenable to spatial and temporal management that enhances recycling potential, efficiency and builds resilience while responding to the enabling environment represented by economic and governance context features, and their interactions.

Agroforestry provides a tangible example of human activity that capitalizes on the biodiversity–nutrition–climate change nexus narrative delineated above. Agroforestry, broadly described as the integration and management of trees on farms together with crops and livestock, is a major land use associated with 43% of all agricultural land globally (Zomer et al. 2016). The planting of fruit trees by low resource endowed farmers, despite their limited and often decreasing farm size, highlights the important role played by agroforestry for improving household nutrition that is consistent with local culture and food traditions (Nyaga et al. 2015). Through the provision of fruits and nuts by existing trees, planted trees, and trees naturally regenerating from the soil seed-bank, agroforestry contributes to enhanced availability and access to nutritious foods, while simultaneously contributing to climate change adaptation (e.g. lower mean temperature and increased soil moisture) and mitigation (e.g. enhancing carbon storage) (Rosenstock et al. 2019a), and to enhanced soil health and ecosystem services (Muchane et al. 2020). On-farm trees also increase efficiency through nutrient recycling and strengthen resilience by supporting the sustained provision of food and other key ecosystem functions and services (Prabhu et al. 2015). Nevertheless, when aiming at multiple benefits through agroforestry there are inherent trade-offs to be considered as all benefits cannot be maximized at the same time, and adequate management practices play a fundamental role in reducing trade-offs between production and other ecosystem services (Wartenberg et al., 2019). For instance, recent studies in West Africa cocoa agroforests show that levels of shade-tree cover of 30% or lower are required to optimize the trade-offs between production, climate adaptation, climate mitigation and biodiversity conservation goals (Blaser et al. 2018). This underlines the critical importance of involving farmers and land managers at the onset of co-creation and sharing of knowledge for informing agroecosystem re-design processes to ensure the identification of relevant options that minimize trade-offs and are adapted to context variation (Coe et al. 2014). The enabling environment for agroforestry in Sub-Saharan Africa has been aligning in a positive way through consensus building across multilateral agreements and conventions. For instance, 71% of African countries have included agroforestry in their Nationally Determined Contributions (NDCs) towards climate change adaptation/mitigation submitted to the United Nations Framework Convention on Climate Change (Rosenstock et al. 2019b).

Furthermore, consumer demand for safer and cleaner food produced through biodiversity- and environment-friendly agricultural products is also increasing, and green markets are becoming established as part of an increasingly circular economy (de Boer and van Ittersum 2018). Agroforestry contributions to environment-friendly agriculture largely involve the enhanced and sustained biological regulation of pest and diseases, through habitat modifications that enhance the abundance and diversity of natural enemies and predators (Landis et al. 2000; Tscharntke et al. 2005; Pumariño et al. 2015), thus reducing the need for pesticide inputs that compromise food safety (Carvalho 2006). Furthermore, increased presence of trees in agriculture has been shown to enhance the abundance and diversity of pollinators that also benefit from lower pesticide applications in agriculture (Morandin and Kremen 2013; Potts et al. 2016). The fact that coffee production is dominated by smallholder farmers, often facing poverty in the context of biodiversity-rich biomes, increasing climatic uncertainty and economic volatility, has encouraged the development of certification programs offering farmers the opportunity to link economic and environmental goals (Perfecto et al. 2005). In 2012, coffee produced in compliance with a voluntary sustainability standard amounted to 40% of global coffee production (Potts et al. 2014). Fair Trade labeled products, for example, aim to certify that coffee beans have been produced in a socially and environmentally responsible fashion and thus receive a higher market price (Potts et al. 2014). Nevertheless, two substantive reviews confirm that while certified coffee markets represent one important contribution to sustainable agriculture and food systems, further efforts are needed to foster broader partnerships among farmers, cooperatives, consumer associations as well as national research and advisory services, rural development organization and local governments, embodied in the mainstreaming circular and solidarity economy (Méndez et al. 2010; DeFries et al. 2017).

### 3.2 Consumers–markets–health nexus

Food consumption patterns exert overwhelming influence over food systems. Changing consumption patterns towards nutritious and healthy foods can have major impacts on value chains and markets thus highlighting the close link between human health and environmental sustainability (Caron et al. 2018; Willett et al. 2019).

In Figure 3, we use the 10 Elements to graphically dissect a plausible theory of transformative change for the consumer entry point to an agroecological transition. A stepwise visual narrative is developed using the consumers–markets–health nexus, as follows:

(i) The consumer demand side of economic activity can be strongly influenced by culture and food traditions which in some cases may prove reluctant to positive change. Education about nutrition, however, can play a key role in raising awareness about the importance of healthy food habits and encourage co-creation of alternative dietary options contributing to changes in consumer demand. When civil society is better informed and organized it can more effectively influence the supply side of governance by requesting policies that support agroecological transitions generating diversified, nutritious and healthy food;

(ii) Both demand and supply factors can interact and feed the knowledge co-creation process, fostering innovation in terms of diversification pathways that can also encourage cleaner food production across shorter value chains, preferential markets and creation of green jobs; and

(iii) These factors can encourage that the fundamental decision-making unit, the farm, continues to diversify and support synergies embodied in enhanced recycling capacities, which may lead to greater resource-use efficiency and ability to withstand and respond to global change.

Public food procurement networks can provide tangible examples of human activity that capitalize on the consumers–markets–health nexus narrative delineated above. The Brazilian School Feeding Programme (i.e. PNAE), for instance, is an institutional market that emerged from a decree (i.e. Law n° 11.947) specifying that at least 30% of food purchases dedicated to public schools should be acquired directly from family farmers and priority given to those using organic or agroecological practices (FNDE, 2009). By allowing sales of a large variety of local products, purchases in small volumes, and delivery in installments, the federal Food Acquisition Program (i.e. PAA) significantly facilitated women's participation and gave visibility to 'women's products' often marginalized in the larger food economy (Siliprandi and Cintrão 2013). The PAA successfully demonstrated that public policy can simultaneously address food and nutrition security, social inclusion and biodiversity-friendly agriculture by providing strong support to family farming that is closely linked to agroecological food production (Sidaner et al. 2012). PNAE provides 45 million public school students with a daily meal that is closely monitored to ensure nutritional value, which basically translates into mandatory inclusion of fresh fruit and vegetables, restricted use of processed foods rich in fat or salt, and the adaptation of regional food culture and traditions (Wittman and Blesh 2017). The special importance of education on nutrition, in contributing to shape farmer practice re-design efforts towards healthier diets, has been also highlighted by Bezner Kerr et al. (2007) at a comparable context in East Africa.

In an analogous example, the public school district of Los Angeles has been enrolled in a procurement programme, called the Good Food Purchasing Program,

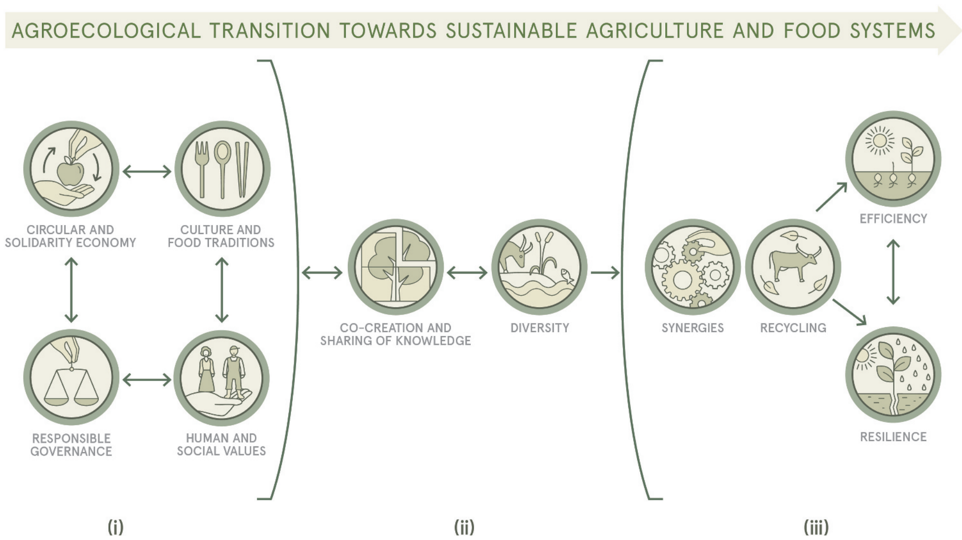


Figure 3. Dissecting a plausible theory of transformative change and agroecological transition trajectory in the consumers–markets–health nexus through visual narratives based on the 10 Elements of Agroecology.

developed as part of a city-led food policy initiative that was purposefully collaborative with other public sector entities, the private sector and a broad range of civil society organizations. A key target for the purchasing programme was the Los Angeles Unified School District, which is the largest food service provider in the state with over 700 000 meals per day. Responding to citizen demands for healthier, more sustainable and equitably procured food in schools, a collaboration was co-created between the city, the Los Angeles Food Policy Council, the Food Chain Workers Alliance and chefs within the system to establish a procurement standard, the Good Food Purchasing Program. The Program standards support five food system values – local economies, environmental sustainability, valued workforce, animal welfare and nutrition. Since 2012, all city departments and the school district of Los Angeles are mandated to use this procurement system. The school district city now annually makes more than USD 17 million in purchases from environmentally sustainable local producers who also meet standards of workplaces, animal welfare and nutrition. At the same time, the school district's enrollment in the program has created at least 220 new jobs in food processing, manufacturing and distributing, and improved the wages, health and safety of workers in the supply chain. The procurement system creates a transparent supply chain and helps institutions to measure and modify their food purchases, continuously encouraging the outreach to and inclusion of small and mid-sized diverse, local food producers using agroecological practices, and local food processors (GFFP, 2019).

### 3.3 Education–governance–youth employment nexus

As highlighted by UNESCO (1997) '*A basic premise of education for sustainability is that just as there is a wholeness and interdependence to life in all its forms, so must there be a unity and wholeness to efforts to understand it and ensure its continuation*'. This quote highlights that transformative change begins with the way we think, hence the essential role of education in developing and nurturing holistic thinking underpinning agroecology, in order to fuel and sustain the transformative change needed for sustainable agriculture and food systems.

In Figure 4, we use the 10 Elements to graphically dissect a plausible theory of transformative change for the education and governance entry points to an agroecological transition. A stepwise visual narrative is developed using the education–governance–youth employment nexus, as follows:

(i) Education can constitute an essential component of human capital enabling positive change in the way humans and nature interact for a sustainable future. Responsible governance can encourage that education, a key public good shaped by human and social values, reaches all citizens. Given the high knowledge intensity of agroecology, new policies promoting educational curricula that encourage and reward the co-creation and sharing of knowledge, while developing integrative or systems thinking skills, should be critical to face the increasing complexities of our interconnected world where disciplinary or sectoral approaches often have limited success;

(ii) Additional support to agroecological transitions could come from educational curricula that recognize the value of linking ecological sciences with social sciences (e.g. ecological economics), of building on traditional, indigenous and local knowledge and experience, of embracing participatory and action-oriented approaches to research, innovation, and gender sensitiveness and interest for youth employment as it relates to green jobs; and

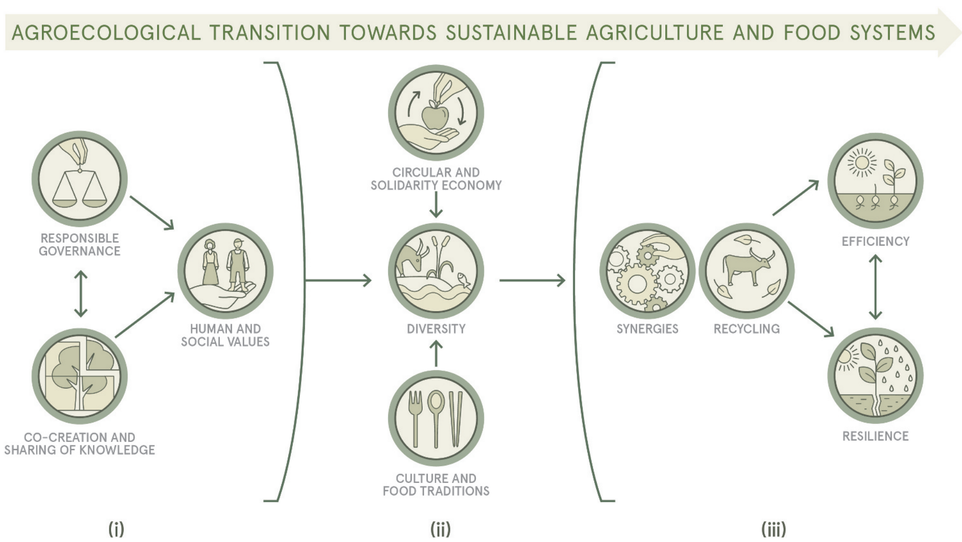


Figure 4. Dissecting a plausible theory of transformative change and agroecological transition trajectory in the education–governance–youth employment nexus through visual narratives based on the 10 Elements of Agroecology.

(iii) Diversification efforts towards building synergies, enhancing recycling and minimizing trade-offs should remain the overall strategy to enhance efficiency and resilience of agricultural and food systems.

The alliance developed by the Kaydara Agroecology School (KAS) and the Fimela town government illustrates synergies developed in the education–governance–youth employment nexus (FAO 2016, 2019f; Gora Ndiaye, personal communication). Like many other towns in the Fatick region of western Senegal, Fimela faces the combined challenges of food and nutrition insecurity, degraded soils largely due to erosion and salinization, and youth migration due to lack of rural employment. It is important to highlight that rural migration to cities constitutes a major challenge in Senegal with as much as 60% migrating to cities due to rural unemployment, and 60% of rural migrants with ages ranging between 15 and 34 years old (FAO 2018e). Rooted in shared human and social values of equity, inclusion, dignity, justice and empowerment, the KAS director (Gora Ndiaye) and the Fimela Mayor (Karim Sene) developed an innovative youth employment model to address the three challenges simultaneously. This model involves the local government providing KAS graduates with official titles to 1 ha of municipal land, initially for 10 years, and an installation package (e.g. seeds, tools) to engage in agriculture using agroecological approaches and practices. This way, the agroecology knowledge and skills acquired at KAS would be readily put into practice through i) system diversification and shorter value chains to address the growing demand for nutritious and safer food with species adapted to the local context (e.g. fruits and vegetables like papaya, guava, leeks, bell peppers, chili peppers, onions); ii) building resilience to environmental change (e.g. salinity-tolerant coconut trees in multistrata agroforestry improving microclimate for understory crops); and iii) restoring degraded soils and increasing resource-use efficiency through enhanced biomass and nutrient recycling (e.g. composting). This exemplary effort is in line with the need to build and sustain an ecologically skilled workforce to better manage or replace non-renewable resources and hence support the transition to sustainable agriculture (Carlisle et al. 2019). While granted land cannot be sold, lifetime use is possible if respecting agroecological approaches and practices. Secure long-term access to land has been increasingly contributing to stabilize young families in the area and reducing youth migration.

## 4. Concluding remarks

The magnitude and complexity of sustainability challenges faced by agriculture, and humanity alike, highlight the profound modifications in different aspects of human activity needed to achieve transformative change. The 10 Elements of Agroecology framework recognizes that transformative change could be taking place simultaneously through many routes, at multiple locations, starting from different baseline conditions, and progressing at different rates. The diversity of trajectory options further highlights its flexibility and major opportunities for adapting actions to local realities. This suggests that the pace of transformative change of agriculture towards desired sustainability outcomes could possibly be faster than anticipated and hence hold greater prospects to achieving the SDGs by 2030.

The 10 Elements of Agroecology framework is not without criticism, particularly because of the heterogeneity of the different elements, including systems of numerous components in which major interactions can be non-linear, interdependent and involve feedback loops, as well as the difficulty of identifying valid thresholds to assess more sustainable development trajectories. Despite these limitations, we consider the 10 Elements of Agroecology to be useful for framing the recognized complexity of food and agricultural systems, into a simplified, yet holistic version of reality that can facilitate decision-making by policymakers, practitioners and other stakeholders at different scales along agroecological transitions towards sustainable agriculture and food systems (Biovision 2019; HLPE 2019; INKOTA 2019; Anderson et al. 2019a). Furthermore, this type of structure can allow different stakeholders to articulate challenges faced, build consensus towards desired goals, use a common language when sharing information on the status of implementation, and encourage collective action and alignment towards achieving the greatest possible impact.

Nevertheless, key knowledge gaps remain:

- There is a need to develop or adapt methodological tools to facilitate integrative thinking and co-creation processes that recognize the value of linking ecological sciences with social sciences, incorporate knowledge that may originate outside of conventional paradigms of science, and embrace culture and food traditions through participatory and action-oriented approaches to research.
- There is need for better understanding of what works in what contexts in agricultural and food systems – in terms of spatial and temporal scale dynamics, including feedback mechanisms – in order to support system re-design efforts aiming at maximizing synergies and complementarities and minimizing trade-offs.
- Despite their crucial role in strengthening resilience in agroecology, we know little about how system components react to more than one environmental or social factor at a time. A better understanding of the impact of increasing the number of interacting and simultaneous global change factors on system change would also be important.

- Developing or adapting existing multidimensional assessment tools (e.g. Grabowski et al. 2018; FAO 2019g; van Wijk et al. 2020) is also central to building such understanding of change and predicting the magnitude of such change across scales, time and place.

Given the crosscutting nature of knowledge gaps identified, improvements achieved addressing any of them could significantly contribute to the different nexus examples highlighted in this paper hence the potential remains for the 10 Elements of Agroecology framework to further facilitate linking knowledge to action.

The 10 elements as a framework helps to think about systems in a broad sense beyond focusing on specific problems, encourages thinking beyond the farm level (i.e. landscapes and community levels), and shows that manageable levels of complexity – consistent with a holistic approach – need not be a burden to promote transformation.

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