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Nutrition as a driver and outcome of agroecology

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The principles of agroecology do not explicitly state a link with nutrition. Yet, we argue that among them, input reduction, biodiversity, economic diversification, social values and diets, fairness, connectivity and participation are directly linked to nutrition. Nutrition can serve as a critical outcome and driver of agroecological practices and can drive transformative change across the food system.

Agroecology has gained substantial relevance in political, agricultural and scientific discourse of sustainable food systems. Defined as 'an integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of food and agricultural systems', agroecology embraces a holistic conceptualization of sustainable agriculture. The latest report by the Intergovernmental Panel on Climate Change referred to agroecology as a transformative adaptation approach[1]. In addition, it is an integral part of the United Nations' Food and Agriculture Organization's (UN-FAO) common vision for sustainable food and agriculture, and was put forward by the Committee on World Food Security as a viable pathway to reach global food security and nutrition goals[2,3]. Benefits of agroecological approaches on food security and nutrition have been reported in a range of studies[4–8]. However, the true impact of agroecology on nutrition and food security outcomes has yet to be fully understood[4,9]. In particular, the multiple pathways through which agroecological methods can impact nutrition and the food system, both from the consumer demand and food supply sides, deserve more investigation.

Here, we propose that nutrition can serve as a critical outcome and driver of agroecological practices and can drive transformative change across the food system.

Nutrition as a hidden principle of agroecology

The interactions between agroecology and nutrition are far from evident. The ten elements of agroecology developed by the UN-FAO in 2018 provided a starting point to frame, structure and further exploit thinking on the pathways of agroecology and nutrition. The High-Level Panel of Experts on Food Security and Nutrition (HLPE) later expanded and complemented these elements to a list of 13 principles, providing the scientific basis for recommendations to policymakers[10]. Out of the 13 principles, we propose that seven (2, 5, 7, 9, 10, 11, 13) could make a direct contribution to nutrition, whereas for six (1, 3, 4, 6, 8, 12) the relationship is less direct (Fig. 1)[10]. Yet, the most apparent link between agroecology and nutrition is made explicit in only one of the 13 principles of agroecology as identified by the HLPE, namely principle 9—social values and diets—which refers to 'healthy, diversified and culturally appropriate diets'[11].

Linkages between principle 2 on 'input reduction' and nutrition have been reported in the literature. The reduction of costly or environmentally damaging inputs has been linked with a redistribution of income and an increase in budget allocation towards food expenditure, enhancing food security and dietary quality[12–14]. The contribution of 'biodiversity' (principle 5) to nutrition is supported by a notable consistency in the literature on the relationship between agricultural biodiversity and dietary outcomes, although the exact mechanisms behind these associations remain unclear[5,15–18]. For principle 7 on 'economic diversification', there is some evidence that greater diversity of on-farm incomes can contribute to financial independence and increased resilience against price volatility and climate change, thereby safeguarding food purchasing[10,19]. Likewise, principle 10 on 'fairness', which encompasses income inequalities, and social and gender inequities, has several touch points with nutrition. For instance,

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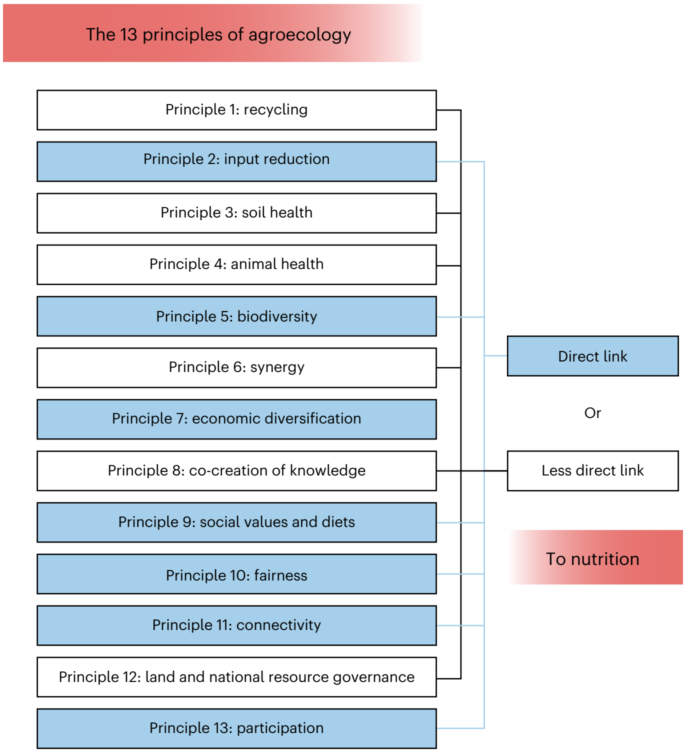

Fig. 1 | The 13 principles of agroecology and their links with nutrition. Out of the 13 principles, seven (2, 5, 7, 9, 10, 11, 13) could make a direct contribution to nutrition, whereas for six (1, 3, 4, 6, 8, 12) the relationship is less direct[10,11].

higher incomes for small-scale producers and actors across the food supply chain can in turn lead to increased food purchasing and better livelihood. In terms of social and gender inequities, their relationships with agroecology and nutrition have been examined in several studies[9,20–24]. Evidence points towards the uneven distribution of food among household members upon increases in food production, or an increase in dietary diversity when spousal discussions about farming take place[9,20]. These findings highlight women's empowerment as a key mediator for increased nutrition. Although research is scarce on gendered implications of agroecology, growing literature points to agroecological initiatives that use transformative methods (that is, increased participation, leadership, feminist movements and networks) that address structural inequities for women and other vulnerable and marginalized groups[23,25–29]. Principle 11 on 'connectivity' is also closely linked to nutrition and can contribute to increased food purchasing. Indeed, as opposed to long supply chains, we know that increased proximity and connectivity between consumers and producers can allow producers to earn a higher share of revenue and increase their margins. Enhanced connectivity can also reduce the risk of food contamination and maintains food integrity compared with long-distance travel. In addition, 'connectivity' also relates to nurturing social spaces, such as local markets and community events, where farmers' inputs and outputs can be exchanged and social interactions on farmers' production and food practices can take place. This includes informal learning exchanges about the importance of nutrition and healthy diets—an important leverage point for dietary change. These knowledge exchanges, as a study in Ecuador reports[30], can also have downstream nutritional impacts on non-agroecological farmers within the community through community-level trade habits including sale, gifting and barter[30]. Moreover, giving agroecological produce and selling more prominence in urban areas through physical and social spaces can also affect consumer demand for these foods. Consumers who buy these agroecologically produced foods are more likely to consume fruits and vegetables, and are less likely to buy processed foods and/or foods that are high in sodium[31]. In addition, such spaces for social interaction can serve as a platform for nutrition education, whereby the consumers can learn about agroecology and its connections to healthier eating habits—a twofold approach that has been observed across initiatives in São Paulo, Brazil[32]. Principle 13 on 'participation' closely links to the above, as places with increased connectivity can lead to greater agency and participation of consumers and food producers[10].

Many of these principles, however, are related to the 'food access' dimension of food security, pertaining to affordability and physical access to food, but less to the 'food utilization' dimension, which refers to food quality and nutrition, and food safety. We argue that nutrition is in itself an important outcome and lens through which these principles should be looked at. This argument gains even greater importance in light of the nutrition transition and growing double burden of malnutrition. In the current context it has never been more important to ensure the provision of nutrient-dense foods, as their consumption is key in addressing all forms of malnutrition (micronutrient deficiencies and undernutrition, as well as overweight and obesity). Indeed, critical dimensions such as nutrient adequacy, food variety and diversity work in concert to contribute to dietary quality and should be taken into consideration when exploring the links between agroecological principles and nutrition. For example, principle 9 on 'social values and diets' requires a deeper understanding of which foods are being produced (rather than how and under which circumstances). Principle 9 and principle 5 on 'biodiversity' (which looks at promoting culturally appropriate foods and maintaining traditional crop varieties) provide an entry point to expand the agroecological narrative to more nutritious foods. Additionally, the cultural dimension of principle 5 is an essential driver in helping people consume healthier foods[30,33–35].

In certain contexts, the role of nutrition in agroecological practices remains uncertain. For instance, some agroecological practices are labour-intensive, and the corresponding work could be carried out disproportionately by vulnerable individuals. In line with principle 2 on 'input reduction', studies have found that without herbicides, the labour burden for the household could increase by requiring more weeding, which is usually carried out by women and girls[36]. Consequently, in low-income households, mothers may even have less time to attribute to care practices, especially during peaks of agricultural activity[20] that require intense physical activity, which in turn may increase their nutritional requirements and affect their nutritional status. However, contradictory evidence has been reported in Malawi, for example, where the increased use of herbicides reduced employment opportunities for poorer women and led to increased food insecurity[37]. Positive outcomes of agroecological practices on labour have been reported in the literature, taking into account a gender perspective[27,38,39]. Yet, these positive outcomes appear to be a result of numerous factors (for example, farm size, type of practices and crops involved, equipment, human resources available, household member caregiving requirements) and depend on hidden trade-offs between the economic, ecological and social dimensions of food production[27,29,38,39]. In general, there is a research gap on labour requirements under agroecological practices and the role of women, an area that needs further investigation.

Recent evidence has also highlighted the positive impact of nutrition-sensitive agroecology interventions on mental health, with food security and nutrition playing a mediating role in this pathway[24]. Evidence as such not only underlines the important role of food security and nutrition, but also puts emphasis on 'participation' (principle 13) as a key determinant of nutritional and mental health outcomes[24].

Thus, applying a nutrition lens to each agroecological principle offers interesting opportunities to address complex interactions between nutrition and agroecology. As described in a recent review[10], there are welcomed linkages between six additional principles and nutrition, offering still underexploited scope for complementarity (Fig. 1).

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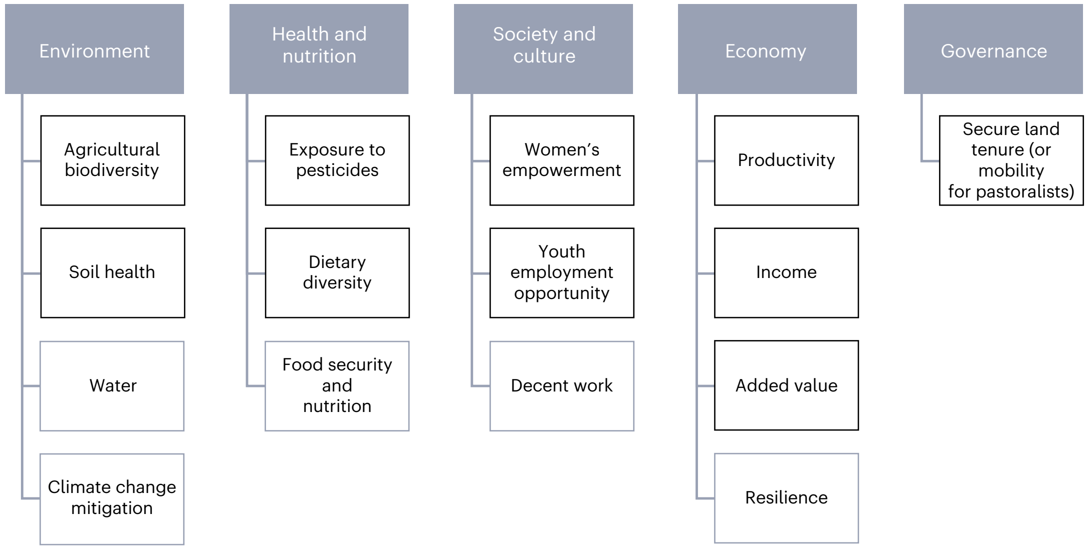

Fig. 2 | Core and advanced criteria of performance in agroecology. Dimensions are listed at the top; core criteria are in black-bordered boxes and optional criteria are in grey-bordered boxes[41].

Agroecological systems' impact on nutrition

A recent review examined the evidence on whether agroecological practices can improve nutrition[4]. The selected studies focused on a broad set of outcomes, such as minimum dietary diversity for children and women, standardized child growth measures/anthropometry (for example, weight for height (wasting), height for age (stunting) and weight for age (underweight)), and changes in vitamin A, iron and zinc status. Although most of the studies showed positive nutrition-related outcomes, only a few looked at nutrition biomarkers that allow objective assessments of nutritional status through biological samples (for example, plasma/serum, blood, urine, breath), as opposed to self-reported or administered dietary intake questionnaires[4,40].

The UN-FAO Tool for Evaluating Agroecological Performance (TAPE) provides a framework to diagnose and evaluate the performance of agroecological practices over time and at different scales on five dimensions to inform and empower policymakers, institutions and actors throughout the food value chain. The dimensions and their ten corresponding core performance criteria are depicted in Fig. 2, along with five non-exhaustive advanced criteria, which are optional[41,42]. The 'Health and nutrition' dimension of the tool has two core performance criteria: 'Exposure to pesticides' and 'Dietary diversity'. For the latter, TAPE considers a qualitative nutrition indicator, which reflects dietary intake (minimum dietary diversity for women (MDD-W)) and two other optional nutrition-related indicators (food self-sufficiency ratio and nutritional value of agricultural production; Fig. 3). Although TAPE acknowledges the indirect nutrition components of the tool (for example, nutrition is mentioned across various other dimensions and criteria of TAPE, particularly agricultural biodiversity), nutrition may take an even more prominent position across the framework. In fact, the nutritional value of agricultural production (currently an optional criterion) is a key component that, we argue, deserves to be listed as part of the core criteria (Fig. 3).

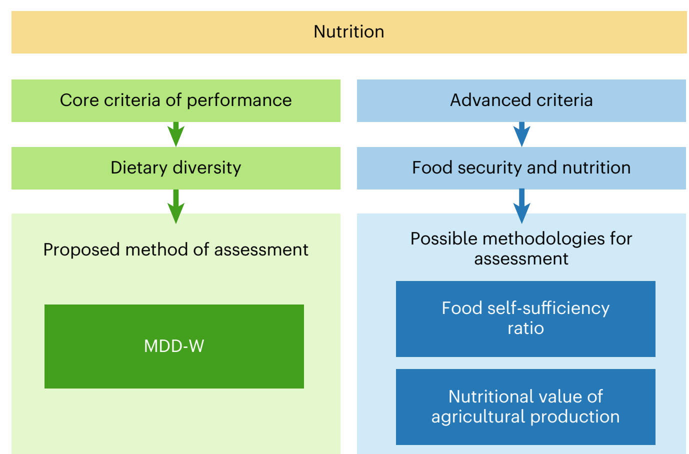

Fig. 3 | Nutrition across TAPE. TAPE considers one qualitative nutrition indicator, which reflects dietary intake (MDD-W), and two other optional nutrition-related indicators (food self-sufficiency ratio and the nutritional value of agricultural production). Although TAPE acknowledges the indirect nutrition components of the tool (for example, nutrition is mentioned across various other dimensions and criteria of TAPE, particularly agricultural biodiversity), nutrition may take an even more prominent position across the framework. In fact, the nutritional value of agricultural production (currently an optional criterion) is a key component that, we argue, deserves to be listed as part of the core criteria[41].

In addition, qualitative dietary indicators such as the MDD-W provide only limited insight into diet quality. In contrast, conducting quantitative 24-hour dietary recalls allows for a more precise estimate of nutrient intake and adequacy, and can generate a deeper understanding on individual diets. Despite its relative complexity, its addition to the list of advanced criteria warrants consideration.

In addition, much remains to be done to assess the impact of agroecological practices on nutritional outcomes both from a programmatic and research angle. In terms of programmes, for instance, the process of value chain selection presents an interesting entry point to create greater synergies between nutrition and agroecology. The selection of nutrition-sensitive value chains can be a valuable step to better integrate nutrition across the value chains right at the beginning of programmes and interventions. The nutrition-sensitive value chains framework developed by the International Fund for Agricultural Development provides a useful guide in that regard by using a nutrition and business lens for the selection of value chains to tackle food and nutrition insecurity[43].

There is a need for research that assesses the impact of agroecological interventions on indicators that go beyond diet quality and include nutritional status. While diet quality remains an important proxy for nutritional status, it provides an incomplete picture of nutritional status in the context of poor nutrient absorption, systemic inflammation

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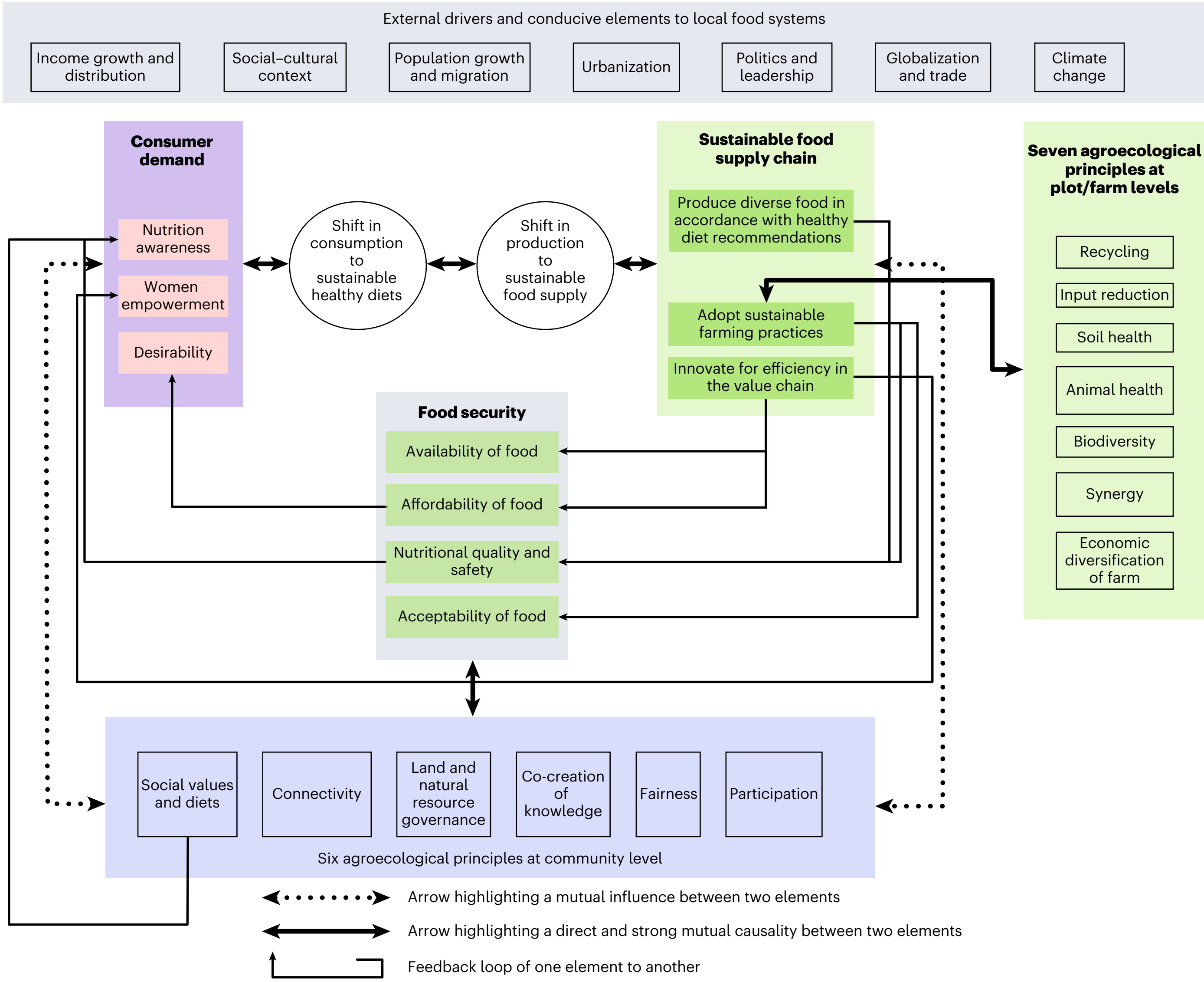

Fig. 4 | A systemic approach to transform agroecology for improved nutrition. Dietary patterns interact with food systems, not only as an outcome thereof, but also as a driver of transformative change through the consumer, forming a circular pathway. We also highlight the importance of food security as a mediating factor in this pathway, as cost, affordability, safety, nutritional quality and cultural acceptability are major determinants of food choices. When aiming to improve nutrition through dietary patterns, a food systems approach that focuses on both the supply and demand of agroecological nutritious foods is essential. Sustainable food value chains, food security and consumer behaviour form an interconnected set of key dimensions at the core of a nutrition-centred approach for sustainable food systems.

and other determinants such as poor water, sanitation and hygiene or high levels of aflatoxins, for instance. The collection of nutrition biomarkers through biological samples should be included if feasible, and if values can be traced back to the implemented intervention and/or programme. Importantly, if agroecology is to gain more prominence in the nutrition discourse and vice versa, there is a need for studies to use more rigorous research designs (randomized controlled trials, longitudinal and case-control studies) and statistical methods that control for confounding variables such as women's empowerment, gender inequity, and land and natural resource governance[4]. Assessing nutrient postharvest losses from a nutritional quality lens (for example, a decline in the nutritional composition of a food product along the value chain) is another valuable approach to bridge agroecological practices and nutritional outcomes. The NUTRI-P-LOSS (nutritional postharvest loss) methodology is an interesting tool that allows for such assessments and highlights the relationship between agroecological practices aimed at reducing postharvest losses and increasing nutritional outcomes[44].

In general, more precise outcomes, methods and assessments will be required to put into evidence the intricate linkages between nutrition and agroecology. Moreover, food safety and its many connections to nutrition and agroecology also warrants additional thought and research.

Nutrition as an outcome or entry point for agroecology

Most notably, to date, agroecology has considered nutrition as an outcome of agroecological practices, heavily relying on the producer and agricultural production (for example, farmer incomes, farmer-to-farmer exchange, increasing self-sufficiency)[4,45]. However, if more emphasis was placed on the needs and responsibilities of consumers (for example, importance of a diverse diet, reduction of food waste, increase in the consumption of plant-based protein)[10], nutrition could serve as a driver to strengthen the agroecological approach. Increasing the demand for agroecologically produced diverse and nutritious foods could result in a consumption pull, with resulting effects on the supply side, thereby supporting the scale-up of agroecological practices. In fact, while hunger and poor nutrition confront us with a key challenge, nutrition also represents a strategic entry point to transform food systems (Fig. 4).

As an outcome, we know that dietary patterns are influenced by availability at every stage in the value chain in any food system (production, storage, processing, distribution, marketing, consumption). These linkages from the food value chain to nutritional outcomes are often indirect—mediated through a variety of factors, including but not limited to incomes and related purchasing powers, the cost of a healthy diet, the quality of infrastructures, food safety, food losses, and consumer awareness and behaviour. Even broader external drivers (such as globalization and trade, population growth and migration, climate change, politics and leadership, among others) can influence agroecological production choices[46].

As a driver, dietary patterns and dietary trends have the power to influence different components of the food system[47,48] and the uptake of agroecological practices. First, the increased need for more diverse diets due to health concerns and consumers' interest in transitioning to a more sustainable diet can drive a change in beliefs and attitudes towards increasing the demand for more local, traditional and agroecologically produced foods.

Second, creating demand for the consumption of more traditional foods can promote the uptake of agroecological practices and related outcomes that are required to produce those foods. In Guatemala and Mexico, the future of the traditional practice of 'milpa' farming—an ancient agroecological system, consisting of a polyculture system of corn, beans, squash, chillis and other edible wild plants—is uncertain. Indeed, some of its practices (for example, slash-and-burn) have become less sustainable over time considering climate change, land degradation and forest loss[49]. Milpa farming allows the preservation of crop resources, biodiversity and, most importantly, the production of various foods, an essential contributor to dietary diversity[50,51]. The safeguard of this practice would require government action, including but not limited to funding, subsidies and agriculture extension services that generate demand for agroecological farming systems in milpa communities[49,52]. This would also contribute to the adoption or continued consumption of a traditional healthy diet that relies less heavily on animal-sourced protein intake.

Third, dietary patterns can impact the environment and shape food supply chains. As seen in high-income countries, the overconsumption of animal-source protein is linked with increased CO_2 emissions, methane and related high environmental costs. Including bean protein in diets is one way to reduce the prevalence of noncommunicable diseases and to significantly reduce the environmental footprint of food production around the world[53]. Beans, peas, algae and insects could be used as a protein source for animal feed[54–56], and intercropping with legumes could improve soil health with corresponding environmental benefits[57]. Furthermore, agroecological practices promoting nutrient recycling models, such as spreading manure and compost, can help farmers reduce synthetic inputs, which in turn can prevent negative environmental and health consequences[11].

Fourth, diets affect livelihoods, which in turn links back to the food supply chain[58]. For example, short-cycle vegetable crops produced with controlled sustainable irrigation, as an agroecological practice, can improve farmers' income and cash flow, as well as dietary diversity[4,10,20]. By contrast, unhealthy diets and malnutrition hinder economic growth and propagate poverty via losses owing to rising health care costs; direct losses in productivity from poor physical health and indirect losses from poor cognitive function and learning deficits[58,59]. Increasing the demand and supply of agroecologically produced foods can improve farmers' income, dietary diversity and livelihood.

Fifth, co-creation of knowledge and dissemination of agroecological practices (principle 8 of the HLPE agroecology principles) are strongly related with nutrition and education. Introducing knowledge of agroecological practices would increase awareness and implementation of agroecology as a model for the transformation of food systems[10,11]. Nutrition can be a starting point and a motivation for farmers to engage in producing culturally appropriate foods.

In light of the above, we propose an adapted framework inspired by the HLPE report and its 2017 sustainable food system framework[58], the impact pathways of nutrition-sensitive value chains model of de la Peña et al.[43] and the 13 agroecological principles proposed by the 2019 HLPE report[11]. The proposed framework (Fig. 4) illustrates a systemic narrative centred on consumer demand and food supply to redesign the food system using agroecology.

Conclusion and call to action

The 2021 UN Food Systems Summit has highlighted the ongoing debate and concerns about the relationship between agroecology, food systems and diets among the agroecological and social justice communities. It also offered an opportunity to strengthen the evidence on the interaction between agroecological interventions in the search for inclusive local solutions to improve the nutritional status and health of the population. In a similar vein, this Perspective recognizes the strong potential of agroecological principles as an actionable framework to catalyse food system transformations and to improve nutrition and health outcomes, from both a supply and demand angle. We argue that nutrition should be given greater importance across the food system's conceptual framework and discourse and the 13 principles of agroecology, as well as across performance and impact indicators of agroecology and their contribution to nutritious and sustainable food systems.

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Author contributions

All authors contributed to the material and all authors reviewed the manuscript.

Competing interests

E.I., M.P. and S.W. are employed by The Syngenta Foundation for Sustainable Agriculture, which is a separate legal entity from the company that provides its core funding. Apart from its Board Chair, the rest of its nine-person board are all independent of the company. All other authors declare no competing interests.

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