# Food Environments

## Using agroecology to enhance dietary diversity

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Changes in farming and land-use practices over the last 60 years have resulted in a significant decline in overall agrobiodiversity. This decline in domesticated crop and livestock breeds, as well as edible wild plant and animal species, is occurring at an incredible rate.

According to the Food and Agricultural Organization of the United Nations (FAO 2004), 75% of plant genetic diversity has been lost as farmers worldwide have abandoned their various locally adapted crop varieties for the genetically uniform, high-yielding varieties promoted by industrial agriculture. Of the 250,000-300,000 known edible plant species, humans use only 150-200. Six local livestock breeds are lost each month to industrial production practices.

A mere 30 crops supply 95% of the calories we obtain from food, while only four crops – maize, rice, wheat and potatoes – supply over 60%. Today, 75% of the world's food is derived from a mere 12 plants and five animal species. Moreover, the astonishing diversity of food products available in supermarkets and local shops is actually based on a handful of staple crops and livestock. The food industry constantly re-engineers and recombines them into a variety of highly processed products. Ingredients such as fructose corn syrup, refined flour, sugar, soy, and palm oil appear over and over again in ultra-processed foods that give the illusion of dietary diversity in the global food system (High Level Panel of Experts on Food Security and Nutrition (HLPE) 2017).

Around the world, there is a major shift in dietary patterns underway towards uniformity. Often termed the 'global dietary transition', this phenomenon is historically unprecedented and is occurring fastest in the urban areas of developing countries, albeit at different rates in different regions and socioeconomic groups (Hawkes et al 2017). About 3 billion people currently have low-quality diets based on a small number of plant and animal species. Their increasingly uniform diets either lack sufficient calories, minerals and vitamins, or contain too many energy-dense, nutrient-poor foods that are high in fat, salt and sugar. And this issue is not simply a problem of poverty: all strata of society are affected, be it low, medium or high income (HLPE 2017). The loss of agrobiodiversity has far-reaching effects on dietary diversity. Dietary diversity reflects household access to a variety of foods and the nutrient adequacy of the diet of individuals (FAO and the EU 2013). It is a key element of a healthy, high-quality diet, providing the spectrum of macro- and micro-nutrients essential for human health (Tontisirin et al 2002), in addition to other key elements, such as access to sufficient quantities of food and clean water, a healthy environment and care.

The current unparalleled reduction in dietary richness is having a significant impact on human health worldwide. For example, the decline in dietary diversity has changed the richness of human gut microbiota, the community of microorganisms living in the gastrointestinal tract. Healthy individuals have highly diverse gut microbiota and many of the common pathologies of the 21st century – obesity, inflammatory bowel disease and type 2 diabetes, for instance –are associated with reduced microbiotic richness (Heiman and Greenway 2016). Food and farming practices that increase dietary diversity can, therefore, improve human health by encouraging species-rich gastrointestinal microbiomes.

Research published in past editions of *UNSCN News* has emphasised that "increasing agricultural biodiversity in landscapes, food systems and diets is an important part of the solution to creating healthier diets from sustainable food systems" (Kennedy et al 2017, p.24). This paper focuses on the contributions that agroecology can make to dietary diversity and high-quality human diets by promoting more biodiverse, equitable and sustainable food systems.

After briefly defining agroecology and sustainable diets, the paper highlights specific examples of agroecological practices that increase the availability of and access to dietary diversity by enhancing biodiversity and ecosystem functions, promoting soil conservation, protecting watersheds, limiting the use of agrochemicals, re-localising the production, distribution and consumption of food within specific territories, and enabling fair access to dietary diversity and inclusion in food systems.

## AGROECOLOGY: FROM UNIFORMITY TO FOOD-SYSTEM DIVERSITY

The central idea of agroecology is that agroecosystems should mimic the biodiversity levels and functioning of natural ecosystems. Such agricultural mimics, like their natural models, can be productive, nutrient conserving, pest resistant and relatively resilient to stresses such as climate change. Because of the portfolio effect of biodiverse agricultural production, they also mitigate the impact on farmers' incomes of market price volatility.

Sustainability and productivity are achieved through agroecosystem designs that enhance functional diversity at the genetic, species, ecosystem and landscape levels. Agroecological methods include genetic mixtures, crop rotations, intercropping, polycultures, mulching, terracing, the management of diverse micro-environments for nutrient concentration and water harvesting, agro-pastoral systems and agroforestry (Gliessman 1990). There is an emphasis on re-use, creating closed-loop systems. For example, in the mulberry grove-fishpond system of China's Pearl River Delta, the leaves of the white mulberry tree are fed to silkworms, which produce silk. Compost from the mulberry tree and silkworm excrement are used to feed the fish, then the excrement of the fish and other organic matter from the pond mud is used as fertiliser for the trees (Zhong 1982).

The design of biodiversity-rich, energy-efficient, resource-conserving and resilient farming systems is based on mutually reinforcing agroecological principles. These modern principles of agroecology have their roots in the collective knowledge, practices and ecological rationale of indigenous and peasant agriculture(s) around the world (Hernández 1977; Altieri 1987). A core principle of agroecological practices is to value and respectfully build on peoples' knowledge and farmer-led experimentation to develop locally appropriate farming practices and agroecological solutions.

From the 1990s, agroecology as a scientific discipline moved beyond the field or farm scale to a greater focus on the ecology of whole food systems, including food production, distribution, consumption, waste management and governance (Francis et al 2003). This broader perspective has encouraged closer links with farmer organisations, consumer-citizen groups and social movements supporting alternatives to industrial food systems.

For social movements and farmer organisations around the globe, agroecology has become explicitly linked to food sovereignty and the Right to Food (Society for International Development 2015). These social movements do not see agroecology as simply a technique to produce food, but as a way to strengthen social organisations, build local knowledge and strengthen the food sovereignty of communities (Anderson et al 2015). Local farmer organisations and their networks play a central role in facilitating collective action for the scaling out and horizontal spread of agroecological knowledge and innovations (Pimbert 2018).

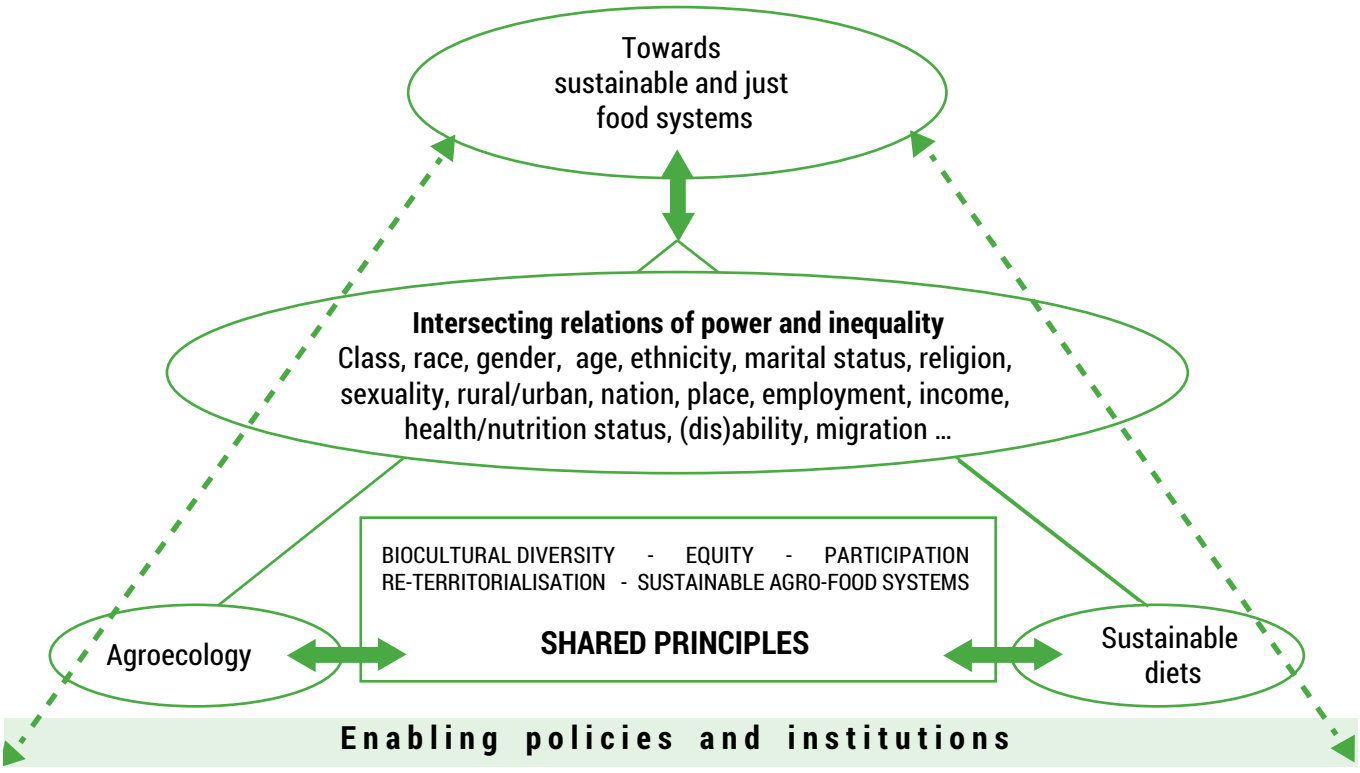
In sharp contrast to the drive for increasing uniformity in industrial food and farming (IPES-Food 2016), agroecology thus seeks to regenerate social, economic and ecological diversity throughout food systems and the landscapes in which they are embedded. By enhancing genetic, species and ecosystem diversity on farms and the wider landscapes, agroecological designs also increase the availability, quality and access to dietary diversity in food chains.

As such, agroecology contributes to sustainable diets – defined as "diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations [and which are] protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources" (Burlingame 2012, p.7).[1] Agroecology and sustainable diets are increasingly recognised in scientific, policy and civil-society arenas as pillars of sustainable food-system development (UNHRC 2010; UNHRC 2011).

1 This definition is based on a concept developed in the 1980s by Gussow and Clancy (1986), realising that the health of humans and the health of ecosystems are inextricably linked. Similarly, the need to integrate nutrition and agriculture had been emphasised already in the late 1970s/early 1980s (Longhurst 2013). Longhurst, in his historical analysis, provides insights into the underlying reasons why the nutrition-in-agriculture agenda was neglected and the role the UNSCN played in supporting the integration of nutrition and agriculture. Only much later, from 2010, did this approach re-emerge in the form of 'nutrition-sensitive agriculture' (see Lemke and Bellows 2016).

As illustrated in Figure 1, agroecology and sustainable diets offer complementary frameworks, supporting biocultural diversity and equity, and sharing the intersecting principles of re-territorialisation of sustainable agro-food systems, and the participation of diverse actors. To achieve participation and greater equity, it is important to pay attention to the intersecting balances of power and inequality between food-system actors. At the household level, this refers to access to resources and the decision-making power of household members, which are determined by gender, age, marital status and health, among other things. At the regional and community levels, farmers' access to markets, credit, agricultural extension and other services are determined by factors including gender, class, race, ethnicity, wealth and place. At the national and global levels, this refers, for example, to the impact of trade relations on a country's agricultural sector and farmers and to the concentration of power in the agribusiness sector. Enabling policies and institutions to support agroecology and sustainable diets is the foundation to which to develop sustainable and just food systems, in dialogue with the various food-system actors concerned.

**Figure 1.** AGROECOLOGY AND SUSTAINABLE DIETS AS COMPLEMENTARY AND INTERSECTING CONCEPTS




Source: *Concepts based on Rosset and Altieri, 2017 for agroecology; Burlingame and Dernini, 2012 for sustainable diets; Collins, 2000 for intersectionality.*

# AGROECOLOGY ENHANCES DIETARY DIVERSITY

Agroecology offers important ways in which to enhance dietary diversity in both temperate and tropical agriculture. Examples of specific diversity-generating agroecological practices for different parts of the food system – from field to plate – are highlighted below.

### 1. Diversifying species, crop varieties and livestock breeds in the agroecosystem – including integrating crops, trees and livestock at the field and wider landscape levels

Agroecological innovations in farmer-led evolutionary plant breeding (EPB) are re-generating a plethora of crop varieties that are uniquely adapted to diverse local environments. In evolutionary plant breeding, a genetically diverse crop population is left to cross freely, allowing natural selection to generate many varieties adapted to different soils, cold and dry conditions, pests and farm micro-environments.

For example, in Iran, farmers working with scientists have planted and mixed 1,600 different varieties of F1 barley lines in the same field and the evolutionary populations continue to spread throughout the country today (Rahmanian et al 2014). The ensuing diversification of the original plant populations through evolutionary selection processes increases the quality and dietary diversity of foods produced. A protein analysis of the Iranian barley varieties, which are mostly used as an animal feed in Iran, showed that the evolutionary population had more protein in them than the local improved variety (Rahmanian et al 2014).

Similarly, farmers growing evolutionary populations of wheat in Iran, France and Italy make a diversity of high-quality breads from the evolutionary populations. Some farmers even market this bread in local artisanal bakeries. The farmers confirmed that creating genetic mixtures not only brings greater yield stability and local adaptations to a multitude of environments, but it also contributes to dietary diversity by producing greater aroma and higher quality when making bread (Demeulenaere et al 2011; Dessimoulie 2017).

In Algeria, Chad and Egypt, farmers encourage high intra-specific genetic variation in their date-palm oasis agroecosystems (Barakat 1995). The principal varieties differ from one oasis to another. In general, there are more than ten varieties of date palm in each oasis. In a well organised and maintained palm grove, the owner plants different varieties of dry and semi-dry dates that mature in different months to meet the demands of local consumption and the market. Moreover, each tree variety confers its own unique stamp on the taste of the fruit and the wine made from it, thereby enhancing dietary diversity.

Agroecology also works to diversify ecosystems and landscapes. In the home gardens that cover 15% of the land in Sri Lanka, family farmers grow trees, shrubs, herbs, crops and animals as a complex multi-layered agroecological system. The garden system is like the complex structure and multiple functions of the forest, though not identical to it. Potential dietary diversity is available in the form of many species of fruit, vegetable, spice and medicine, staple food items, fodder, fishery products, livestock products, poultry products and bee honey. Research shows that home gardens enhance dietary diversity and food security by (a) providing direct access to a variety of nutritionally rich foods, (b) increasing purchasing power from savings on food costs and income from the sale of garden produce and (c) providing fall-back foods during periods of temporary food scarcity (Pushpakumara et al 2012).

### 2. Strengthening the 'immune system' of agricultural systems through the enhancement of functional biodiversity by creating appropriate habitats for the natural enemies of pests, allelopathy and antagonists and through adaptive management

Many methods of pest control in agroecology rely on biodiversity to eliminate or reduce the use of toxic insecticides, herbicides and fungicides. Genetic mixtures deployed in temperate and tropical agroecosystems can be effective in containing disease in small grain crops (Wolfe 1985), as well as insect outbreaks, for instance, in corn (Power 1988) and potatoes (Cantelo and Stanford 1984). There are also many documented experiences showing that insect pests tend to be less abundant and damaging in agroecosystems with higher plant diversity, for example, intercrops, polycultures, crop rotations, cover crops, mixed tree stands and mixtures of annual and perennial plants (Altieri 1994).

In Italy, free-ranging chickens in olive orchards effectively reduce weed infestation and help control pests such as olive fly and weevils (Paolotti et al 2016). Shropshire sheep not only control weeds in commercial apple and pear orchards in northern Europe, they also help limit the spread of fungal diseases by eating fallen leaves (Geddes and Kohl 2018). By relying on an appropriate mix of plant and animal species (functional biodiversity), these agroecological practices help reduce pest and disease outbreaks, while simultaneously enhancing the dietary diversity offered by the agroecosystem.

### 3. Enhancing beneficial biological interactions and synergies throughout the system and among the components of agro-biodiversity, thereby promoting key ecological processes for sustainable production and resilience to stresses and shocks.

There are more than 100,000 known pollinators (bees, butterflies, beetles, birds, flies and bats). About 90% of all plant species are pollinated by animals and about 75% of the world's agricultural crops depend on pollination provided by insects and other animals (IPBES 2016). The use of synthetic pesticides and other management practices that reduce the species or abundance of pollinators can result in less genetic variation in crops dependent on pollinator visits for reproduction, both in temperate and tropical climates. With a loss of pollinators, seed production declines and the vulnerability to pests and climatic change increases, with a resulting loss of genetic diversity.

Agroecological practices help increase the profusion of pollinators by maintaining or creating greater diversity of pollinator habitats and flowering plants in agricultural and urban landscapes, as well as supporting the local adaptive management of habitat patchiness at different scales. Moreover, by removing the need to use pesticides and relying instead on natural pest-control practices based on the functional diversification of farms (genetic, species and ecosystem diversity), agroecology helps conserve pollinator species that are vital for the sustainable production of food-crop species and their long-term resilience to shocks and stresses (IPBES 2016). In turn, this enhances the availability and continued supply of dietary diversity, both now and into the future.

Not using toxic agro-chemicals and relying instead on agroecological methods for pest control also allows significant numbers of diverse wild foods to survive in the farm landscape. This potentially increases dietary diversity and community resilience to seasonal food shortages and climate change. Historically, in South East Asia, a large proportion of all foods consumed have been wild foods from paddy fields, including fish, snakes, insects, mushrooms, fruit and vegetables. Wild foods found in rice paddy accounted for about 50% of all foods consumed in North-East Thailand in the 1980s (Somnasang et al 1988).

However, the intensive use of pesticides in Green Revolution rice farming significantly reduced the abundance and quality of these wild foods. This trend has been reversed in parts of South-East Asia, where horizontal networks of farmer field schools have learned to use agroecological principles to control weeds, insect pests and diseases in rice paddy fields (Pontius 2002). For example, in Indonesia, pesticide-free agroecological innovations have helped bring back these diverse wild foods in and around paddy fields, thereby increasing available dietary diversity for local communities (Fakih et al 2003).

### 4. Creating favourable soil conditions for plant growth and recycling nutrients, particularly by managing organic matter and enhancing soil biological activity

By closing nutrient loops through recycling, using cover crops, composting copious amounts of organic matter, minimum tillage and crop rotations, and by building soil fertility and its organic matter content (Kittredge 2015), agroecological practices can arrest and reverse the deterioration in the micronutrient quality of our food intake. This is important, because several studies comparing the changing mineral content of vegetables, fruit, meat and some milk and cheese products in industrial farming since the 1940s (Davis et al 2004; Mayer 1997; Thomas 2003) show that there has been a significant loss of minerals and trace elements in these foods over the last 70 years. In the UK, for instance, there was a dramatic reduction in the copper present in vegetables between 1940 and 1991 (76%) and zinc between 1978 and 1991 (59%). The iron content of milk has dropped by more than 60% and by more than 50% in cream and eight varieties of cheese between 1940 and 2002 (Thomas 2003).

Agroecological practices are regenerative of the intrinsic dietary quality of diverse plant and animal foods because they address the main causes of soil demineralisation: the excessive use of NPK (nitrogen, phosphorous and potassium) fertilisers, the trace mineral depletion of the soil itself, the adoption of more genetically uniform crop varieties and the loss of micro-flora/fauna within the soil (Ward et al

2001; Thomas 2003; Hodges and Scofield 2012). Similarly, organically manured soils and their diverse micro-flora/fauna help improve the quality and biochemical diversity of diets by enhancing the concentration of many health-conferring molecules in plants and livestock animals, such as secondary plant metabolites, polyphenols and other anti-oxidants (Benbrook 2005; Hodges and Scofield 2012). Compared with conventionally grown foods, agroecological and organic plant-based foods may contain 20-40% more antioxidants, for example (Baranski et al 2014).

## 5. Enhancing the conservation and regeneration of soil, water and agro-biodiversity on the farm and neighbouring landscape, as well as the watershed

Farmers' agroecological practices can enhance available dietary diversity by creating micro-environments and more structural diversity on farms and the wider landscape. By building terraces, swales, tree belts, hedges and ponds to conserve soil and water, farmers' individual and collective action generate ecological complexity and heterogeneity at different scales. In turn, this creates habitats and micro-environments for wild edible species to co-exist in agroecosystems and human-managed landscapes.

This is important because different types of agricultural biodiversity ('cultivated', 'reared' or 'wild') are used by different people at different times in different places, and so contribute to livelihood strategies in a complex fashion. For example, wild resources are particularly important to the food and livelihood security of indigenous peoples (Kuhnlein et al 2009), as well as the rural poor, women and children, especially in times of stress, such as drought, changing land and water availability or ecological change (Guijit et al 1995; Scoones et al 1992). These groups generally have less access to land, labour and capital and thus need to rely more on the wild diversity available.

The mean use of wild foods by agricultural and forager communities in 22 countries of Asia and Africa (36 studies) is 90–100 species per location. In countries such as Ethiopia, India and Kenya, aggregate country estimates can reach 300–800 species (Bharucha and Pretty 2010; Guijit et al 1995). In Zimbabwe, some poor households rely on wild fruit species as an alternative to cultivated grain for a quarter of all dry-season meals (Wilson 1990). In India, women Dalit farmers in the Medak district of Telengana include more than 40 species of highly nutritious wild greens in their diets in different seasons (Salomeyesudas and Satheesh 2009). The food list of these dryland farmers includes an impressive 329 species or varieties of cereals, millets, pulses, oil seeds, fruit, vegetables, wild greens, roots and tubers. Roots, leaves, flowers, fruits, gums and bark are consumed seasonally. Knowledgeable non-literate women farmers harvest these highly nutritious wild foods from environments they have co-created with nature: collectively managed watersheds, common lands, tree plantations and woodlands, field edges and organically manured farm plots (Salomeyesudas and Satheesh 2009). Women depend on access to this land to gather diverse foods and collect firewood or building materials for alternative and supplementary livelihood activities (Doss et al 2014). In Malawi, the food insecurities of women and their families have worsened as women have lost access to land through land deals (Bezner Kerr 2005). Tsikata and Yaro (2013) show for Northern Ghana that women were not compensated for the loss of access to land they had used for farming, fuel wood, shea and other trees, with severe impacts on households, including dietary diversity, and the local economy.

## 6. Agroecological markets for dietary diversity

More transformative agroecological paths to sustainable living build alternative food networks that re-localise production and consumption. This approach seeks to reinforce connections between producers and consumers and integrate agroecological practices with alternative market relationships within specific territories (Gliessman 2014; CSM 2016). For example, policies for the procurement of locally produced agroecological/organic foods have promoted access to more dietary diversity in schools, hospitals and public canteens in Italy, Austria, Denmark and Brazil (Foodlinks 2015; Sonnino 2009; Swensson 2015). Supportive municipal policies for sustainable territorial development based on agroecology and re-localised food systems in the bio-districts of Italy, Spain, France, Morocco and Senegal have boosted household access to dietary diversity (International Network of Eco-Regions 2016). Throughout Europe, as is the case in other parts of the world (for example, Japan, the US and Canada), rising numbers of short food webs and alternative food networks, such as Community Supported Agriculture (CSA), bring agroecological producers and food eaters into closer contact, provide income-generating markets for producers and increase consumers' access to dietary diversity (Kneafsey et al 2013; European Community Supported Agriculture (CSA) Research Group 2016).

Similarly, a network of barter markets run by women farmers in the Andean region of Peru ensures that indigenous households (and women, in particular) have access to the broad range of crops and wild foods that grow at different altitudes: from the citrus and other vitamin-rich fruits of the lower Amazon forest to the many crops growing on the Andean mountainside – such as maize, quinoa, beans, wild greens, potatoes and hardy root crops that grow above 3,700 metres (Argumedo and Pimbert 2010). Re-territorialised markets for agroecological production combined with economic exchange based on solidarity, reciprocity, gift relations and citizen oversight ensure that access to dietary diversity is more inclusive and socially just (Pimbert 2015).

# CONCLUSION

By reorganising the material basis of the food system in the image of nature, the agroecological practices highlighted in this paper are generative of dietary diversity. However, although agroecology can increase the availability and quality of and access to dietary diversity for healthy nutrition, it should not be seen as a 'technical fix' by policymakers. Diversity on the farm does not automatically lead to diversity on the plate. More than agroecology, alone, is required to ensure fair access to dietary diversity in society. Gender-equitable rights of access and use of land, trees and their products, water and seeds, as well as socially inclusive forms of economic exchange, are all needed in addition to shifts in the balance of power and entitlements to realise the right to food and nutrition for all (Bellows et al 2016).

Women's position in societies is crucial to enhanced dietary diversity, nutritional status and the wellbeing of all. Households have better food security and dietary diversity if women can take decisions on the distribution of household resources and the nutrition of household members (Lemke et al 2003; Doss 2013; Bezner Kerr et al 2013). Furthermore, women grow more food for household consumption than men (Vargas Hill and Vigneri 2014).

However, globally, women continue to have less access to a variety of resources, health services and care, and decision-making (Quisumbing et al 2014), and they are still largely responsible for the gender-determined labour- and time-intensive chores of collecting water, fuel, cooking, taking care of children and sick people, and taking on additional agricultural tasks, with men migrating for work (FAO 2016). Desired dietary diversity for good nutrition and development outcomes can only be achieved if these structural inequalities and gender-based violence are addressed as part of broader societal changes.

In addition to more funding and policy support for agroecology (IPES-Food 2016; FAO 2018; Pimbert and Moeller 2018), deep structural changes in wider society are needed if equity and non-discrimination are to drive dietary diversity for good nutrition. Coordinated citizen action is needed to overcome the concentration of power and privilege that locks food systems into pathways that are ever more harmful for people and planet (IPES-Food 2016; Pimbert 2009). In turn, this transformation calls for a clear commitment to a politics of democracy and inclusion, gender justice and freedom.

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