The Land Gap Report

2022

Governments' over-reliance on carbon removals could push ecosystems, land rights and food security to the brink with new land area equivalent to 50 percent of the world's croplands currently being required to meet targets. Climate pledges should focus on protecting and restoring existing ecosystems with carbon benefits.

Chapter 5: Agroecology for socioecological resilience

KEY MESSAGES

- Business-as-usual in agriculture and food systems is not an option. Transformative change is urgently needed to move away from emissions-intensive industrial agriculture.
- Alternatives based on biologically diverse systems can contribute to both climate adaptation and mitigation. Agroecology provides these and other multifunctional benefits centred on ecological and social resilience that is achieved through the sustainable management of biodiversity.
- Agroecology contributes to the realization of various human rights. Human rights-based approaches help to address climate change challenges and biodiversity loss, while strengthening the agency of right-holders such as indigenous peoples, peasants and women.
- Key policy actions are needed to foster the restoration and sustainable use of agricultural biodiversity by elevating agroecology as a means to practice biologically diverse agriculture, a key holistic approach for climate change adaptation and mitigation.

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This chapter refocuses the climate and agriculture debate, not on the potential of agriculture for land-based carbon removals *per se* – since as **Chapters 1** and **2** have demonstrated, there are many associated risks, not least as there is simply not enough land to be devoted exclusively to carbon removals. The perspective explored here is the scope for multifunctional agriculture and food systems, particularly agroecology, to ensure healthy food production and livelihoods, and to contribute to both climate adaptation and mitigation. The chapter starts by examining what is wrong with business-as-usual in the agriculture sector and strict conservation and mitigation initiatives, and why these need to be changed. It then places emphasis on the multifunctional benefits that agroecology can bring and reiterates its importance for implementing a rights-based approach for climate action. The chapter concludes by outlining the key policy elements needed to create climate resilience in agriculture, by supporting agroecology.

5.1 The perils of business-as-usual in agriculture, biodiversity conservation and climate mitigation

Agriculture covers almost 40 percent of the Earth's terrestrial surface (FAOSTAT, 2022). To address the land gap that has been discussed in previous chapters, it is essential to understand the role of unsustainable agriculture and the global industrial food system in generating climate change. However, the climate crisis is not isolated and it cannot be addressed without tackling the underlying causes, including the economic dynamics of industrially-driven food and agriculture systems that result in ecological disruptions (see **Section 5.1.2**). The global food system contributes to multiple planetary stressors (Rockström *et al.*, 2020), which, if addressed from an integral perspective, can enable multiple objectives to be met (Altieri *et al*., 2015; Conijn *et al*., 2018; Gerten *et al*., 2020). Aside from climate change mitigation, these objectives include healthy food production, biodiversity restoration, water conservation, human and ecosystem health, and dignified livelihoods for people, especially those who live in rural areas (IPES-Food, 2016; HLPE, 2019).

Governments around the world have submitted their NDCs as per their commitments under the Paris Agreement. Many governments include the agriculture sector in their NDCs, referring to both mitigation and adaptation. **Chapter 2** presents the results of an analysis of reliance on land for carbon removal in their climate mitigation commitments. In terms of the contribution of the agriculture sector to land-based removals, 272 million ha of land were identified as relating specifically to agroforestry and silvopasture. However, the implications for agricultural lands will be greater than that, given that 633 million ha were pledged that would require a land-use change.

A strong emphasis has been placed in many climate pledges on the restoration of rangelands and other degraded lands, but countries have not provided much detail on what types of agricultural management need to be developed to replace what caused the degradation in the first place. Agroforestry and silvopastoralism are also identified as actions that can help to sequester carbon, but our research found that only about 20 countries mention agroforestry systems in their NDCs and other relevant strategies (see **Table 5.1**). Moreover, very few countries specify area-based targets. An exception is Malawi, which states in its updated NDC: "Agroforestry: Targeted planting of an additional 25 trees/ha on 155,000 ha of crop fields, equivalent to 20% of total arable land, 31,784 ha of village forest areas; and expansion of new fruit area on 27,000 ha to achieve at least a 10% tree cover. Scaled-up potential for all agroforestry types estimated at 700,000 ha." (Republic of Malawi, 2021, p.44). It is important that countries mention specific area targets in their NDCs, since that would enable a more accurate quantification of the pledges and how much total area and what arrangements would be needed to fulfil them, as well as the corresponding monitoring.

Other countries point to sustainable agriculture as an approach that could help to mitigate climate change, but with very little detail on what it actually entails and the outcomes foreseen. A handful of countries and regions have attempted to specify this further. Examples are Bhutan, with its policy of growing 100 percent organic food by 2020; Zambia's intention to have 50 percent of its land under sustainable agricultural practices by 2030 compared with 2015; and the European Union's aim to have at least 25 percent of its agricultural land under organic farming by 2030. Other countries like Colombia, Kenya and Senegal have put forward agroecological measures (GAFF, 2022). Yet these are few and far between and provide little information about what they consider to be organic, sustainable or agroecological. There is also a need for greater clarity in the NDCs to identify which countries are responsible for the bulk of the emissions from unsustainable agriculture, and who should bear the mitigation burden. Moreover, an assessment of 14 selected NDCs found that no country has specified the need to shift subsidies or incentives away from industrial agriculture and redirect them towards agroecological management – measures that would also support small-scale farmers (GAFF, 2022).

The current crises in agriculture, including the contribution of the sector to climate change, is primarily caused by industrial agriculture and its practices that are fossil fuel-dependent, promote land-use change, and are monoculture-focused. Small-scale, traditional and biologically diverse forms of agriculture have

Table 5.1 **Countries' pledges that identify agroforestry as a strategy for land-based carbon removals**

Country	Key elements of agroforestry pledge*
Brazil	Agroforestry identified as one of several mitigation measures.
Belize	Agroforestry practices incorporated into at least 8 000 ha of agricultural landscapes by 2030, with 4 500 ha of this implemented by 2025.
Colombia	Increasing investment for the implementation of agroforestry listed among the main mitigation measures for the agriculture sector.
European Union	Agroforestry identified as needing increasing support due to its potential for, *inter alia*, mitigating climate change.
The Gambia	'Multistrata agroforestry' described as an unconditional target, with potential mitigation of 169 Gg CO_2e in 2030.
Guinea-Bissau	Development of a national reforestation and sustainable management programme for forest and agroforestry ecosystems by 2025.
India	National Agroforestry Policy (NAP) of India aims to encourage and expand tree plantation in complementarity and integrated manner with crops and livestock.
Malawi	Targeted planting of an additional 25 trees/ha on 155 000 ha of crop fields, equivalent to 20% of total arable land, 31 784 ha of village forest areas; and expansion of new fruit area on 27 000 ha to achieve at least 10% tree cover. Scaled-up potential for all agroforestry types estimated at 700 000 ha.
Madagascar	Large-scale adoption of agroforestry planned to reduce emissions.
Mexico	Communal lands identified as opportunity to address environmental and development concerns through agroforestry and sustainable forest management.
Mozambique	Integrated agroforestry systems mentioned as a measure to recover areas degraded by shifting cultivation.
Myanmar	Agriculture described as the second largest sectoral source of greenhouse gas emissions and a new conditional cumulative target of sequestrating 10.4 million tCO_2e over the period 2021–2030 has been set for the sector. Promotion of tree planting and agroforestry to raise the average tree canopy cover across 275 000 ha of agricultural land with <10% tree canopy cover per hectare. The <10% tree cover class per hectare is mentioned as being of primary relevance as it covers the largest area of land nationwide (estimated at 112 068 km2 or 58% of total agriculture land in 2010). The mitigation pillars in the Climate-Smart Agriculture Strategy 2014 where agroforestry can contribute are identified as: 1) watershed and land management; 2) reducing land degradation and soil erosion; and 3) developing new farming systems and techniques.
Namibia	Planting of 10 000 ha of trees per year under agroforestry, which would account for 2% of Agriculture, Forestry and Other Land Use (AFOLU) emissions reduction in 2030. This accounts for potential emissions reduction of 0.358 $MtCO_2e$ in potential mitigation and 1.63% of business-as-usual scenario in 2030.
Nepal	Promotion of, *inter alia*, agroforestry as a conditional target for agriculture.
Senegal	AFOLU targets include rice cultivation and agroforestry to reduce emissions by 0.35% (2020), 0.51% (2025) and 0.63% (2030).
Sierra Leone	Reforestation of 14 000 ha of degraded land and agroforestry.
South Sudan	Promotion of agroforestry for carbon sequestration and other benefits.
Suriname	Promotion of agroforestry.
Tajikistan	Promotion and scaling of, *inter alia*, agroforestry as a source for generating mitigation co-benefits.
Tonga	By 2025, 30% of land targeted for agroforestry or forestry, which will include planting of 1 million trees by 2023. Promotion of integrated agroforestry is planned in areas earmarked for agriculture.
United Kingdom	Support to increased agroforestry (trees and agriculture coexisting on the same land) through environmental land management schemes from the early 2020s.
Zambia	By 2030, 50% of agricultural land will be under sustainable agricultural practices compared with 2015, which will include uptake of agroforestry.

Low **Moderate** **High**

* Usefulness in relation to specificity and quantification

Source: Authors' elaboration based on review of agriculture-related country climate pledges (see **Chapter 2**) comparatively minimal input to greenhouse gas emissions, but make a valuable contribution to climate mitigation (Verchot *et al*., 2007; Lin *et al*., 2011; Bryan *et al*., 2013; Altieri and Nicholls, 2017; Repin *et al*., 2020; Rakotovao *et al*., 2021). For these types of farming systems and the farmers dedicated to them – particularly those in the global South – there is an urgent need to support their production systems as an effective climate adaptation measure and climate justice action, as although they have done little to cause the climate crisis, they are suffering the most.

The agricultural commitments in the NDCs focus largely on carbon removals and, to some extent, on the need for reductions in synthetic nitrogen fertilizers. This represents a missed opportunity for a climate justice approach that emphasizes the multiple benefits of biodiverse agricultural systems, such as agroecology, including the restoration and conservation of biodiversity and its functions, as well as the realization of human rights (Tomich *et al*., 2011; IPES-Food, 2016).

The focus of this chapter on agroecology is therefore deliberate. Agroecology can certainly play a major part in removing emissions from agricultural production (see Dooley *et al*., 2018; IPCC, 2019a; Sinclair, 2019). However, most importantly, agroecology is a holistic approach with multifunctional benefits, including adaptation to climate change, biodiversity conservation and sustainable use, ecological and social resilience, healthy nutrition and diets, and sustainable livelihoods (IPES-Food, 2016; HLPE, 2019; Sinclair, 2019; Leippert *et al*., 2020) (see **section 5.2**).

Conceptualized in this way, attention moves from a singular focus on carbon as a metric, to measuring the multiple benefits of working respectfully with ecosystems and the people living in them. This means a focus on longer-term benefits for peasants and other smallholders and for society at large, such as ecosystem health, livelihood resilience, genuine healthy food and nutrition, and the economic viability of farms in the face of debt and climate shocks (IPES-Food, 2016). Measures such as nutritional quality, resource efficiency, restoration of biodiversity, provision of ecosystem functions, equity and justice are highly relevant. By these counts, agroecology certainly contributes robustly to climate-resilient and sustainable agricultural and food systems (IPES-Food, 2016).

5.1.2 **Industrial agriculture and food systems**

The world's industrial food systems are the single most important contributor to GHG emissions (IPCC, 2019a), representing more than one-third of current global anthropogenic emissions (Crippa *et al*., 2021). Industrial agriculture and land-use change contribute one-quarter of those GHG emissions (IPCC, 2019a). Cropland that is managed unsustainably is the primary anthropogenic source of nitrous oxide, with synthetic nitrogen fertilizers accounting for 82 percent of global increases in GHG emissions since the pre-industrial era (1860s) (Tian *et al*., 2019). Likewise, large-scale conventional agriculture (mainly industrial livestock and rice monocrops) contributes 36 percent of global anthropogenic methane emissions (IPCC, 2014b).

Furthermore, land conversion for industrial agriculture and agricultural intensification is the prime cause of global biodiversity loss through land-use change (IPBES, 2019; Benton *et al*., 2021). Biodiversity is declining faster than at any time in human history, and perhaps as fast as during any mass extinction (Ceballos *et al*., 2020). Industrial and conventional agriculture also plays a significant role in water pollution and is responsible for 70 percent of all freshwater use globally (Rockström and Karlberg, 2010; Mateo-Sagasta *et al*., 2018; Mekonnen and Hoestra, 2020). More than 50 percent of synthetic nitrogen fertilizers applied in conventional agriculture are lost, adding excess reactive nitrogen to the surrounding environment through leaching and gaseous losses (Galloway *et al*., 2008; Lassaletta *et al*., 2014). Synthetic nitrogen inputs from river runoffs constitute a significant source of eutrophication in estuaries and coastal waters, and are responsible for the exponential increase in hypoxic zones worldwide since the 1960s (Diaz and Rosenberg, 2008; Sinha *et al*., 2017).

Globally, soils store in their first metre three times more carbon than the above-ground biomass of all forests in the world combined, and double the carbon dioxide content of the atmosphere (Lal, 2004). The alarming rate of soil degradation results in a decrease of this ecosystem function (carbon sequestration), among others. Soil erosion, compaction, salinization, nutrient depletion (due mainly to the decline in organic matter content) and contamination are the major symptoms of soil loss and deterioration, and are all associated with industrial agriculture (Bindraban *et al*., 2012). Moreover, the pesticides used in industrial agriculture and monocrops contaminate soils, water, air and wildlife, and are important factors in acute and chronic human illness and deaths, disproportionally affecting farmers and farmworkers (Rani *et al*., 2021).

The industrial food systems affect health through multiple and interconnected pathways, generating severe human and economic costs. In relation to the food-health nexus, the International Panel of Experts on Sustainable Food Systems (IPES-Food) identifies five key channels through which food systems impact health: occupational hazards, environmental contamination, consumption of contaminated unsafe food, unhealthy dietary patterns, and food insecurity (IPES-Food, 2017). In addition, agricultural intensification and land-use change are major causes of the emergence of infectious diseases (Jones *et al*., 2013). Some 60 percent of these are of zoonotic origin, and 72 percent of these originate in wildlife (Jones *et al*., 2008). The spillover of these zoonotic diseases to the human population is intricately related to the intensification of agriculture and livestock production through the ecosystem and animal health degradation that they generate (Wallace, 2016).

The global industrial food system also contributes to increasing inequalities (for example in terms of access to land and support services), by favouring large-scale industrial plantations over small- and medium-scale family farming, resulting in the loss of livelihoods for millions of smallholder farmers worldwide (Holt-Giménez and Altieri, 2013; Moseley *et al*., 2015; Kansanga *et al*., 2019; Debela *et al*., 2020). Smallholder farms are defined as less than 2 ha in area and represent about 84 percent of all global farms (Lowder *et al*., 2016). Smallholders' ecological relevance (for example, agrobiodiversity *in situ* conservation) and social relevance (for example, diversified food production) is compromised when their livelihoods are jeopardized. A recent meta-analysis concluded that on average, smallholder farms shelter higher (agro)biodiversity and have higher yields in comparison with larger farms (Ricciardi *et al*., 2021). Depending on the set of countries considered, smallholders and family farmers provide at least 53 percent (Graeub *et al*., 2016) and up to 80 percent of all food consumed globally (FAO, 2014).

This figure is important in the context of land-sparing arguments that advocate for agricultural intensification to increase yields and spare land for conservation and climate change mitigation (Cohn *et al*., 2014; Carter *et al*., 2015; Lamb *et al*., 2016). Although smallholder agriculture represents 84 percent of the total number of farms, it constitutes only 12 percent of all farmland (Ricciardi *et al*., 2021), and 53 percent when including all family farms (Graeub *et al*., 2016). In other words, on 53 percent of the world's farmland, smallholders and family farmers are producing between 53 and 84 percent of the total food consumed globally. This large percentage of food is produced by a sector that receives very little financial and technical aid. Most countries do not prioritize smallholders in their agricultural policies, reducing access to financial resources and leading to the marginalization of smallholders in rural areas (Maas Wolfenson, 2013). Furthermore, the land-sparing argument is based on the assumption that land is indeed spared as a result of agricultural intensification. However, there is very little evidence that this is the case, and when it does occur, it is under very particular circumstances, such as strong forest conservation policies (Rudel *et al*., 2009). For instance, in a study of 10 major crops in 161 countries, Rudel and colleagues (2009) show that as yield increased from 1970 to 2005, the amount of cultivated area increased as well, contrary to the land-sparing expectations. Indeed, empirical evidence suggests that agricultural intensification programmes frequently result in higher levels of deforestation locally (Angelsen and Kaimowitz, 2001; Perfecto and Vandermeer, 2010).

Loss of biodiversity and habitat is predominantly caused by the intensification, colonization and appropriation of land that was and is used by rural people, who manage it in a less intensive way.

All the impacts of the unsustainable global food and land-use systems result in an immense economic cost that is frequently hidden. In 2019, the Food and Land Use Coalition estimated the hidden ecological, health and socioeconomic costs of the global food and land-use systems to be USD 12 trillion. This estimate includes a consideration of some of the effects of climate change, biodiversity loss, undernourishment and poverty. Given the estimated market value of the global food systems of USD 10 trillion, this represents a negative balance of USD 2 trillion annually (FOLU, 2019; see **Figure 5.1**).

This quick review shows that business-as-usual is not an option, and that food system transformation is urgently required (McIntyre *et al*., 2009). This observation was already made by the International Assessment of Agricultural Knowledge, Science and Technology for Development in 2009. In the time since then, there have been a slew of proposals that claim to be able to fix our unsustainable food systems and/or to conserve biodiversity. While promising, these also have to be interrogated closely and we briefly discuss one such proposal below, given its close links with land and forests.

5.1.3 The 30X30 initiative

Many conservationists and climate change advocates are excited about the possibility of expanding protected areas (PAs) to cover 30 percent of the planet by 2030. The so-called 30X30 initiative was launched by the High Ambition Coalition for Nature and People in 2020. The initiative was proposed as one of the targets of the Post-2020 Global Biodiversity Framework to be discussed at the Fifteenth meeting of the Conference of the Parties (COP 15) to the CBD. By June 2022, more than 100 countries had joined the coalition (High Ambition Coalition for Nature and People Statement, 2022).

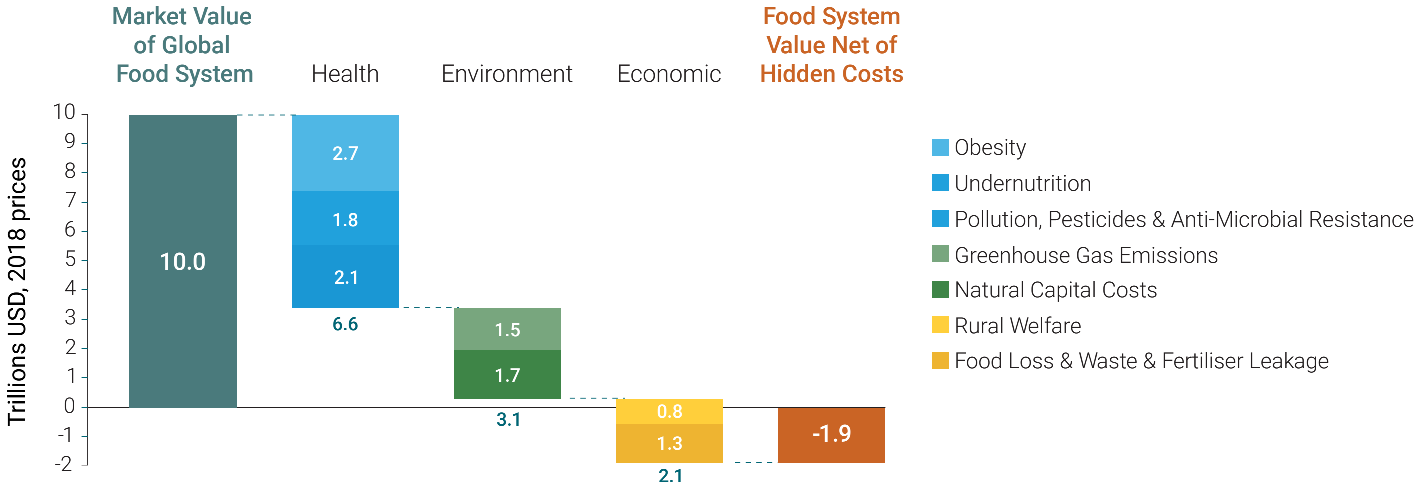
However, not everyone is enthusiastic about the initiative. The PA approach has been reported to frequently violate the rights of rural people, particularly indigenous peoples, peasants, forest dwellers, artisanal fishers and pastoralists (Obura *et al.*, 2021; UNEP-WCMC and IUCN, 2021), as detailed in **Chapter 4**. This is particularly true of approaches that embody strict or 'fortress' conservation, which are frequently linked to eviction, restriction of use of traditional lands, and violations of human rights (Boyd and Keene, 2021) to 'protect' ecosystems of value to some other, usually non-local, entity. In addition to criticisms over human rights violations, the PA approach is misguided in several important ways (Aubertin and Weill, 2022).

First, protected areas have a highly variable record regarding their effectiveness in protecting biodiversity and habitats. The establishment of PAs frequently fails to prevent deforestation and habitat degradation (Brun *et al.*, 2015; Schulze *et al.*, 2017). In tropical regions, conversion from forest to cropland was shown to have increased in PAs even more than in matched unprotected zones (Geldmann *et al.*, 2019). There have been some reported cases of exceptions. For example, a study focusing on Southeast Asia found that PAs were more effective at conserving forests than similar landscapes without protection (Graham *et al.*, 2021). However, the predominant trends are situations of human rights violations and lack of biodiversity protection in PAs, particularly in the global South (Boyd and Keene, 2021).

Second, a long-term historical perspective indicates that, with rare exceptions, the current loss of biodiversity and forested habitat is not caused by anthropogenic conversion or degradation of pristine ecosystems, which are usually the prime intentions of conservation with PAs. Instead, loss of biodiversity and habitat is predominantly caused by the intensification, colonization and appropriation of land that was and is used by rural people, who manage it in a less intensive way (Ellis *et al.*, 2021). Indeed, it has been estimated that 75 to 95 percent of the terrestrial biosphere has been altered by human societies (Kennedy *et al.*, 2019; Ellis *et al.*, 2000, 2021; Williams *et al.*, 2020). Forests under secured land tenure in favour of indigenous peoples are better preserved and the traditional agriculture practised on those lands has been shown to reduce the pressure on other areas, contributing to the conservation of larger areas of forests (Ceddia *et al.*, 2019; FAO/FILAC, 2021). This suggests that supporting rural people who are already managing their lands in a sustainable manner may be a more effective way to conserve biodiversity and reduce the carbon footprint than establishing strict conservation in presupposed pristine areas.

Third, and related to the second point, the contribution to carbon storage of agricultural lands devoted to biologically diverse production systems has been greatly underestimated. Approximately one-third of the estimated 3 trillion trees on Earth grow outside

Figure 5.1 **The hidden costs of global food and land use systems sum to *$12 trillion*, compared to a market value of the global food system of *$10 trillion***



Source: Growing Better: Ten Critical Transitions to Transform Food and Land Use, Food and Land Use Coalition, 2019 the 4 billion ha of closed canopy forests (FAO, 2020), mostly in agricultural lands, rangelands and agroforestry-type systems (Zomer *et al*., 2022). It has been estimated that 43 percent of all agricultural land globally has at least 10 percent tree cover, and during the decade between 2000 and 2010, tree cover in agricultural lands increased by 3.7 percent (Zomer *et al*., 2016). Taking these figures into account, the contribution to carbon storage of agricultural lands that include the tree component rises fourfold (Zomer *et al*., 2016; Cardinael *et al*., 2018). This shows the potential and actual contribution to carbon storage of agricultural and livestock systems that integrate trees in their design and management.

Finally, establishing PAs in 30 percent or even 50 percent (which is the target for 2040) of the Earth begs the question, what happens to the other 70 or 50 percent? Proponents of the PA paradigm tend to have a land-sparing approach to conservation, under the assumption that increasing agricultural productivity in some areas will spare land for conservation in others (Phalan, 2018). Therefore, the assumption is that intensifying agricultural production and the production of other resources for human consumption, and concentrating populations in the 50 percent of areas devoted to human activities, would allow the conservation of the remaining 50 percent. This narrative of the separation of ecosystems and people, which follows a linear instead of a systemic approach, has been shown to lead to further ecological degradation and social injustices and inequalities (Agrawal *et al*., 2021; Obura *et al*, 2021; Pascual *et al*., 2021). Furthermore, as previously discussed, the literature reports that in actual terms land-sparing rarely leads to land being allowed to remain fallow after agricultural intensification programmes. Instead, agricultural intensification frequently leads to more deforestation (Angelsen and Kaimowitz, 2001; Perfecto and Vandermeer, 2010). Coupled with the move to apply 'nature-based solutions', there is a risk that the 30X30 initiative will appropriate forests and lands, compromising land rights and threatening to dispossess IPs and LCs, including smallholders, such as peasants, small-scale farmers, gatherers, pastoralists and artisanal fishers.

The four points described above strongly suggest that rather than expanding the failed and unjust model of PAs, policy-makers need to support a complete transformation of agriculture and the global food system. We propose agroecology as a key path for that transformation. **Section 5.2** examines some of the existing evidence in this regard, while **Section 5.4** describes the type of policies that need to be promoted to address the climate crisis and dignify the livelihood of those smallholders who put food on our tables.

5.2 The multifunctional benefits of agroecology

5.2.1 What do we mean by agroecology?

Agroecology is the transdisciplinary and multi-actor approach to designing, managing and transforming agroecosystems and food systems by applying a territorial perspective, in accordance with ecological, social, cultural and political principles. Their implementation takes place considering the local contexts, and with the overall aim of achieving sovereignty, socioecological resilience, justice and integral well-being (for human communities and ecosystems) (Francis *et al.*, 2003; Altieri and Nicholls, 2006; Gliessman, 2015; Rosset and Altieri, 2016; Bezner Kerr *et al.*, 2022). Some examples of those principles are biological diversification of agricultural management and diets, soil health restoration and conservation, protection and use of native varieties and traditional knowledge, a decrease in external dependencies and an increase in self-reliance, democratization of healthy food, strengthening grassroot groups, and enhancing the different dimensions of sovereignty (in terms of food, technology and energy) (Altieri *et al.*, 2011; Gliessman, 2015; Giraldo and Rosset, 2021).

Therefore, agroecology is not a technological package or a set of good practices (productive or social) for 'green', 'clean' or 'responsible' agriculture and livestock farming. Instead, it is the adaptive application of principles that go beyond the technical vision of the ecological management of production farms, commonly expressed by input substitution, from synthetic to biological. Neither is agroecology about complying with certain predefined standards to fulfil certification schemes whose implementation and payment increases the price of healthy food. Agroecology is a comprehensive approach to caring for and respecting the diversity of life systems through food production and consumption. To achieve this, a shift in perspective, organization and implementation of agriculture and food systems, as well as of social networks and political structures, is required (Giraldo and Rosset, 2021).

5.2.2 Agroecology and biodiversity

The design and management of biodiverse systems is a key attribute of agroecology, on which the implementation of several ecological, social and political principles is based (Altieri, 1999; IPES-Food, 2016). These include soil health restoration, removal of dependence on external inputs, promotion of diversified diets, and strengthening of food sovereignty. Biodiversity restoration, conservation and sustainable use are therefore essential in agroecology, both as an approach and as an aim. This is due to the role of biodiversity in enhancing and sustaining ecosystem functions relevant to supporting human and non-human life systems (Tilman *et al*., 2014; IPBES, 2019).

Functions such as storing and cycling nutrients and water, biomass production, carbon fixation, habitat provision, pollination, prevention of soil erosion, climate regulation and many others, are directly related to biodiversity (Hooper *et al*., 2005; IPBES, 2016) and, accordingly, to biologically diverse (or biodiverse) agroecosystems (Altieri and Nicholls, 2003, 2006; Nicholls and Altieri, 2013; Guzman *et al.,* 2019). Such functions are the result of positive interactions among species along space and time; meaning that no single species can trigger or foster an ecosystem function by itself, but rather, a variety of species is needed (Zavaleta *et al*., 2010). This highlights the relevance and advantages of biologically complex systems (such as polycultures and agroforestry) in comparison with simplified ones (such as monocultures). The greater the biodiversity, the greater the ecosystem functions and, consequently, the services that are provided (Isbell *et al*., 2011; Gamfeldt *et al*., 2013; Tilman *et al*., 2014).

However, the importance of biodiversity in agroecological production and food systems is not only ecological. Biodiversity also embraces a deep sociocultural, socioeconomic and political relevance. This has its origins in the fact that biodiversity and human communities have interacted historically through adaptive and co-evolutionary processes (Pilgrim and Pretty, 2010). The result has been a biological and cultural amalgam – expressed in biocultural richness – that is clearly recognized in traditional livelihood systems, such as those of indigenous peoples and peasant communities (Altieri, 2004, 2021; Toledo and Barrera-Bassols, 2008). In these, the management of biologically complex and knowledge-intensive systems is a crosscutting feature that supports their longstanding socioecological resilience, although indigenous and peasant production and food systems face increasing pressures and challenges (Altieri *et al.,* 2015; Forest Peoples Programme, 2020; Altieri, 2021; FAO *et al.,* 2021).

A key socioeconomic dimension of biodiversity (wild and domesticated) relates to food and healthy diets, which is extensively documented (Chappell and LaValle, 2011; Sunderland, 2011; Vinceti *et al.,* 2013; Pellegrini and Tasciotti, 2014; Powell *et al.*, 2015; FAO/Commission on Genetic Resources for Food and Agriculture, 2020; Campbell *et al.,* 2021). The role of biodiversity in food systems directly derives from the provision of varied sources of nutrients. For example, research shows that there is a clear connection between the diversity of crops cultivated and the diversity of foods consumed, especially in rural households (Pellegrini and Tasciotti, 2014), and hence the nutrient provision, particularly that of micronutrients (Lachat *et al*., 2018).

Moreover, biodiversity influences food production and provision through its ecosystem functions, particularly soil nutrition, pest regulation, water cycling and adaptation to climate change (Frison *et al*., 2011; Lin, 2011). Biodiversity and biodiverse production systems, such as agroecology, are also fundamental to foster and strengthen self-reliance, expressed in higher levels of autonomous production and use of genetic resources (mainly seeds and local animal races), food, energy and knowledge (including locally-adapted innovations and technologies) (Perfecto *et al*., 2009; Altieri *et al*., 2011; Chappell *et al*., 2013). Such a role is a key foundation for food and technological sovereignty, which encompasses the political dimension of biodiverse systems.

The functions of biodiversity described here and others documented in the literature are inherently attributes of agroecology because, as mentioned, its key feature is managing biodiverse systems. This is done by restoring, conserving and sustainably using the biodiversity above and below the ground, and inside and in the surroundings of the agroecosystem, fostering ecosystem functions that include properties such as health, resilience and sustainability (Nicholls and Altieri, 2008; Sánchez de P. *et al.,* 2012; Altieri *et al.,* 2015). From there, agroecology is a crucial strategy to cope with an array of challenges that characterize the Anthropocene, without putting more pressure on land and people. These include the production of sufficient and healthy food, the prevention of agricultural and human health outbreaks, and adaptation and mitigation to climate change.

The following sections provide a brief overview of the evidence on agroecology's contribution to addressing food production and climate change adaptation and mitigation. The purpose of this review is to shed light on the numerous and synergistic benefits of agroecology as a result of its adaptive management, which fosters biologically diverse production systems while also restoring ecosystem functions. It also aims to help visualize the premise that with agroecology it is possible to adapt to and mitigate climate change, while ensuring sufficient and healthy food without depending on technological fixes (such as climate-smart technologies) based on mechanistic approaches, and without isolating people from their surrounding ecosystems (for example, strict conservation).

5.2.3 **A quick review of the evidence of agroecology for achieving socioecological resilience**

1.Agroecology and food production

There are diverse interlinked factors that explain the productive capacity of agroecology. Those factors are triggered by the management of biodiversity – at genetic, species and (micro) habitat levels – within and surrounding agricultural fields and herds, which prompts functions that are expressed in effective, stable and diverse production systems (Altieri *et al*., 2015). The biodiversity spatially and temporally nurtured through agroecological management results in the: regulation of pest populations, decreasing their levels of spread and infestation; organic matter accumulation in the soils, contributing to improved and constant nutrients and energy availability, as well as enhanced soil water infiltration and holding capacity; temperature and humidity regulation by the different layers of vegetation in the vertical and horizontal profile of polycultures, creating shade and barriers that reduce water loss by evapotranspiration; and a range of other interrelations and functions (Altieri, 1999; Altieri and Nicholls, 2003; Vandermeer *et al.*, 2010; Lin, 2011; Kremen *et al.,* 2012; Sánchez de P. *et al.,* 2012; Gliessman, 2015). These ecosystem attributes, restored and enhanced by agroecological management, prevent biotic (such as pest) and abiotic (such as nutrient, temperature and water) stresses, with positive impacts on production and yields.

The agroecological practice of replacing monocrops with crop diversification (such as intercropping, crop rotation, cover crops, prairie strips) has positive effects on productivity and other production indicators, even in conventional management. For instance, experimental research with different crop associations, including maize, in comparison with maize production as a monocrop, found a three-year-average increase in grain yields ranging from 27 to 42 percent, together with 25 to 152 percent higher water-use efficiency, 256 percent more energy production, and a decrease in carbon emission of 42 to 52 percent (Chai *et al*., 2014). Two meta-analyses, one on crop associations (Raseduzzaman and Jensen, 2017) and the other on crop rotation (Davis *et al*., 2012), conclude that these result in higher productivity and profitability, the latter benefit resulting from stabilization of yields and reduction of the need for external synthetic inputs over time (Davis *et al*., 2012). Reducing dependence on external inputs also helps to achieve resilience, to an even greater extent than any increases in productivity (Casimiro-Rodríguez *et al*., 2020).

Agroecological management shows that production efficiency depends on biological diversification using functional biodiversity,[1] which results in effective use of space, nutrients, water and energy (Gliessman, 2015), as well as the development of a buffer capacity to biotic and abiotic shocks (Lin, 2011; Altieri *et al*., 2015). This explains the rates of food production in systems with agroecological-based management, such as organic farming. For instance, Badgley *et al*. (2007), based on 293 cases, report an average of organic to non-organic yield ratio of 1.8 in developing countries for 12 basic food categories, concluding that organic systems have the capacity to produce enough food per capita to feed current and future larger populations, without exerting further pressure on agricultural lands.

Research demonstrates that when only yields and no other efficiency indicators that agroecology outperforms on (such as energy use, input-to-yield ratio, contaminant reduction) are considered, the difference between conventional and agroecological farming is small. This is the case of the study carried out by Ponisio *et al*. (2015) which, based on 115 studies, reveals a smaller yield gap between organic farming and conventional agriculture when the former includes polycultures and crop rotations, demonstrating the relevance of biodiversity for increasing yields. This is consistent with experimental research applying a crop rotation with six crops in organic production plots over six years, where no difference in yield was found in comparison with conventional management, and with the organic system showing greater yield stability over time. The greater yield stability was attributed to the increase of soil biota and health and decreasing groundwater pollution (from nitrates) (Schrama *et al*., 2018). The sustainability of agroecology was further demonstrated in a 30-year comparison between associated maize and soybean production and cultivation of each crop separately with conventional agriculture, which showed comparable yields. In those trials, the agroecologically-managed system generated threefold higher profits, as well as soil health improvement (Rodale Institute, 2011).

Furthermore, part of the socioecological resilience provided by agroecology results in economic income to livelihoods in vulnerable ecosystems. Such an impact is reported by Son *et al*. (2020), who found that intercropping increased household income significantly in two communities of Viet Nam's Northern Mountainous Region susceptible to flash flooding and landslides, based on a survey of 384 households. For example, the authors report that banana production intercropped with medicinal plants doubled household income per hectare per year, in comparison with monocrops such as maize. Significant income increases were also observed in maize intercropping with leguminous species, with the secondary crop harvest covering the corresponding initial investment costs.

2. Agroecology and adaptation and mitigation to climate change

The IPCC (2022a, p. 23) states that effective adaptation options such as "agroecological principles and practices, ecosystem-based management in fisheries and aquaculture, and other approaches that work with natural processes support food security, nutrition, health and well-being, livelihoods and biodiversity, sustainability and ecosystem services (*high confidence*). These services include pest control, pollination, buffering of temperature extremes, and carbon sequestration and storage (*high confidence*)." Once again, the biodiversity managed in agroecological systems and its functions that are consequently restored, are the

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[1] Functional biodiversity refers to biodiversity that exerts regulating roles in the ecosystem's functioning and, therefore, influences directly or indirectly, human well-being (Moonen and Bàrberi, 2008).

bases for such adaptation capacity, leading to improved socioecological resilience to weather and climate variability (Altieri *et al.*, 2015). The biological complexity thus fostered serves as a climate buffer strategy, due to its ability to regulate water and temperature fluctuations through the density and synergies in biodiversity above and below ground in agroecologically-managed areas (Lin, 2011).

The literature reports the capacity of agroecological systems to endure with greater resilience, and recover more quickly, from extreme climate events. Holt-Giménez (2002) reported that better soil health and deeper topsoil in agroecological plots in hills in Guatemala, Honduras and Nicaragua, contributed to reduced erosion and economic losses during Hurricane Mitch in 1998. Philpott *et al*. (2008) reported that coffee plantations produced under agroforestry systems showed less physical damage (fewer landslides) and loss compared with conventional monocrop coffee plantations in Chiapas, Mexico during Hurricane Stan in 2005. Rosset *et al*. (2011) reported agroecological farms with 50 percent damage, compared with 90 percent and 100 percent loss in conventional production, caused by Hurricane Ike in 2008. More recently, Vázquez-Moreno (2021) reported close to 63 percent harvest recovery in agroecological plots that included trees, compared with only about three percent recovery in conventional monocrops plots in Cuba after Hurricane Irma in 2017.

Healthy soil properties result from agroecological management, such as increased organic matter, improved soil structure – allowing better water infiltration and retention – and the proliferation of beneficial soil microbiota (such as arbuscular mycorrhiza fungi). In combination with related agroecological management, such soil properties have been shown to increase climate resilience. For example, mulching is reported to reduce the effect of wind speed by 99 percent and to decrease evapotranspiration, while cover crops have the capacity to improve soil properties through increased water infiltration and reduced runoff by between twofold and sixfold (Altieri *et al*., 2015). These are two essential characteristics for adapting to heavy rain patterns. The social dimension of climate resilience achieved through healthy soils is manifested in production impacts, among others. Empirical research indicates that the loss of soil organic matter is directly related to reductions in yield. In contrast, the Rodale Institute (2011) reports increases in yields (31 percent) of organic maize in comparison with conventional production in years of drought.

Agroecology also helps with climate change mitigation. A ten-year model for agroecological farming and food in Europe calculated that replacing unsustainable agriculture would make it possible to feed the entire European population, while reducing agricultural GHG emissions by 40 percent (Poux and Aubert, 2018). The model also shows that agroecological practices such as the maintenance of permanent legume grassland have a capacity for soil carbon storage of 0.7 tonnes of carbon per hectare per year and 150–250 kg of atmospheric nitrogen (N) per hectare per year. These findings challenge the notion of land-sparing and agricultural intensification as 'sustainable' approaches to climate change and resilience; indeed, they point to the fact that the solution lies in promoting agroecological management to restore multiple ecosystem functions that sustain climate adaptation, socioecological resilience and, as a co-benefit, climate mitigation.

Another example of effective agroecological management is tree-crop integration, which provides 50–320 kg of N fixation per hectare per year (Sinclair *et al*., 2019). The integration of trees into crop and animal production results in a significant increase in carbon sequestration (Snapp *et al*., 2021). A study in Africa found that agroforestry systems can store more than twice as much carbon as parklands (with a 50-year rotation) and more than four times as much as rotational woodlots (with a rotation of 5 years) (Mbow *et al*., 2014). These figures do not take into account the reduction in GHG emissions from synthetic inputs, which agroecology does not use; thus, the mitigation potential of agroforestry systems is even greater.

Agroecology's potential to adapt to and mitigate climate change is the result of the properties (such as productivity, efficiency, resilience and sustainability) that emerge in agroecosystems and adjacent landscapes as a result of agroecological management, which combines multiple practices consistent with agroecological principles. This was confirmed by Debray *et al*., (2018), who conducted a literature review and identified a number of agroecological practices that have a direct and indirect positive impact on climate change adaptation, while also increasing carbon sequestration. These practices include the use of biodiversity and biological processes to prevent soil degradation, improve soils, enhance water management, prevent and regulate pest populations and implement agricultural management that is climate-adaptive. The authors conclude that it is the combination and synergies of practices – as opposed to isolated practices – that contribute to climate adaptation, while also providing a mitigation co-benefit.

5.3 **Agroecology consistent with rights-based approaches**

The intertwined and interdependent dynamics of ecological and social processes explain the increased potential for realizing human rights through the agroecological management of production plots, food systems, landscapes and territories. This is

Box 11 **Examples of human rights and the corresponding international human rights instruments, whose implementation is supported by agroecological management and action**

By being based on biologically diverse systems and thus restoring biodiversity, agroecology, its components (such as land and water), and ecosystem functions (including climate regulation), helps to support livelihoods that rely on it directly. Furthermore, because it is based on participatory and inclusive processes, agroecology strengthens local organizations and agencies, leveraging processes that contribute to socioecological resilience. As a result, agroecology fosters the realization of numerous rights. Some of these are listed below, along with examples of international instruments that address the corresponding human right.

a. **Social, economic, cultural, political and environmental rights** are contained in the Universal Declaration of Human Rights; the Declaration on the Right to Development; the UN Declaration on the Rights of Indigenous Peoples; the International Convention on the Elimination of all Forms of Racial Discrimination; the International Covenant on Civil and Political Rights; the International Covenant on Economic, Social and Cultural Rights; the Convention on the Elimination of All Forms of Discrimination Against Women; the International Labour Organization Indigenous and Tribal Peoples Convention; the Convention on the Rights of the Child; the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas; and the Human Rights Council Resolution 48/13 on the "Human right to a clean, healthy and sustainable environment".

b. **Civil and political rights** such as sovereignty over natural resources are set out in Art.1 of the the Declaration on the Right to Development; Art.2 of the the International Covenant on Civil and Political Rights; and Art.15 of the International Labour Organization Indigenous and Tribal Peoples Convention.

c. **Rights to the conservation and protection of the productive capacity of lands, territories and resources** are enshrined in Art.29 of the UN Declaration on the Rights of Indigenous Peoples; Art.17, Art.19 and Art.24 of the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas; and Art.15 of the International Labour Organization Indigenous and Tribal Peoples Convention.

d. **The right to traditional knowledge and cultural expressions** is described in Art.31 of the UN Declaration on the Rights of Indigenous Peoples; and Art.19 of the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas.

e. **The right to have access to natural resources and to use them in a sustainable manner** is mentioned in Art.5 of the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas.

f. **The right to genetic resources and seeds** is a provision of Art.31 of the UN Declaration on the Rights of Indigenous Peoples; Art.19 of the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas; and Art.9 of the International Treaty on Plant Genetic Resources for Food and Agriculture.

g. **The right to food** is contained in Art.25 of the Universal Declaration on Human Rights; Art.8 of the Declaration on the Right to Development; Art.15 of the UN Declaration on the Rights of Indigenous Peoples; and Art.11 of the International Covenant on Economic, Social and Cultural Rights.

h. **The right to health** is indicated in Art.8 of the Declaration on the Right to Development; Art.5 of the International Covenant on Economic, Social and Cultural Rights; Art.27 of the International Labour Organization Indigenous and Tribal Peoples Convention; Art.25 of the Convention on the Rights of the Child; and UNEP/EA.4/17 p.1e.

i. **The right to a safe environment** is contained in the Human Rights Council Resolution 48/13 on the "Human right to a clean, healthy and sustainable environment".

j. **The right to just and favourable, safe and healthy working conditions** is provided for by Art.23 of the Universal Declaration of Human Rights; Art.14 of the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas; Art.7 of the International Covenant on Economic, Social and Cultural Rights; Art.11 of the Convention on the Elimination of All Forms of Discrimination Against Women; and Art.20 of the International Labour Organization Indigenous and Tribal Peoples Convention.

k. **The right to an adequate standard of living for health and well-being** is described in Art.25 of the Universal Declaration of Human Rights; Art.21 and Art.24 of the UN Declaration on the Rights of Indigenous Peoples; Art.4, Art.16 and Art.24 of the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas; Art.7 and Art.11 of the International Covenant on Economic, Social and Cultural Rights; Art.14 of the Convention on the Elimination of All Forms of Discrimination Against Women; and Art.27 of the Convention on the Rights of the Child.

critical given that the people who emit the least GHGs are the ones who suffer the most from climate change. The process of realizing human rights through agroecological management begins with the improvement of biophysical properties (such as soil health) in biodiverse production systems and of the socioeconomic conditions associated with them (such as food production, income generation, and knowledge sharing) (Altieri *et al*., 2011; Anderson *et al*., 2019; Bezner Kerr *et al*., 2022). These result in the creation of conditions to realize a myriad of social, economic, cultural, political and environmental rights in accordance with international law (see a. in **Box 11**).

For example, the ecosystem functions restored and enhanced by agroecological management sustain self-regulated ecological dynamics and resilient socioeconomic processes that are paramount for the realization of civil and political rights. These may include, for example, sovereignty over natural resources (see b. in **Box 11**), and social, economic and cultural rights, such as the right to the conservation and protection of the productive capacity of lands, territories and resources (see c. in **Box 11**). The knowledge systems involved in the inherent management of biodiversity relate to the right to traditional knowledge and cultural expressions (see d. in **Box 11**).

The literature increasingly reports on the contributions of agroecology to equity, justice inclusion, and to dignifying conditions through improved social well-being, sustainable livelihoods, food sovereignty and health (D'Annolfo *et al*., 2017; Rosset and Altieri, 2017; Anderson *et al*., 2019; Bezner Kerr *et al*., 2019, 2022; Frison and Clément, 2020; Giraldo and Rosset, 2021; Petersen *et al*., n.d.). Such contributions are particularly important for those who are in situations of disadvantage, discrimination or vulnerability. This is the case of rural women who, thanks to agroecological management, may be able to establish self-reliance and production systems, including the use of native species and varieties that support them in carrying out their productive and care roles (Zuluaga Sánchez, 2011; Catacora-Vargas, 2021; Catacora-Vargas *et al*., 2022). As a result, they can exercise the right to have access to natural resources, and to use them in a sustainable manner (see e. in **Box 11**); and the right to genetic resources and seeds (see f. in **Box 11**), in addition to a reduction in socioeconomic and other forms of discrimination.

Agroecology's management and practices provide farmers with a means to spread risks during adverse and extreme weather events, adapt to climate change and build socioecological resilience, making agroecology an essential component of the response to climate change.

Diversified and healthy diets resulting from the increase in agrobiodiversity cultivated in agroecological systems (Pellegrini and Tasciotti, 2014) and the reduction in synthetic inputs, together with improved productivity (Altieri *et al*., 2021), are crucial for the realization of the right to food (see g. in **Box 11**); the right to health (see h. in **Box 11**); the right to a safe, healthy and sustainable environment (see i. in **Box 11**); and the right to just and favourable, safe and healthy working conditions (see j. in **Box 11**).

All the above are examples of the broad contribution of agroecology to socioecological resilience, including the right to an adequate standard of living for health and well-being, which are particularly relevant in the context of climate change.

5.4 The relevance of agroecology in climate policy-making

The preceding analysis demonstrates that, for the agriculture sector, agroecology is best placed to face the challenges of climate change, both in terms of climate adaptation and mitigation. Its management and practices provide farmers with a means to spread risks during adverse and extreme weather events, adapt to climate change and build socioecological resilience, making agroecology an essential component of the response to climate change. At the same time, agroecological practices reduce emissions and increase carbon sequestration. A key point is that due to its multifunctional benefits – such as sustained productivity and yields, as well as increased nutrition through diverse diets and secure farm livelihoods – agroecology helps to reduce the land gap by offering a holistic and effective strategy for managing agricultural land in a way that best meets multiple demands.

Yet in spite of its benefits, agroecology has largely been implemented without much policy or financial support; the scaling up of agroecology will therefore benefit from an enabling policy environment (HLPE, 2019). In the first place, this should include removing incentives that are propping up monoculture-focused, emissions-intensive industrial agriculture, while promoting agroecology as a climate-resilient agricultural and food system at all levels – from local to global – with an important role for national and subnational governments to coordinate efforts. The inclusion of agroecology in NDCs will be a critical lever to provide overarching policy support for both climate adaptation and mitigation in agriculture (Leippert *et al*., 2020; GAFF, 2022).

Indigenous peoples, peasants and other smallholders, as well as women within these groups – who make up the majority of the world's small-scale producers – play a key role in initiatives for promoting agroecology-based agriculture and food systems. To facilitate their full and active participation, there is a need to strengthen their agency, protect their rights (including tenure rights), and devise tools and approaches to develop and share capacities in accordance with their local context (such as farmer-to-farmer networks) (Mier y Terán Giménez Cacho *et al*., 2018; HLPE, 2019).

The following section briefly outlines the elements that are necessary to create climate resilience in agriculture through agroecology (drawing from Stabinsky and Lim, 2012). These include dismantling perverse incentives, increasing investments in agroecology, managing risks, and protecting the rights of indigenous peoples, smallholders, women and other right-holders severely affected by climate change.

5.4.1 Dismantling perverse incentives and subsidies that promote unsustainable and high-emissions agriculture

Current agricultural policies continue to prop up and lock in industrial agricultural practices that are responsible for the bulk of agricultural GHG emissions (IPES-Food, 2016). Incentives that promote the use of synthetic pesticides and fertilizers, and fossil fuels, or that encourage land degradation, entrench this unsustainable production system (FAO, UNDP and UNEP, 2021).

Agricultural incentives and subsidies therefore need to be redirected away from climate-destructive monocultures and climate-harmful inputs (HLPE, 2019; FAO, UNDP and UNEP, 2021) towards climate-resilient management, such as agroecology (Leippert *et al*., 2020; GAFF, 2022). It has been estimated, for example, that a reduction in the use of synthetic nitrogen fertilizers could already create a net GHG benefit of 0.69 $GtCO_2eq$ per year, while just one agroecological practice, agroforestry, could sequester 1.04 $GtCO_2eq$ per year in above-ground carbon (Dooley *et al*., 2018).

The intellectual property systems that act as drivers of corporate consolidation and corporate dominance of agriculture need to be addressed.

The redirection of subsidies requires action in a just and equitable way, targeting incentives that are provided to multinational corporations and industrial agriculture, while enabling special and differential treatment for developing countries. This should also involve the mitigation of negative impact, especially for the most vulnerable groups, which include smallholders and women small-scale producers (FAO, UNDP and UNEP, 2021). It should also entail redirecting financial savings to support smallholders implementing the sustainable use of (agro)biodiversity and to fund adaptation efforts, as well as providing new and additional financing to enable developed countries to meet their obligations under the UNFCCC (South Centre, 2010) and other relevant multilateral agreements, such as the CBD.

5.4.2 Increasing investment in agroecology

National, regional and international agriculture and climate policy frameworks need to be focused on agricultural adaptation, giving agroecology a central role (Weigelt *et al*., 2019). This is critical, as agriculture is increasingly vulnerable to climate change impacts, with millions of people exposed to food crises (IPCC, 2022a). In particular, increased emphasis on the conservation of agricultural biodiversity through sustainable use, building healthy soils, and developing and sharing water harvesting and other water management techniques is essential (IPCC, 2019a; Sinclair *et al*., 2019; Weigelt *et al*., 2019), particularly in National Adaptation Plans.

Particular attention needs to be paid to the agricultural and food system transformation rooted in agroecology. Some of the leverage points to foster such transformation are capacity building and knowledge generation on agroecological management through participatory processes; strengthening local organizations through horizontal and collective processes; respecting biocultural processes, such as peasant seed systems; securing access to land, water and seeds; and promoting and protecting equity, justice and other human rights (IPES-Food, 2018; Mier y Terán Giménez Cacho *et al.*, 2018; Anderson *et al.*, 2019; Giraldo and Rosset, 2021).

At the national level, there is a need to identify policy and financial barriers and gaps to an agroecology-based transformation, in order to promote policy coherence (Sinclair *et al*., 2019; Leippert *et al*., 2020). Transitions leading to transformations need to be designed with local actors (such as peasants, smallholder farmers and rural women), in order to be effective and sustainable (IPES-Food, 2018). The initial costs and risks associated with transformation efforts to implement agroecology require support, for instance, through public funding (Herren *et al*., 2011).

Given the multifunctional benefits of agroecology, scaling it up calls for support that is consistent with its ecological, social, economic and political principles. Devoting public budgets, for example from the agriculture sector, could support this endeavour, though this is currently not the case. For instance, in the United States of America, support for agroecology accounts for only a small portion of agricultural public funds (De Longe *et al*., 2016). In sub-Saharan Africa, agricultural investment overwhelmingly reinforces the damaging model of industrial agriculture, sidelining agroecology (Biovision and IPES-Food, 2020).

5.4.3 Implementing an agroecology research and knowledge-sharing agenda for climate-resilient agriculture

Current agricultural research is dominated by the private sector and perpetuates industrial, input-dependent and high-emissions agriculture. In this context, the intellectual property systems that act as drivers of corporate consolidation and corporate dominance of agriculture need to be addressed (Fakhri, 2021).

Agroecology draws on transdisciplinary approaches and integrates these with traditional and local knowledge, cultures and innovations, whose intergenerational transmission and re-creation is fundamental for building resilient food systems, particularly those of indigenous peoples (FAO *et al*., 2021). To overcome the combined challenges of, *inter alia*, climate, biodiversity and food crises, research from the scientific community needs to be complemented by other knowledge systems, such as traditional and local knowledge systems (IPCC, 2019a).

All these observations highlight the need to refocus research and development efforts towards agroecology research and capacity building in the context of climate change, while at the same time strengthening existing traditional knowledge and innovation (Leippert *et al*., 2020). Doing so will require an agenda that is co-constructed, implemented by and monitored with local actors, fostering their organizational strengthening and allowing them to play a central role. At the same time, this implies increased networking, knowledge sharing, and new collaborative research frameworks (HLPE, 2019; Sinclair *et al*., 2019; Weigelt *et al*., 2019; FAO *et al*., 2021). It also involves reorienting the ways in which knowledge is created, documented and shared, moving from top-down, diffusionist and 'expert'-led processes, to research agendas that are rooted in local needs, implemented collaboratively *in situ*, participatory-action-research-oriented, and which apply pedagogic processes that are consistent with the social and political proposals of agroecology (such as farmer-to-farmer knowledge sharing).

5.4.4 Protecting the rights of indigenous peoples and local communities and other right-holders

Agroecology for climate resilient food systems cannot be implemented without a focus on rights, in particular those of indigenous peoples, peasants and other smallholders and people working in rural areas, with particular attention paid to women and youth (HLPE, 2019). This includes protecting rights such as the right to freely use, exchange and sell farm-saved seed (Fakhri, 2021), protecting traditional knowledge systems, promoting secure land tenure (IPCC, 2019a), and recognizing territorial customary self-governance.

Such an approach requires enacting legislation and measures to promote, protect and realize human rights; strong policy commitment to the obligations established in this regard in international law (such as UNDROP and UNDRIP, see **Box 10**); and addressing the power asymmetries and inequities that impede the realization of these rights (Ishii-Eiteman *et al*., 2020; Fakhri, 2021). Corporate and elite control over land, seeds, water and other productive and ecosystem components needs to be replaced with other cooperative and democratic models of ownership and use (Ishii-Eiteman *et al*., 2020).

In relation to indigenous peoples, **Chapter 4** elaborates on ways forward to enable them to exercise self-determination in the sustainable use of their lands and territories, a crucial aspect in order to foster sustainability in agriculture, food systems and climate resilience.

5.4.5 Managing climate risks and reducing vulnerability

It is critical to recognize that agroecology will not be able to solve all structural challenges associated with agriculture, food systems and climate change on its own. In relation to climate change, the financing and transfer of appropriate technologies (such as for climate information, research, infrastructure, communication) by developed countries are needed, in accordance with the principle of common but differentiated responsibilities and respective capabilities.

A focus on building adaptive capacity and resilience would reduce vulnerability and improve social safety nets to enable smallholders to prevent and cope with climate-related disasters, particularly in rural areas. Special attention and specific support need to be given to women in the different production and care roles that they assume, and to secure their full and effective participation in decision-making. The governance practices of indigenous peoples, including safety nets and solidarity mechanisms based on social organization and customary governance systems, can be particularly important (FAO *et al*., 2021).

5.5 **Conclusions**

This chapter has highlighted the potential of agroecology for reducing the 'land gap' between governments' reliance on land for mitigation purposes and the role that land can realistically play, in a manner that does not cause further climate change or adverse impacts on biodiversity, while ensuring that farmers are able to adapt to an increasingly heating planet.

It is the multifunctional benefits – based on the establishment and management of biodiverse production and food systems and the creation of socioecological resilience – that confer on agroecology its transformative role. This is enhanced by the human rights-based approach that agroecology represents, which can be scaled up even further by securing access to land and water, respect of traditional livelihoods, and the protection of systems of traditional knowledge, innovations and practices, in favour of indigenous peoples, smallholders and women.

Policy action focused on agriculture's contribution to climate mitigation or land-based removals alone is not enough. Instead, this chapter has provided arguments for a systemic approach that both dismantles the structures that keep emissions-intensive industrial agriculture in place, and increases investments in agroecology to foster climate-resilient agriculture and food systems. Recommendations for building supportive international policy frameworks for agroecology are presented in **Chapter 6**.