Zero Carbon Analytics

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An introduction to sustainable agriculture in smallholder farming

Key points:

- Smallholder farmers produce at least one-third of the world's food
- Smallholder farmers are disproportionately experiencing the effects of climate change and are particularly vulnerable to climate shocks, yet it is estimated that they receive only 1.7% of total climate finance
- The FAO describes sustainable agriculture as meeting "the needs of present and future generations, while ensuring profitability, environmental health, and social and economic equity"
- Various farming approaches can be considered sustainable, such as sustainable intensification, climate-smart agriculture, regenerative agriculture, organic farming and agroecological farming
- The WEF recognises that farmers are key to addressing the current ecological and climate crises and need to be supported through the provision of financing and fair economic opportunities in order to embrace sustainable food production practices
- Ninety-five percent of climate finance for small-scale agriculture comes from the public sector, including government donors, multilateral development finance institutions and bilateral development financial institutions
- Smallholder farmers are vulnerable to production risks, so they need initiatives and investments that are relatively low-risk and that offer short-term returns on investment
- Impact-oriented funds, blended finance and green bonds offer finance solutions for climate resilient and sustainable agriculture.

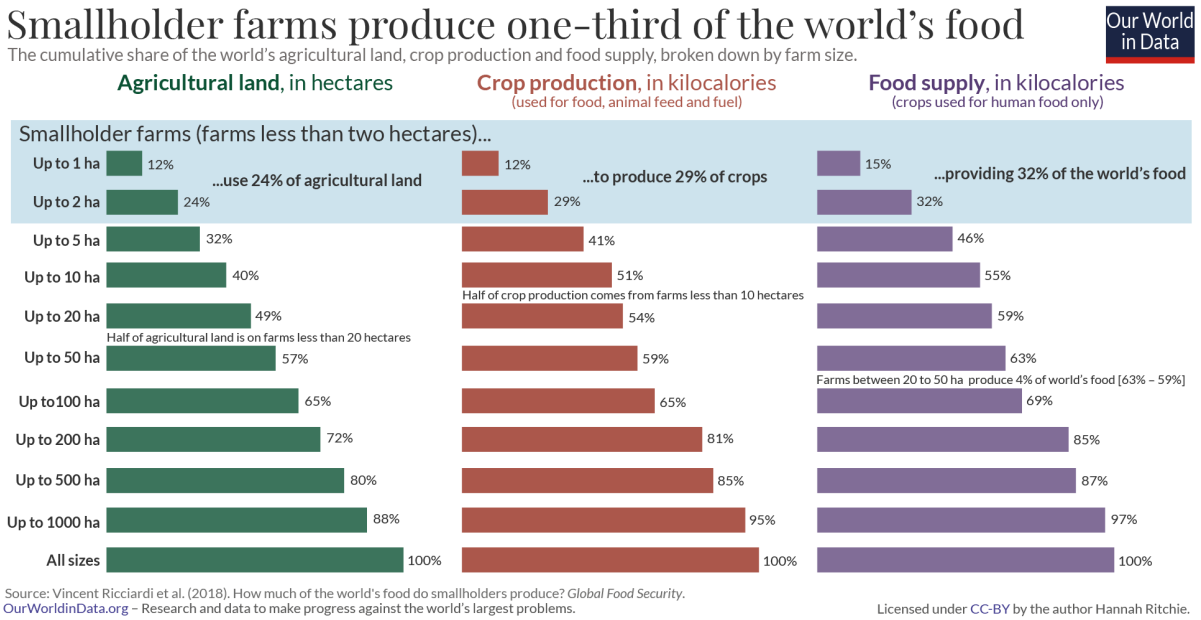
Smallholder farming

More than half of agricultural land globally is degraded, leading to productivity losses of USD 400 billion every year. Projections indicate that globally, agricultural production will need to expand by 60% by 2050 to meet increased demand, and most of this will need to come from increased productivity. Food production also makes up more than a third of greenhouse gas emissions worldwide, of which 58% is from animal-based agriculture (including livestock feed) and 29% is from the production of plant-based foods.

Smallholder farms of less than two hectares in size produce around one-third of the world's food. Farms of up to 20 hectares produce over half (see the chart below).[1] These farms face various production risks due to a range of factors, including they are small in

[1] Small-scale farmers are typically those that produce food on up to two hectares of land in Asia and Africa and up to 15 hectares in Latin America. Small-scale farmers may or may not hold land titles.

size, are held under traditional or informal land tenure, are more vulnerable to market shocks, are constrained by low soil productivity and low-quality or marginal lands, feature complex production systems hosting a diversity of plants and animals, face regulatory regimes in the Global North that have strict and ever-changing policies on food security and safety, suffer from isolation and low levels of technology, and may be subject to armed conflict and state fragility.



Source: Our World in Data

Small-scale farmers, particularly in developing countries, therefore play a crucial role in ensuring food security despite experiencing major food insecurity themselves. Smallholder farmers are disproportionately vulnerable to the effects of climate change and climate shocks, yet it is estimated that they receive only 1.7% of total climate finance. The World Economic Forum (WEF) recognises that farmers are key to addressing the current ecological and climate crises and need to be supported through the provision of financing and fair economic opportunities in order to embrace sustainable food production practices.

Sustainable agriculture

The Food and Agriculture Organization (FAO) describes sustainable agriculture as meeting "the needs of present and future generations, while ensuring profitability, environmental health and social and economic equity". Various types of agricultural production can be considered sustainable, and these are discussed below.

Sustainable intensification

The main aim of sustainable intensification is to increase crop and livestock yields and the associated economic activity without negatively impacting soil, water or the integrity of natural ecosystems. In general, this means a move away from the typical seed, fertiliser and pesticide technologies used in modern agriculture to restorative practices that rely more on ecological processes and internal resources. It also means increasing output on existing agricultural land and reducing the loss of natural habitat for agricultural production.

Examples of how agricultural systems in both developed and developing countries may be redesigned to fit the principles of sustainable intensification are provided in the table below:

Redesign type	Illustrative redesign sub-types of intervention
1. Integrated pest management (IPM)	IPM through farmer field schools Integrated plant and pest management Push-pull systems
2. Conservation agriculture (CA)	Conservation agriculture practices Zero- and low-tillage Soil conservation and soil erosion prevention Enhancement of soil health
3. Integrated crop and biodiversity redesign	Organic agriculture Rice-fish systems Systems of crop and rice intensification (SCI, SRI) Zero-budget natural farming (ZBNF) Science and technology backyard platforms Farmer wisdom networks Landcare and watershed management groups
4. Pasture and forage redesign	Mixed forage-crop systems Management intensive rotational grazing systems (MIRGs) Agropastoral field schools
5. Trees in agricultural systems	Agroforestry Joint and collective forest management Leguminous fertilizer trees and shrubs
6. Irrigation water management	Water user associations Participatory irrigation management Watershed management Micro-irrigation technologies
7. Intensive small and patch scale systems	Community farms, allotments, backyard gardens, raised beds Vertical farms Group purchasing associations and artisanal small producers (in Community Supported Agriculture, tekei groups, guilds) Micro-credit groups for small-scale intensification Integrated aquaculture

Note: i) This is an illustrative list of sub-types; ii) Some sub-types span a number of types (e.g., organic agriculture also appears in elements of 4 and 7); iii) Community Supported Agriculture operations (CSAs) are group purchasing associations in North America and the UK, tekei groups are in Japan, guilds in France, Belgium and Switzerland.

Source: Global Assessment of Agricultural System Redesign for Sustainable Intensification

Many argue that sustainable intensification can only be achieved if public investments encourage the adoption of innovations and support farmers by making technologies accessible and affordable. As smallholder farmers are vulnerable to production risks, they need initiatives and investments that are relatively low-risk and that offer short-term returns.

For example, agroforestry, which is one of the tools that can be used in different types of sustainable agriculture and involves planting trees alongside pasture and crops, is being supported by the non-profit research institute CIFOR-ICRAF. Their Trees for Food Security II project trained smallholder farmers in Africa in agroforestry principles and business skills, allowing them to participate more effectively in timber, fruit and fodder value chains while increasing outputs and improving sustainability. Another initiative is designed to demonstrate to smallholder oil palm producers in Cameroon that the use of industrial mills is more efficient than small local mills and could improve their productivity and income. Research supported by research centre CIFOR-ICRAF has shown that pests in Zambia and

Malawi that would ordinarily be controlled using pesticides can be managed through the use of low-cost agroecological farming principles.[2]

Sustainable intensification and climate-smart agriculture (discussed below) are closely interlinked, with sustainable intensification forming the foundation of climate-smart agriculture. Therefore, the constraints, solutions and financing options discussed below under climate-smart agriculture will be broadly applicable to sustainable intensification.

Climate-smart agriculture

Climate-smart agriculture aims to guide agricultural systems towards supporting food security in the context of a changing climate, through "integrating climate change into the planning and implementation of sustainable agricultural strategies". As climate change presents considerable risk in terms of unpredictable weather patterns, climate-smart agriculture focuses on building resilience in order to respond more rapidly to these risks and reduce the chances of becoming food insecure. It has three broad principles:

- Increased sustainable production to meet food security and equitably increase incomes, food security and development
- Enhanced resilience to climate shocks and risks through adaptation and resilience building
- Development of opportunities to reduce greenhouse gas emissions from agriculture, thereby reducing the greenhouse gases emitted per calorie of food.

Climate-smart agriculture uses existing approaches focused on supporting ecosystem services for achieving these principles, with sustainable intensification being a foundation.[3] The tools and approaches that are used will vary depending on the regional context, but some examples include:

- Integration of crop, livestock, agroforestry and aquaculture systems
- Improved management of pests, water and nutrients, including using nitrogen fertiliser more efficiently
- Landscape approaches, which focus on the use of collaborative initiatives in farming
- Improved management of forests and grasslands, and the integration of trees into agricultural systems
- Reduced tillage and the use of a variety of breeds and varieties
- Restoration of degraded land
- Manure management, which may include the use of anaerobic bio-digesters.

A recent analysis of climate-smart agriculture on small-scale farms found the common barriers to be poor education, skills and knowledge; potentially high investment costs and delayed benefits; and uncertainty.

[2] Conventional pesticides are expensive for these farmers, who often do not have access to adequate protective clothing.
[3] Ecosystem services are the basic services that are provided by the natural environment that offer benefits to humans, such as pollination

The constraints and potential solutions have been summarised in the table below:

Major CSA Practices	Adopting Factors/Constraints	Potential Solutions
Water management, including irrigation	awareness, experience/skills, information, high costs-access to finance, labor-intensity	education, extension services, farmer friendly incentives, microfinancing, sorjan method
improved, more tolerant varieties	awareness, experience/skills, information, input accessibility	education, extension services, secured inputs, knowledge sharing
conservation agriculture	awareness, experience/skills, information, high costs-access to finance	education, extension services, policy incentives, farmer friendly incentives, microfinancing
integrated/mixed farming (e.g., crops-livestock)	awareness, experience/skills, information,	education, extension services, knowledge sharing
agroforestry	awareness, experience/skills, information,	education, extension services, policy incentives
crop rotation and diversification	experience/skills, information	education, extension services, knowledge sharing
climate information services	poor Internet, awareness and climate change perception	access to weather forecasts, knowledge sharing

Source: Climate-Smart Agriculture on Small-Scale Farms: A Systematic Literature Review

This analysis highlights that knowledge sharing and education, among other factors, are key to realising climate-smart agriculture. Solutions also need to consider that the benefits and costs of agricultural transitions differ in different social groups and contexts.

An analysis by McKinsey identified the approaches that could be taken by government, development partners and the private sector to encourage the adoption of climate-smart agricultural measures for smallholder farmers. Among other things, it recommended the following:

- Provision of opportunities for land-use optimisation linked to financing and incentive mechanisms
- Redesign of subsidies and tax incentives for the adoption of adaptation and mitigation measures
- Design of agricultural lending products that are are linked to the adoption of adaptation and mitigation measures
- Investment in infrastructure to reduce postharvest losses and investment to make infrastructure more resilient (such as flood protection)
- Improvement of traceability and sustainability certifications for applicable crops
- Launch of a results-based payment scheme tied to specific goals
- Scaling of investment in research and development of technologies for mitigation and adaptation, such as pest-resistant seeds, biostimulants and livestock breeds.

The World Bank Group is supporting the development of climate-smart agriculture and is committed to working with countries to increase productivity, improve resilience and reduce agricultural emissions. It has developed more than 10 Climate Smart Agriculture

Investment Plans, offering financing of over USD 2.5 billion for climate-smart agriculture projects that are aligned with its objectives. Two examples include:

- Investment of USD 50 million in a Livestock and Dairy Development Project in Bangladesh
- Supporting the design of the USD 50 million second phase of the Smallholder Agricultural Development Project in Lesotho through identifying potential climate change challenges and solutions.

Various green bonds have also been developed to support climate-smart agriculture in the Global South. For instance:

- Bank Windhoek has issued green bonds for climate-smart agriculture in Namibia
- The Nigerian sovereign bond includes investments in sustainable agriculture and climate-smart farming
- The Trust Funds for Agricultural Development (FIRA) supports water efficiency and protected greenhouses in Mexico
- The Sovereign Bond Issuance in Egypt supports the development of crop species that are resilient to salinity and temperature increase.

The CGIAR, a global partnership linking international organisations concerned with food security, aims to improve the resilience of small-scale farmers to climate shocks through providing climate adaptation solutions through national innovation schemes. Examples include 'climate-smart villages', which identifies villages or regions that are likely to be badly affected by climate change and then connects community representatives and researchers to work together to identify climate-smart solutions.

The African Development Bank Group and the International Fund for Agricultural Development (IFAD) have launched the 'Mission 1 for 200' initiative, which aims to "double agricultural productivity through the use of state-of-the-art, climate-smart technology and advice" and "build resilience by helping food systems and farmers adapt to climate change and reducing agriculture's environmental impact and emissions".

Organic farming

The aim of organic farming is "to create integrated, humane, environmentally and economically sustainable production systems, which maximize reliance on farm-derived renewable resources and the management of ecological and biological processes and interactions, so as to provide acceptable levels of crop, livestock and human nutrition, protection from pests and disease, and an appropriate return to the human and other resources". Increasing awareness of the negative impacts on inputs, such as pesticides, on human health and the environment has spurred public interest in organic products. It is suggested that organic agriculture has room to expand globally, and given its various sustainability benefits over conventional farming, such as improved soil and food quality, greater biodiversity, less pollution and greater social benefits, it could contribute greatly to feeding the world.

Organic farming systems can promote food security by using minimal external inputs and promoting environmentally-friendly techniques. They are characterised by the following five features:

- Respect for the environment and animals, such as through reduced pesticide pollution and lower nitrate leaching

- Promotion of sustainable cropping methods, such as crop rotation and legume intercropping, as well as the promotion of crop and livestock diversity
- Use of non-chemical fertilisers and pest/disease/weed control means, such as green fertilisers, compost and animal manures, natural pest control and no prophylactic antibiotics
- Production of high-quality foodstuffs, such as those with no pesticide residue
- Zero use of genetically modified crops.

There are various advantages of organic farming for small-scale producers, including:

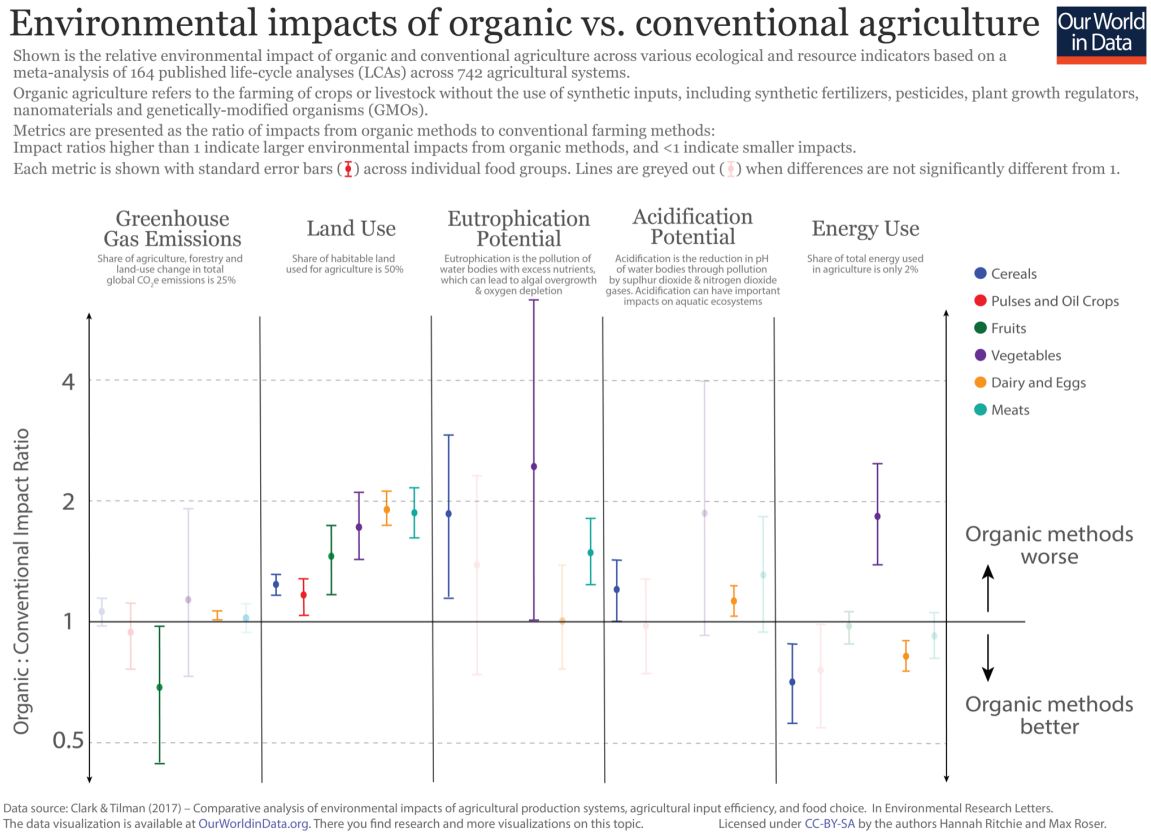
- Increased social capital through higher bargaining power and improved access to credit and markets
- Saving money due to lower costs of inputs and energy, including potential savings from the use of non-fossil energy
- Increased income through the sale of certified organic products at premium prices (10%–300% higher than conventional products)
- Increased social interactions between farmers and consumers, greater employment of farmworkers and cooperation among farmers

Some disadvantages include:

- Yields are approximately 25% lower than yields from conventional farms[4]
- It may not be possible to produce sufficient compost and green manures in certain regions due to landscape constraints
- The average return on investment for farmers is around five years
- Achieving organic certification requires around three years, and during this time farmers will need to produce organic products but will not be able to sell their products at premium and will also need to endure reduced yields at the same time
- Higher labour costs[5]
- Challenges with soil nutrient management.

Compared to intensively-managed agriculture, organic farming tends to improve species richness and abundance, although there may not be a major difference between organic farms and small-scale farms made up of different agricultural fields and species. Organic farming has been found to have higher soil carbon levels, better soil quality and less soil erosion than conventional farms. Organic farming, on average, has a lower climate impact than conventional farming, whether considering the carbon footprint per land unit (43% fewer greenhouse gas emissions) or the carbon footprint per product unit (12% fewer greenhouse gas emissions). However, there are some examples of where organic farming performs less well than conventional farming:

[4] Despite the lower yields, the economic profitability is around 22%–35% higher than conventional agriculture.
[5] In certain regions, this could be viewed as an advantage, such as by promoting rural employment.



Source: Our World in Data

As the chart above shows, while organic farming mostly performs better in certain impacts, such as greenhouse gas emissions, it performs less well in others, such as land use. For some impacts, the effects might be mixed – for example, energy use for producing vegetables in organic farming is higher because of certain alternative pesticides that may be used. The eutrophication (enriching a body of water with minerals and nutrients) potential in organic farming is high due to differences in the nutrient release of synthetic fertilisers versus manures.

Regenerative agriculture

Regenerative agriculture has been broadly defined as "a system of farming principles and practices that increases biodiversity, enriches soils, improves watersheds and enhances ecosystem services". It strongly emphasises the improvement of soil health and the restoration of degraded soils, which in turn enhances the quality of water and vegetation, improves land productivity and restores the carbon content of the soil. Another core feature of regenerative agriculture is the reversal of biodiversity loss.

A wide variety of practices may be promoted under regenerative agriculture, as summarised in the table below:

Principles	Practices	Restoration of soil health	Reversal of biodiversity loss
Minimize tillage	Zero-till, reduced tillage, conservation agriculture, controlled traffic	***	–
Maintain soil cover	Mulch, cover crops, permaculture	***	*
Build soil C	Biochar, compost, green manures, animal manures	***	–
Sequester carbon	Agroforestry, silvopasture, tree crops	***	**
Relying more on biological nutrient cycles	Animal manures, compost, compost tea, green manures and cover crops, maintain living roots in soil, inoculation of soils and composts, reduce reliance on mineral fertilizers, organic agriculture, permaculture	***	–
Foster plant diversity	Diverse crop rotations, multi-species cover crops, agroforestry	**	***
Integrate livestock	Rotational grazing, holistic [Savory] grazing, pasture cropping, silvopasture	**	?
Avoid pesticides	Diverse crop rotations, multi-species cover crops, agroforestry	*	***
Encouraging water percolation	Biochar, compost, green manures, animal manures, holistic [Savory] grazing	***	–

Source: Regenerative Agriculture: An agronomic perspective

In terms of financing, in Brazil Rizoma-Agro has issued green bonds for regenerative agriculture, while Biotrop has issued green bonds worth BRL 100 million for regenerative agriculture. PepsiCo has issued a 10-year USD 1.25 billion green bond focused on investments into environmental sustainability, including regenerative agriculture.

Agroecology

Agroecology is "the integrative study of the ecology of the entire food system, encompassing ecological, economic and social dimensions". It offers a framework for supporting sustainable agriculture and food systems that is focused on three aspects:

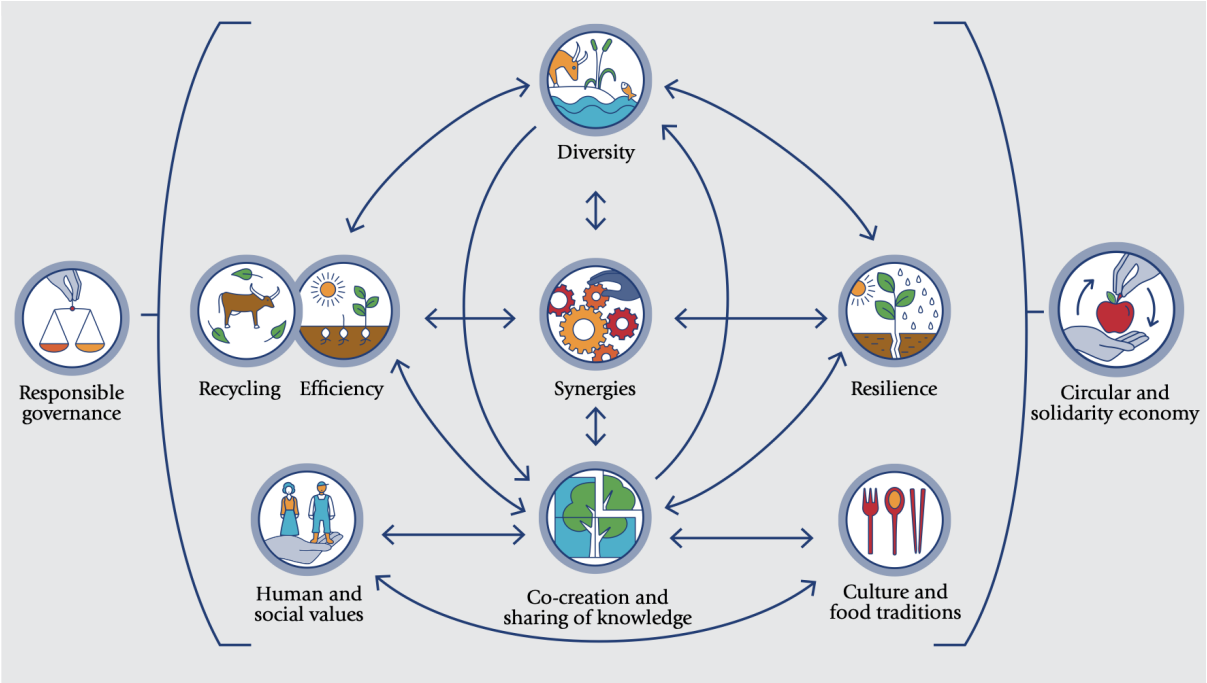
- The **scientific aspect**, which uses modern ecological knowledge to design and manage sustainable farming ecosystems
- The **practical aspect**, which values the local, empirical and indigenous knowledge of farmers to develop innovative and effective farming practices
- The **social change aspect**, which advocates for changes to the food system that ensure food security for all.

Rather than altering the practices of existing unsustainable agricultural systems, agroecology requires the complete transformation of food and agricultural systems. The way in which agroecological principles are applied will depend on the local context.

The 10 Elements of Agroecology, which is a framework that was developed by the FAO and multiple stakeholders, offers a guideline:

- Diversification is key to agroecological transitions to ensure food security and nutrition while conserving, protecting and enhancing natural resources
- Agricultural innovations respond better to local challenges when they are co-created through participatory processes
- Building synergies enhances key functions across food systems, supporting production and multiple ecosystem services
- Innovative agroecological practices produce more using less external resources
- More recycling means agricultural production with lower economic and environmental costs
- Enhanced resilience of people, communities and ecosystems is key to sustainable food and agricultural systems

- Protecting and improving rural livelihoods, equity and social well-being is essential for sustainable food and agricultural systems
- By supporting healthy, diversified and culturally appropriate diets, agroecology contributes to food security and nutrition while maintaining the health of ecosystems
- Sustainable food and agriculture requires responsible and effective governance mechanisms at different scales, from local to national to global
- Circular and solidarity economies that reconnect producers and consumers provide innovative solutions for living within our planetary boundaries while ensuring the social foundation for inclusive and sustainable development.



Source: International Fund for Agricultural Development

For a project to be considered agroecological, it should be:[6]

- Increasing resource use efficiency while reducing and/or substituting external inputs
- Recycling water, nutrients, biomass and/or energy
- Diversifying and integrating different farming sectors (various crops and/or animals)
- Facilitating efficiency and recycling, spreading risks, increasing resilience and producing a greater variety of nutritious food.

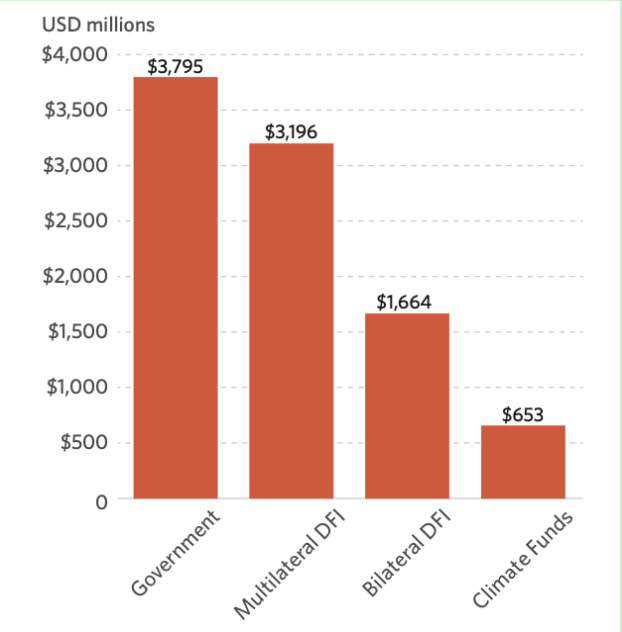
The Scaling-up Agroecology Initiative is a UN-led platform that aims to support national agroecology processes through policy and technical capacity. The International Fund for Agricultural Development (IFAD) supports the initiative, and of the 207 IFAD-supported projects completed between 2018-2023, around 60% are implementing agroecological principles. The total investment in all IFAD projects in these years was USD 8.25 billion, though more financing was allocated to non-agroecological farming projects. Financing from the Adaptation for Smallholder Agriculture Programme (ASAP) and the Global Environment Facility (GEF) has been key in providing access to funds for agroecological

[6] This is according to the International Fund for Agricultural Development Agroecology Framework

practices - around 87% of projects with ASAP financing and 90% of projects with GEF financing entirely or partially promote agroecology. While the public sector is the primary financing source for both agroecological and non-agroecological IFAD, ASAP and GEF-supported projects, the private sector has played very little role in this financing, highlighting a key financing source to be developed.

Finance for small-scale farms in the Global South

IFAD is a UN-linked international financial institution focused on small-scale agriculture and supporting farmers through projects that provide small-scale farmers with access to finance, markets and technology, including via grants and low-interest loans. Together with finance and policy advisory organisation the Climate Policy Initiative (CPI), it released a report on the climate finance gap for small-scale farming. Climate finance is aimed at "reducing emissions and enhancing sinks of greenhouse gasses, and aims at reducing vulnerability and maintaining and increasing the resilience of human and ecological systems to negative climate change impacts". The report found that 95% of climate finance for small-scale agriculture comes from the public sector, including from government donors, multilateral and bilateral development finance institutions (see the chart below).



Source: International Fund for Agricultural Development

The financial instruments used by the public sector mostly include grants (50%), followed by concessional (low cost) debt (33%) and non-concessional debt (16%). Of these grants, the majority (80%) were provided by governments, while concessional debt was largely issued by multilateral and bilateral development finance institutions. Multilateral development banks also provided the majority of the non-concessional debt.

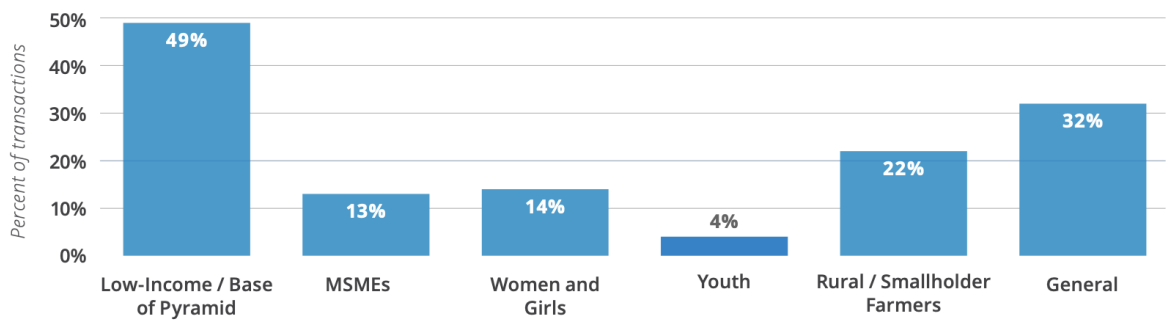
There are various impact-oriented funds aimed at small-scale agriculture, including:

- The Land Degradation Neutrality (LND) Fund, which is an "an impact investment fund blending resources from the public, private and philanthropic sectors to support achieving LDN through sustainable land management and land restoration projects implemented by the private sector".

- The Meloy Fund, which is an "impact investment fund focused on proving the triple bottom line viability of investing in fishing and seafood-related enterprises that will lead to better management and protection of these formerly under-appreciated and undervalued natural assets".
- &Green, which aims to "finance the delinking of major commodity supply chains from deforestation in a way that is commercially viable and replicable" through offering "innovative financial instruments that take away part of the risks of investing".
- Root Capital, which "provides credit and capacity building to small and growing agricultural businesses around the globe".

Blended finance, which is "the strategic use of development finance and philanthropic funds to mobilise private capital flows to emerging and frontier markets", is viewed as a finance solution for climate resilient and sustainable agriculture. Blended finance helps reduce both real and perceived risks in an investment, thereby facilitating private capital investment. Between 2014-2019, around 22% of blended finance transactions globally went to rural and smallholder farmers (see the chart below). The median transaction size for smallholder farmers during this period was USD 35 million, though the scale of these transactions has increased in recent years.

FIGURE 13 END BENEFICIARIES OF BLENDED FINANCE TRANSACTIONS (2014-2019)



Source: Convergence

Blended finance is helping small-scale farmers through market initiatives such as Aceli Africa, which is supporting loans to agricultural small and medium sized enterprises in Africa. For instance, Aceli's financial incentives helped Tanzania Commercial Bank provide loans for business to purchase cassava from smallholder farmers. Another example is the African Agricultural Capital Fund, which has made investments ranging from USD 250,000 to USD 2.5 million in small and medium sized agricultural businesses in Africa.

The Commission on Sustainable Agriculture Intensification (CoSAI) commissioned a report that found that around USD 60 billion was spent each year on agricultural innovation in the Global South between 2010-2019, of which 60%-70% came from national governments, 20%-25% from the private sector (mostly related to the research and development and marketing of new products related to mechanisation, crop protection, and seed development and biotechnology), and 10%-20% from development partners, including institutional investors, bilateral and multilateral agencies, and international philanthropies.[7] Of this funding, less than 7% was directed at sustainable intensification specifically.

[7] Examples of innovation funding in the report included research into new seed varieties, training on new agroforestry practices, the adoption of agricultural policies such as fertiliser subsidy reforms, digital marketplaces for agricultural sales and purchases, and the maintenance and management of research institutes or infrastructure, such as the modernisation of slaughterhouses.