Agroecology

What it is and what it has to offer

Laura Silici

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About the authors

Laura Silici, Researcher, IIED Natural Resources Group, Agroecology team
laura.silici@iied.org

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International Institute for Environment and Development
80-86 Gray's Inn Road, London WC1X 8NH, UK
Tel: +44 (0)20 3463 7399
Fax: +44 (0)20 3514 9055
email: info@iied.org
www.iied.org

@iied
www.facebook.com/theIIED

In a context of a changing climate and growing concerns for more healthy food systems, agroecology is gaining momentum as a scientific discipline, sustainable farming approach and social movement. There is growing anecdotal and case study evidence of its multiple benefits, from climate resilience to farm productivity. Yet its promotion in public agricultural policies, research and extension is still limited.

This paper explores why this is. It calls for consolidating the evidence base for agroecology through multi-dimensional tools that not only measure yields, but also its many other benefits: economic, environmental and social. Mainstreaming agroecology will require a fundamental cultural and philosophical shift in how we as a society define 'productive' and 'efficient' agriculture.

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Summary

Agroecological farming is coming of age. Once the exclusive domain of food sovereignty and ecology movements, it has begun to be promoted enthusiastically in both developed and developing countries by non-government organisations, international development organisations and others seeking more sustainable food production and consumption systems. Though difficult to quantify, a growing body of anecdotal evidence and small-scale studies highlights the environmental and social benefits that these practices can bring. For example, a review of 40 initiatives employing different agroecological practices showed an average crop yield increase of 113%, in addition to environmental benefits such as carbon sequestration, reduction in pesticide use and soil restoration.[1] Yet despite the fact that agroecological practices can bring resilience and broad-based productivity to rural communities and provide important ecosystem services across the landscape, they are still not being widely promoted in agricultural policies or by agricultural research organisations in developed nor developing countries, nor scaled-up at a significant level. This paper asks why, tracing the multiple interpretations of agroecology: what it means to different people and how it is used. It lists the benefits and challenges of agroecological practices and how they compare with input-intensive, large-scale farming. Finally, it asks what more needs to be done to mainstream agroecology more widely in agricultural policies and practices?

What is agroecology?

Agroecology – 'the application of ecological concepts and principles to the design and management of sustainable agro-ecosystems'[2] – has three facets. It is:

1. a scientific discipline involving the holistic study of agro-ecosystems, including human and environmental elements
2. a set of principles and practices to enhance the resilience and ecological, socio-economic and cultural sustainability of farming systems
3. a movement seeking a new way of considering agriculture and its relationships with society.

What can agroecology offer?

A growing body of evidence reveals agroecology's multiple advantages over conventional high-external input farming:

- a multi-functional approach to farming, capable of meeting environmental, economic and social needs
- greater environmental sustainability and resilience, especially in marginal areas subject to environmental degradation and extreme climatic events, and higher agrobiodiversity
- the ability to support farmers' food sovereignty, reducing their dependence on costly and sometimes difficult-to-access chemical inputs
- higher overall productivity (at farm rather than crop level) achieved through a diverse range of agricultural products and environmental services, which reduce risks of crop failure in the long term.

What are the barriers to agroecological practicesbecoming more widespread?

- Agroecology is knowledge- and management-intensive. A common deterrent to its adoption is the large amount of 'soft' inputs (such as knowledge and skills) and labour that some practices require in the initial seasons. Poorer and more marginal farmers, in particular, may decide not to adopt these practices if they do not have enough time and resources to invest in learning and experimentation.
- Policies and market signals are stacked against agroecology. The prices of conventional agricultural products are distorted by heavy subsidies – both direct (such as farm and input subsides) and indirect (the health and environmental consequences of unsustainable practices that are paid for by taxpayers).
- Insecure land tenure and lack of access to natural resources can also inhibit the spread of agroecology by discouraging farmers from adopting practices that require long-term investment in land and other assets.

- Agroecology is viewed as 'alternative' and sometimes in direct opposition to conventional farming. Yet the differences are often blurred. Emphasising the two approaches as mutually-exclusive may undermine the constructive search for more common ground.

What needs to be done?

- Consolidate the evidence base to support agroecology through multi-dimensional analyses that provide comparable measures not just of crop yields, but also non-commodity outputs, such as feed available for livestock, mulching crops, provision of ecosystem services and contributions to the incomes and resilience of farming households.
- Promote a fundamental cultural and philosophical shift in the evaluation of what is regarded as 'productive' and 'efficient', not just by farmers, but by society as a whole. The emphasis should be on optimising rather than maximising production (and profits). This is probably the most challenging step required to mainstream agroecological principles into agricultural policies and practices.
- Assess the constraints to the adoption of agroecological practices and the policy options to overcome them. These may include innovative tools and approaches such as participatory innovation systems, economic incentives for early adopters, payments for environmental services and rewards for landscape conservation. Relevant policy changes may also concern land tenure, natural resources management as well as support to farmer organisations, local business development and markets for agroecological products.
- Reduce the polarisation between agroecology and external input-intensive agriculture. Encouraging the adoption of aspects of agroecology by the latter could help reduce the negative environmental and social impacts of this production model, and the first step towards greater sustainability. On the other hand, selected 'modern' technologies such as precision farming and new breeding techniques can help agroecological farmers to respond to new challenges posed by the changing climate, water stress, land degradation and fast cultural and socio-economic transformations.

What is agroecology?

The concept of agroecology has evolved as a scientific discipline, a set of practices and a social movement. As a science, it studies how different components of the agro-ecosystem interact. As a set of practices, it seeks sustainable farming systems that optimise and stabilise yields. As a movement, it pursues food sovereignty and new, multifunctional roles for agriculture.

1

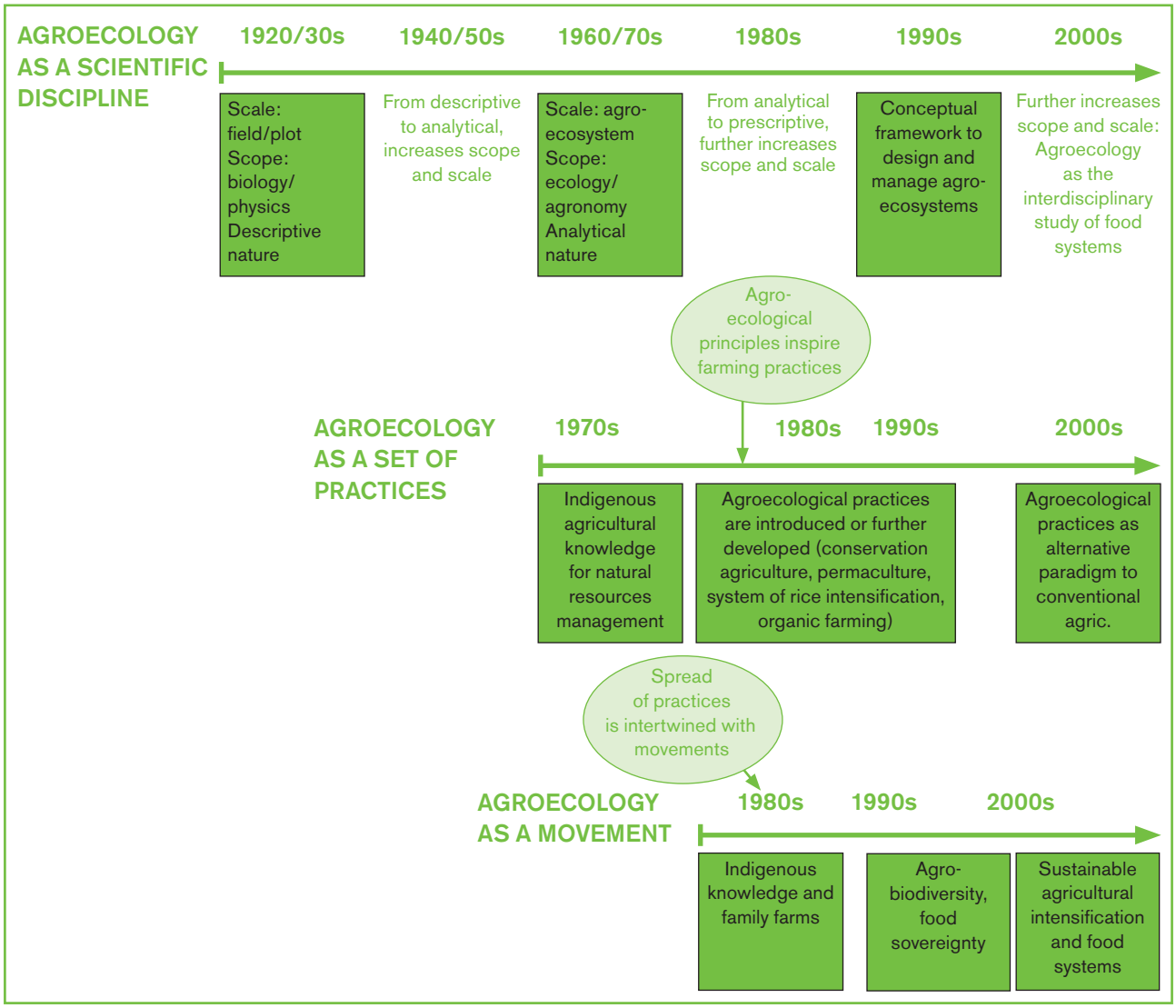
The most commonly used definition of agroecology is 'the application of ecological concepts and principles to the design and management of *sustainable agro-ecosystems*'.[3] This definition best illustrates the concept of agroecology today: it captures its evolution both as a conceptual framework based on a set of principles *and* as a range of practices that can be used in different combinations to enhance the resilience and sustainability of farming systems.

The term agroecology first appeared in the scientific literature in the 1930s, when it referred primarily to the scientific study of the biological interactions between single crops and different components of the agro-ecosystem. Since the 1960s, however, the science of agroecology has progressively widened its scale of analysis (from the plot or farm level to the whole agro-ecosystem and to the wider food system) and scope (from ecological and agronomic analysis to an inter-disciplinary approach including socio-economic and political considerations). Since the 1980s, it has provided a conceptual framework for the increasing promotion of agroecological practices both in developed and developing countries, especially in Central and South America. These practices in turn have inspired a number of agroecological movements that emerged and consolidated during the 1990s. The evolution of agroecology as a scientific discipline, practice and movement is charted in Figure 1.

A science

The first agroecological studies (between the 1930s and 1960s) were rooted in the biological sciences – zoology, agronomy and crop physiology – and sought to observe the biological interactions between elements of the ecosystem and agriculture as part of agronomic research. During the 1960s and 1970s, thanks to the emergence of ecologist movements – and partially in response to the negative impacts of the Green Revolution – the ecological analysis of agriculture within the agro-ecosystem[4] gained momentum.[5]

Figure 1: Agroecology: An evolving concept



BOX 1: THE CORE PRINCIPLES OF AGROECOLOGY[8]

Planning:

- Use a holistic approach to the identification, the analysis and the resolution of issues related to farming – the agro-ecosystem is regarded as *ONE* and its health as a whole is valued more than the productivity of single crops.
- Harmonise the farming system with the productive potential and the physical limits of the surrounding landscape.

Resource use:

- Recycle and optimise the use of nutrients and energy on the farm. In particular:
  - Enhance the recycling of biomass, with a view to optimising organic matter decomposition and nutrient cycling over time.
  - Minimise losses of energy, water, nutrients and genetic resources by enhancing the conservation and regeneration of soil and water resources and of agro-biodiversity.
  - Avoid the unnecessary use of agrochemical and other technologies that adversely affect the environment and human health.
  - Minimise the use of external, non-renewable resources (including fossil fuels).

Field and landscape management:

- Enhance beneficial biological interactions and synergies among the components of agro-biodiversity, thereby promoting key ecological processes and services, rather than focusing on individual species.
- Diversify species and genetic resources in the agro-ecosystem (i.e. at field and landscape level) over time.
- Strengthen the 'immune system' of agricultural systems by enhancing functional biodiversity (natural enemies, antagonists, etc.); pests and diseases should be managed and prevented rather than controlled.
- Use local crop varieties and livestock breeds so as to enhance genetic diversity and adaptation to changing biotic and environmental conditions.
- Provide the most favourable soil conditions for plant growth, particularly by managing organic matter and by enhancing soil biological activity.

From the end of the 1970s and throughout the 1980s, the agroecology workstream began to be strongly influenced by a social component in the agronomic literature and by the new interest in traditional farming systems as important natural resource management systems. 'By the 1990s, agroecology had emerged as a scientific discipline with a conceptual framework and defined methodology for the holistic study of agro-ecosystems, including human and environmental elements'.[6] According to this holistic view, an area used for agricultural production is seen as a complex system in which ecological processes occur along with human activities (economic but also social and cultural activities): agroecology focuses on the dynamics of their interrelationships.[7] As a result of this new approach, the 'ecological foundations of agriculture' – a series of principles that help achieve environmental sustainability and environmental services from agriculture – emerged and were consolidated. These principles – summarised in Box 1 – constitute the foundations of the conceptual framework that inspires agroecological farming today.

Agroecology as a scientific discipline studies the interactions between the ecosystem and a set of human activities without necessarily judging the resulting outcomes according to their degree of sustainability. Nonetheless, the 'ecological foundations of agriculture' and the agroecological principles listed in Box 1 go beyond the neutrality of a scientific discipline to provide a practical analytical framework to assess what biological and ecological phenomena can be used or strengthened in order to produce an agro-ecosystem that is environmentally more sustainable.

In recent years, agroecology as a scientific discipline has evolved from being a subcomponent of agronomic research to a science in its own right, focused on environmental sustainability. It has broadened its scope to include the whole food system and has become more interdisciplinary in the process.[9] Along the way, the science has become progressively less 'neutral' and agroecology has metamorphosed into a collective term for a more 'virtuous' sustainable food production and consumption approach, in contrast with food systems that are increasingly perceived as unsustainable. Indeed, agroecological farming can contribute to sustainable food systems both directly (by enhancing the sustainability and the resilience of agricultural production) and indirectly (encouraging the reduction and recycling of food waste and the re-localisation of food production and consumption).[10] However, this comprehensive definition is not widely accepted. Some

practitioners prefer a more restricted definition because of the particular evolution of the concept in their country or in their specific field of expertise. Others question the assumptions and the methodological implications of an overly broad approach, given that we lack commonly agreed operational tools and analysis models that can combine the many dimensions covered by such a multi-disciplinary approach.[11]

An overly broad definition of agroecology could also expose the concept to multiple interpretations, with the subsequent risk that the term is misused in order to pursue specific interests not necessarily coherent with the principles and the original purposes of the discipline. For instance, in 2010 the fast food corporation McDonald's launched an 'agroecology strategy' to reduce its environmental footprint in France and promoted it as extremely ambitious. However, the report does not explicitly define agroecology and includes only a few – and often vague – examples of 'agroecological practices'. These include precision farming, testing and mixing new crop varieties, the rational use of synthetic fertiliser and crop protection products, farmer training, innovative irrigation systems, and developing mathematical models to predict pest trends.[12] These practices can all potentially reduce the environmental impacts of agricultural production, but they have little to do with the complex management of biological interactions evoked by agroecological principles. The lack of a commonly agreed definition of agroecology may have allowed the corporation to misinterpret or interpret very broadly the concept, with the intention of gaining good publicity from an increasingly popular term.

A set of practices

While recognising that agroecology as an alternative agriculture production paradigm is an important component of sustainable food systems, most advocates continue to maintain a narrower focus on the production benefits of agroecology, treating food systems and policy issues separately.[13]

Since the 1980s, in fact, the scientific discipline has become progressively more prescriptive and practically-oriented. 'Implicit in agroecological research is [now] the idea that, by understanding […] ecological relationships and processes, agro-ecosystems can be manipulated to improve production and to produce more sustainably, with fewer external inputs and lower negative environmental or social costs'.[14] Agroecological practices thus aim to enhance farming systems by mimicking natural processes and by emphasising the multifunctional role of agriculture. They are highly knowledge-intensive, based on the conceptual framework developed by the scientific discipline while also increasingly drawing on farmers' own knowledge and experimentation.[15]

Generally speaking, agroecological practices consist of farming approaches that are inspired by some or all the principles outlined in Box 1: The core principles of agroecology8, and have the immediate objectives of:

- building soil structure, improving soil health, recycling nutrients and ensuring local sourcing
- conserving and using water efficiently
- sustaining and improving functional diversity (both on a spatial and a temporal scale).

Box 2 illustrates some farming methods that fall under the definition of agroecological practices. Most of these methods pre-date the development of agroecology as a concept – in fact they are part of most traditional farming systems. What 'agroecology' as a science and movement has done is to provide a coherent framework that conceptualises the effects of these practices (and their mutual reinforcement).

Agroecological farming is based on homeostasis, self-regulation and biodiversity. As such, it differs substantially from the paradigm of industrial agricultural production: artificial control of natural processes, extensive use of synthetic inputs and genetic uniformity.[17] Agroecology shows greater resilience and environmental sustainability because of its complexity, diversity and adaptive capacity and because it does not deplete the natural resource base. Other important environmental features include the recycling and replenishing of inputs, the emphasis on multi-functional agriculture and the capability to mitigate climate change – as opposed to waste and depletion of natural resources, profit-only oriented models, pollution and greenhouse gas (GHG) emissions. Table 1 compares agroecological and high-external input production systems in relation to environmental sustainability and resilience.

The practices listed in Box 2 can be used in different combinations; farmers may apply only a few or else may adopt them all. For example, farming methods such as permaculture or biodynamic agriculture largely apply all the agroecological principles; others – such as the system of rice intensification (Box 3), organic and conservation farming – may apply some but not all the agroecological principles (e.g. conservation farmers may use chemical herbicides, but in no-till fields). In some cases, the same farmer may choose to use different farming methods in different plots (e.g. high external input agriculture for commercial crops and agroecological practices for food crops) or to apply individual agroecological practices along more conventional lines. For example, integrated pest management (see Box 2) might be used in monocultures, or integrated soil fertility management might be combined with reduced amounts of inorganic fertiliser. Agroecological practices tend thus to be considered as a sort of toolkit from which farmers

BOX 2: EXAMPLES OF AGROECOLOGICAL PRACTICES[16]

Conservation tillage: no or minimum tillage improves soil structure – including aeration and water infiltration and retention capacity – and organic matter

Mixing crops in a single plot, such as intercropping and poly-cultures: biological complementarities improve nutrient and input efficiency, use of space and pest regulation, thus enhancing crop yield stability

Crop rotation and fallowing: nutrients are conserved from one season to the next, and the life cycles of insect pests, diseases, and weeds are interrupted

Cover crops and mulching: reduce erosion, provide nutrients to the soil and enhance biological control of pests

Crop-livestock integration, including aquaculture: allows high biomass output and optimal nutrient recycling, beyond economic diversification

Integrated nutrient management, such as use of compost, organic manure and nitrogen-fixing crops: allows the reduction or elimination of the use of chemical fertilisers

Biological management of pests, diseases and weeds, such as integrated pest management, push and pull methods and allelopathy: decrease long-term incidence of pests and reduce environmental and health hazards caused by the use of chemical control

Efficient water harvesting (especially in dryland areas) such as small-scale irrigation allows to reduce the need for irrigation while increasing its efficiency

Manipulation of vegetation structure and plant associations: improves efficiency of water use as well as promoting biodiversity

Agro-forestry, especially the use of multifunctional trees: maintains and improves soil fertility through nitrogen fixation, enhances soil structure and modifies the microclimate

Use of local resources and renewable energy sources, composting and waste recycling: allows a reduction in the use of external inputs as well diminishing pressure on the natural resource base

Holistic landscape management: around field perimeters (windbreaks, shelterbelts, insect strips and living fences), across multiple fields (mosaics of crop types and land-use practices) and at the landscape-to-regional scale (river buffers, woodlots, pastures and natural or semi-natural areas)

can choose, depending on their environment, socio-economic conditions and cultural preferences.

A movement

Since the 1990s, the term agroecology has been used by some to explicitly describe a movement and to express a new way of considering agriculture and its relationships with society. Ecologists, agronomists and ethno-botanists started to support indigenous farming practices and agroecological principles in an attempt to overcome the socio-economic and environmental costs of capital-intensive, large-scale agriculture and to pursue alternative agricultural production models. Agroecological practices became the practical basis for different agroecological movements, many of which were created with the main purpose of introducing and up-scaling specific technologies or sets of practices.

In industrialised countries, agroecological movements usually take the form of farmers' groups that seek to better respond to ecological and environmental challenges through social partnerships. This is the case for soil conservation associations in the USA or permaculture and organic movements in Europe. Often these movements respond to shifts in consumer behaviour, with an increasing demand for 'organic' and 'local' food by a growing segment of the population. In developing countries, agroecological movements have been traditionally concerned with rural development and food security. Examples include the *Asociacion Nacional de Agricultores Pequenos* in Cuba or the *Campesino a Campesino* (farmer-to-farmer) movement in Latin America. Several NGOs and church-based groups have also promoted agroecology as a component of rural development projects. Specific sets of agroecological practices have been promoted through inter-organisation collaboration, such as the Farmer Field Schools led by the United Nations Food and Agriculture Organization (FAO) in collaboration with local NGOs and farmers' groups.

Agroecological movements in developing countries have become progressively more concerned with food sovereignty,[18] advocating 'for a more radical transformation of agriculture, one guided by the notion that ecological change in agriculture cannot be promoted without comparable changes in the social,

Table 1: Agroecological versus high external input agriculture

Agroecological farming systems are more resilient to climate change, resistant to pests and adaptive to changing conditions in the short and long term because they rely on:	High external input agriculture is vulnerable to climate change, vulnerable to pest outbreaks and poorly adapted to changing conditions because it relies on:
• Homeostasis and self-regulation • Adaptive models, complex systems and local specificity • Functional use of enhanced agro-biodiversity • Crop diversification and crop and livestock integration • Multi-functionality	• Artificial natural equilibria controlled by dosing external inputs • Lock-in models, uniformity and homogenisation • Genetic improvement and reductionism • Mono-cropping and intensive livestock rearing • Maximisation of profits based on production intensification
Agroecological farming systems are environmentally sustainable as they:	High external input agriculture is environmentally unsustainable as it:
• Mitigate climate change through carbon sequestration and by reducing GHG emissions • Recycle and replenish natural resource inputs, including water and soil organic matter • Minimise environmental impacts • Enhance agro-biodiversity and provide ecosystem services	• Contributes to GHG emissions (due to use of fossil fuels and nitrogen fertilisers, heavy mechanised tillage, intensive livestock production) • Wastes inputs and depletes the natural resource base, such as through soil erosion • Has serious environmental and health impacts due to the use of chemicals and fossil fuels • Reduces biodiversity and inhibits ecosystem services

political, cultural and economic arenas'.[19] Indeed, the agro-ecosystem is a semi-domesticated environment, where ecological functions coexist with human activities. If one accepts that sustainable agroecological systems encompass not only environmental, but also socio-economic sustainability, agroecological approaches should be concerned with issues such as equity, the preservation of indigenous knowledge, food sovereignty and the sustainability of local food systems.[20] Undeniably, indigenous knowledge provides the basis for many agroecological practices and the agroecological movement has been particularly strengthened by peasants' movements that integrate agroecology in their programmatic agenda on food sovereignty. Notable examples are *o Movimento dos Sem Terra* in Brazil, and *La Via Campesina*, the international peasant network of 164 organisations across 79 countries.

In the last few years, a number of reports released by influential international organisations such as the United Nations Environmental Programme (UNEP), the UN Conference on Trade and Development (UNCTAD) and the Consultative Group on International Agricultural Research (CGIAR), has further raised the public profile of agroecology as a holistic approach to the stewardship of rural landscapes. The underlying message of all these reports is that in order to preserve the ecological foundations of food security, a paradigm shift is needed towards multi-functional agriculture. Under this new paradigm, the 'non-commodity' outputs of agriculture – agro-biodiversity, healthy ecosystem services,[21] resilience to climate change, landscape amenities and cultural heritage, to name a few – are valued as much as the commodity outputs. The paradigm shift being evoked by these organisations is deeply concerned with the role of policy in shaping alternative, more sustainable food systems both at national and international levels. Agroecology is thus conceived as a means *to re-orient rather than to intensify* agricultural production.

What can agroecology offer?

Agroecological practices support food sovereignty by enabling farmers to boost and diversify their production, stabilise yields and decrease dependency on expensive and often hard-to-access inputs. The benefits of scaling up agroecology across the landscape include greater agro-biodiversity, lower environmental impact, improved landscape stewardship and increased climate resilience.

2

Since the mid-2000s, the number of scientific studies on agroecology has steadily increased: according to the bibliographic database Scopus, more than 780 journal articles related to agroecology were published between 2010 and the first half of 2014, compared to less than 300 published in the previous five years (from 2005 to 2009). Most of these articles take a scientific approach to analysing agronomic and ecological benefits of practices such as agro-forestry, integrated pest management, no-tillage, grassland management and other practices (such as those listed in Box 2). In addition to the academic literature, several international development organisations and scientific committees have recently released reports that demonstrate the benefits of agroecology. These include reports by the UN Secretary-General (2013), UNCTAD (2013), UNEP (2012), the UN Special Rapporteur on the Right to Food (2010), the scientific panel of the International Assessment of Agricultural Knowledge, Science and Technology for Development (2009), the International Food Security Network (2012) and the CGIAR (2013).[22]

Environmental sustainability, climate resilience and higher agro-biodiversity

The results of these studies show that agroecological farming systems are resilient to climatic changes, resistant to pests in the long term and adaptable to changing conditions. This is because they are often rooted in local traditional knowledge, crop and livestock diversification and a high degree of agro-biodiversity, which together reduce risk and provide options for future adaptation. Agroecological practices also offer several other environmental advantages, such as climate change mitigation (fewer greenhouse gas emissions due to greater carbon sequestration by the soil[23] and less reliance on fossil fuel-based inputs and machinery); the use of few or no polluting inputs; enhanced agro-biodiversity; and the provision of ecosystem services.

Significantly, these benefits are more evident in marginal environments and under adverse climatic conditions, where agroecological practices are often more productive than conventional farming. Several cases in the last two decades have been reported from Central America (Nicaragua, Honduras and Guatemala), Mexico (Chiapas) and Cuba in which farmers using more diversified farming systems suffered significant less damage after extreme climatic events than those with monocultures. The lower extent of land degradation and the higher agro-biodiversity on their fields helped them to minimise their crop losses and ensured greater resilience.[24] Case studies in Bolivia, Kenya and China also found that local crop diversity has been key in enabling farmers to adapt to worsening pests, drought and increased variability, and that farmers have reverted to planting diverse local crops to cope with climate change.[25]

Greater overall productivity, optimisation of yields and 'intensified sustainability'

Whereas the yields of individual crops in agroecological fields are not necessarily higher than those obtained through input-intensive farming, the total agricultural output is larger because farmers rely on a diversified pool of crops and livestock. In addition, greater resilience to extreme climatic events and resistance to pests and other environmental stresses make yields less volatile over time. Accounting for ecosystem service provision would increase the overall productivity of agroecological farming even further.

Agroecological approaches look at the entire agro-ecosystem and at the multiple relationships within it, rather than addressing each component separately as with most conventional agricultural research. Agroecological farmers thus pursue multi-functionality and yields that are optimised rather than maximised. Optimisation of the system is reached when farmers realise the greatest degree of 'agroecological integration', i.e. the extent to which agroecological principles are employed in the management of different resources.[26] Instead of focusing exclusively on crop yields, agroecological farmers thus measure productivity by looking at the degree of agro-biodiversity of the farming system as well as its capacity to provide ecosystem services. In Bourgeois' words, such approach seeks to achieve 'intensified sustainability' in agriculture, rather than 'sustainable intensification'.[27]

The efficiency in the use of inputs and other resources, along with a diversified pool of agricultural products and 'by-products' (such as animal feed), should in principle guarantee the financial viability of agroecological practices. However, this assumption is rarely verified by accurate comprehensive economic and financial analyses that take into account the returns to labour and other inputs, the opportunity costs of excluding alternative methods, the commercial viability of the amounts produced, and so on. Similarly, while the ecosystem services offered by agroecological farms surely represent a positive externality, there is still little agreement on how to evaluate them correctly – especially in view of creating markets for environmental services – and little understanding of how farmers internalise them in their own cost-benefit considerations. Exploring this area will require innovative investigation tools capable of bringing together environmental,

financial and economic considerations, as will be discussed further below.

Livelihoods and food sovereignty

Advocates of agroecology also highlight the potential positive impacts on farmers' livelihoods. As the former UN Special Rapporteur on the Right to Food – Olivier De Schutter – has often stressed, agroecology is 'a mode of agricultural development which shows strong conceptual connections with the right to food'. Agroecological practices in fact contribute to food security by encouraging diversity in production (and thereby in diet) and by enhancing crops' nutritional value.[28] But they also contribute to food sovereignty by placing the farmer and the household at the centre of decisions on food production, while at the same time avoiding dependence on external input and top-down technological transfers.[29] The reliance on self-produced and locally-sourced inputs (including seeds) also reduces farmers' dependency on expensive and often hard-to-access products, their vulnerability to price volatility and consequent risk of indebtedness.

One of the most important advantages of agroecology is indeed its multi-functionality. This enables farmers to achieve a range of different objectives that, according to the UN Secretary General, 'are necessary to enhance sustainable productivity in the medium- and long-run and address existing inequalities amongst farming households'.[30]

A flexible toolkit

While at a first glance the differences between conventional and agroecological farming are striking (see Table 1 above), in practice the boundaries are somewhat blurred. The degree to which agroecological methods are adopted can vary from one farmer to the next. While farmers practising permaculture or biodynamic agriculture largely apply agroecological principles and take a holistic approach to the agro-ecosystem, organic or no-till farmers may apply only some agroecological principles (Box 3). For instance, large industrial organic farms that rely on monocultures and do not recycle inputs and resources have only small positive impacts on agro-biodiversity and soil biota. Small-scale organic farmers who supply international value chains are as vulnerable as their 'conventional' peers because they depend on the purchase of inputs sold by 'approved' suppliers in order to adhere to certification standards and because they are subject to international price volatility.

On the other hand, many 'conventional' farms use some agroecological practices such as crop rotations, no or minimum-tillage, combinations of organic and inorganic nutrients, and a mix of fossil and renewable energy sources. In addition, precision farming techniques allow farmers to use chemical inputs more efficiently and to minimise the impacts of mechanical operations.[31]

Some advocates of agroecology see this blurring as a strength, because it allows farmers with different socio-economic conditions to access certain 'modern' technologies such as high-yielding crop varieties (HYVs). Some agriculture institutions, such as the CGIAR (formerly the Consultative Group on International Agricultural Research), FAO and the Montpellier Panel,[32] support this position. Others take a more radical view. Altieri and Nicholls, for instance, criticise those who 'have tried to co-opt agroecology by stating that it is an option that can be practiced along with other approaches such as transgenic crops, conservation farming, microdosing of fertilisers and herbicides, and integrated pest management', and conclude that 'in this way the term agroecology would be rendered meaningless'.[33]

Providing conclusive evidence to inform this debate is impossible. There are many competing visions on how to achieve new models of agriculture which are at the same time resilient, productive and resource-efficient. Agroecology provides a toolbox of practices; farmers can select those which are best adapted to their production system. The adoption of agroecological practices by large-scale, high-external input farmers is unlikely to reduce these farms' environmental impacts significantly, but would nevertheless represent a step towards greater sustainability.

BOX 3: A CONTINUUM OF AGROECOLOGICAL APPROACHES

Approaches that share all or most of the agroecological principles and incorporate many agroecological practices:

- Permaculture models self-maintained agricultural systems on natural ecosystems. The central concept of permaculture is maximising useful connections between components and synergy of the final design. The design principles are in turn derived from the science of systems ecology and study of pre-industrial examples of sustainable land use. (Sources: http://www.permaculture.org.uk/; http://en.wikipedia.org/wiki/Permaculture)
- Biodynamic agriculture is based on the 'holistic understanding of agricultural processes'. It treats soil fertility, plant growth and livestock care as ecologically interrelated tasks, emphasising spiritual and mystical perspectives. Biodynamic agricultural practices include: use of manures and composts instead of artificial chemicals; management of animals, crops, and soil as a single system; use of traditional and development of new local breeds and varieties; the use of an astrological sowing and planting calendar. (Source: http://en.wikipedia.org/wiki/Biodynamic_agriculture)

Approaches that share the agroecological principles but incorporate only some agroecological practices:

- Conservation agriculture (CA) can be defined as 'a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment'. CA is founded on three interrelated principles: (1) minimum mechanical soil disturbance; (2) soil protection through permanent organic soil cover and (3) crop rotation and intercropping. While farmers are encouraged to apply all three principles, this may not always be the case. Minimum and no-tillage and intercropping can be practised on a very large scale under highly mechanised systems that use chemical inputs. However conservation practices such as planting pits can also be tailored for small-scale, resource poor farmers. (Source: http://www.fao.org/ag/ca/)
- Organic farming has been defined as 'a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved'. Certified organic agriculture is regulated by bodies that specify which practices, methods of pest control, soil amendments and so forth are permissible if products are to achieve organic certification. Source: http://www.ifoam.org/growing_organic/definitions/doa/index.html
- The System of Rice Intensification (SRI) is a methodology for increasing the productivity of rice and, more recently, other crops by changing the management of plants, soil, water and nutrients. The SRI methodology is based on four main principles that interact with each other: (1) early plant establishment, (2) reduced plant density, (3) soil enrichment with organic matter and (4) reduced and controlled water application. Farmers can adapt recommended SRI practices to respond to different agroecological and socio-economic conditions (including changing weather patterns, soil conditions, labour availability, water control, etc.) and depending on whether they decide to practise fully organic agriculture or not. Source: http://sri.ciifad.cornell.edu/aboutsri/methods/index.html

How can agroecological practices be more widely adopted?

In order to mainstream agroecology, we must first understand the diverse factors influencing farmers' decisions for adopting it. It also means addressing several policy constraints: inadequate research and extension support, lack of incentives (including payment for ecosystem services), insecure land tenure, and agricultural and trade policies biased towards the interests of the agro-food industry.

3

According to the International Fund for Agricultural Development (IFAD), 80% of the food consumed in Sub-Saharan Africa and Asia is produced by 500 million smallholders.[34] These regions have the highest incidence of food insecurity – mostly among those living in rural areas and relying on agriculture. This is why boosting the productivity of small-scale farmers in these regions would critically help increase both the supply and access to food. Agroecological practices are especially productive at a small scale and at the same time help reduce farmers' vulnerability to climate change, resource degradation and volatile agricultural prices. In marginal environments and for resource-poor farmers with no or weak links to markets, agroecological practices may actually represent the *only* available option for producing food. Nonetheless, common beliefs about the need to 'modernise' the agricultural sector and pressure of corporate interests on agricultural markets drive agricultural policies that support intensive use of inputs and mechanisation even in rather fragile agroecological conditions.

It is thus extremely important to understand the constraints to the wider adoption and diffusion of agroecological practices, especially among smallholders living in marginal areas, and the technical and institutional solutions to overcome them.

Agroecological systems also offer potential to supply the increasing urban and peri-urban markets in developing countries. But realising this potential depends on addressing both technical and political issues, as well as the way different patterns of agrarian transitions affect access to land, availability of labour, the localisation of agro-food systems, and so on. This is why discussions on mainstreaming agroecology should be framed within a wider policy scope and take a long-term perspective.

Understand what drives farmers' choices

Agroecological practices are often defined as 'low external input' because farmers are expected to minimise the use of external inputs and rely on internally produced or recycled inputs. However, the appropriate management of complex energy flows and internal resources requires large amounts of 'soft' inputs such as labour, management skills and knowledge. Managing complex and synergistic systems is easier in small farms because they are labour intensive and because labour is very productive, i.e. has a high return per unit of input.[35] In addition, when social capital[36] is present, control and management of shared local resources by many smallholders is more efficient and appropriate than centralised control by a few, larger actors.[37]

Labour intensity and lack of community cohesion and institutional support for the management of local natural resources such as forests and water catchments are sometimes reported as major deterrents to the adoption of agroecological practices by smallholder farmers. However, this is likely to only be an issue in the short term if farmers need to acquire new management skills and dedicate more time to learning and experimentation.

Still, in some situations farm labour may be truly deficient (especially where HIV/AIDS and out-migration reduce both labour availability and productivity). And even when labour is available, small-scale farmers may not be willing to invest their assets and resources in new crops and methods if the results are not immediately visible and they do not quickly reduce risks. Poorer households, in particular, may not be able to shift to new farming practices if the additional time required for learning and experimentation diverts labour from other income-generating activities, even in the short term.

Agroecological farmers also need a high degree of social skills. For instance, while some conservation work can be done on individual farms, the holistic management of the landscape requires farmers to often work co-operatively, for instance in order to plant trees in the upper parts of a watershed, to agree on grazing rules in crop-livestock integrated systems, and so on. In fast-changing rural societies, relying on trust and social capital founded on tradition and local institutions may be increasingly challenging; these challenges could undermine agroecological farmers' full potential for providing environmental services. Policies and statutory laws can certainly play a role by providing the right incentives, although they more usually erode rather than strengthen the conservation values embedded in indigenous cultures.

Several immediate trade-offs thus influence farmers' choices about whether and what degree of agroecological practices to adopt. For instance, farmers need to balance short-term with long-term objectives – i.e. immediate production (and profits, which may be initially affected by low returns to labour) versus the achievement of long-term resilience and the provision of wider benefits such as food sovereignty and environmental protection. In highly degraded environments, farmers may also have different environmental objectives and priorities for ecosystem conservation depending on their valuation of environmental services (which are based on economic as well as cultural values). However, these trade-offs may be less of an issue for indigenous and traditional farmers who still maintain agroecological practices, see environmental and production objectives as inter-dependent and whose beliefs include conserving all forms of life.

The way farmers balance these trade-offs ultimately depends on their current livelihood strategies and

farming practices, the incentives provided by the agricultural, trade and tenure policies in place, their individual and cultural values, as well as the wisdom they share with community members, technical advisors and policymakers. These are in turn influenced by the changing circumstances that affect access to resources and to economic opportunities. As a result, it is difficult to evaluate farmers' agroecological choices and the compromises they opt for, especially considering that agroecological solutions (as well as the problems they seek to address) are by definition context-specific. Locally specific parameters (such as measuring overall on-farm productivity according to the traditional use of both commodity and non-commodity agricultural outputs) and flexible evaluation frameworks (in order to take into account the aspects of sustainability that local communities value most) may be the only means of doing so.

An appropriate analysis of farmers' choices and their drivers is necessary in order to understand the hurdles to agroecology's acceptance and mainstreaming in agricultural policies and practices. Such analysis should be supported by stronger evidence of the financial viability of agroecological practices and their returns to labour, especially in a context of rapid rural transformations and economic diversification. An agroecological practice that has been proven successful in certain circumstances is likely to be easily up-scaled in contexts with similar ecological and social characteristics. However, some degree of adaptation to local socio-cultural, environmental and technological conditions will always be needed. To this end, the analysis should be flexible and recognise that the factors that influence farmers' choices and priorities change from place to place. It should also be able to evaluate farmers' capability to innovate, rather than just adopt others' innovations; and to identify underlying drivers and limitations.

Provide supportive policies and institutions

Farmers' choices and priorities are largely influenced by the technological options available and the incentives and the opportunities provided by prevailing policies and institutions. Identifying the exogenous barriers to the widespread adoption and dissemination of agroecology, as well as the policy options to overcome them, is thus another essential step for mainstreaming agroecology. Table 2 offers an analytical framework to understand the major challenges to the adoption and the dissemination of agroecology, and lists a number of policy options to overcome them. Such analysis is important because it can help expose current, biased policies (and the vested interests behind them) and ultimately help 'unlock the ideological barriers to the political recognition' of agroecology.[38] Indeed, beyond a deeper understanding of all these issues, mainstreaming and scaling-up agroecological practices also require addressing the pitfalls and inefficiencies of our current food systems; and many of the issues related to the governance of the agro-food system are indeed highly politically sensitive. Indeed, the powerful economic and institutional interests that back research and development for the conventional agro-industrial approach have been one of the major constraints to the spread of agroecology to date.[39]

As we saw above, one obstacle to the adoption of agroecological practices is farmers' perceptions that they are complex and management-intensive. Another is the ability of farmers to use and share their knowledge in innovative ways in order to adapt techniques to local conditions. Indeed, agroecology 'is by definition an innovative, creative process of interactions among small-scale producers and their natural environments'.[41] More funds are therefore needed – not only to incorporate ecological and agroecological principles into agricultural science curricula and research, but also to pursue a new approach to generating and disseminating knowledge through local and participatory innovation processes in which farmers are at the centre of the agricultural innovation system and actively participate in setting the agenda for research and extension services.

Beyond the lack of supportive research and extension, the limited uptake of agroecological approaches is also due to biased agricultural and trade policies. Agroecological farming is often regarded as less competitive than 'conventional' practices. This is partly due to the fact that the prices of agricultural products under current agro-food systems are distorted by heavy subsidies – both direct (such as farm and input subsides) and indirect (the health and environmental consequences of unsustainable practices that are paid for by taxpayers) – whereas the positive externalities of agroecology are not taken into account by public policies. Agricultural and trade policies should be re-oriented in order to correct these distortions, take into greater account the multi-functionality of agriculture and the associated positive externalities and create appropriate incentives, including markets for ecosystem services. A related problem is that food security is generally perceived by policymakers as requiring increased production, whereas for marginal farmers, minimising risk (e.g. of crop failure) and hence resilience, is likely to be as or more important.

Insecure land tenure and lack of access to natural resources can also inhibit the uptake of agroecology by discouraging farmers from adopting practices – such as agroforestry and soil conservation – that require investment in land and other assets. Sound land and natural resource policies can help overcome these challenges by supporting small-scale farmers, and in

Table 2: Mainstreaming agroecology: Challenges and policy options[40]

CHALLENGES	POLICY OPTIONS
Agroecological practices are locally-specific and knowledge and management-intensive: • Adoption requires access to skills and information, strengthening of local knowledge, incremental learning and links to social networks • Extension advice should be context-specific and creative and respond to farmer demand rather than imposing standard solutions	Ensure that **research priorities and funding** are re-directed to strengthen research on agroecology and incorporate ecological principles into agricultural science curricula and research Pursue **a new approach to generating and disseminating knowledge** – a shift is needed from top-down research and extension to bottom-up approaches and local innovation: • The identification of the problems should be an integral part of research, development and implementation and be achieved through participatory processes that involve farmers and local communities • Scientific research should incorporate local practices and indigenous traditional knowledge • Extension services should be decentralised • Farmer-to-farmer exchanges and grassroots extension methods should be facilitated
Thinking in systems and systemic change requires a holistic understanding of competing objectives	Agricultural research should follow an **interdisciplinary approach** that integrates ecology, natural resource management, socio-economic and cultural aspects
Market failures: • Agricultural subsidies and protectionist trade policies keep the costs of unsustainable production models low • The positive externalities of agroecology are not recognised in the prices farmers receive, whereas the environmental costs of 'conventional' practices are paid for by the state and taxpayers • Non-commodity outputs (such as environmental services) of farming are not recognised or are under-produced because their market price is distorted or non-existent	**Re-orient national and international trade policies:** • End subsidies to agriculture in industrialised countries and manage supply to ensure that public support does not lead to over-production and dumping • Agree on the valuation and incorporation of externalities in national and international markets, especially in view of trade liberalisation **Re-orient agricultural and rural development policies:** • Value multi-functionality of agriculture and farmers' roles in the stewardship of ecosystem by providing appropriate incentives and creating markets for ecosystem services (including landscape conservation)
Lack of access to natural resources and insecure land tenure discourage practices that require investment in assets and knowledge and co-operative behaviours, such as agroforestry and soil conservation schemes	**Re-orient/introduce policies to support small-scale farming:** • Secure equitable rights of access and use for land, water, forests, common property resources and seeds • Encourage the formation of farmers' groups and co-operatives
The strong influence of vertically integrated and highly concentrated agri-business corporations on agricultural research and food policies limits small-scale farmers' capacity to link independently with markets and access demand-led research and extension	Provide adequate incentives and technical assistance to support small-farmers and small and medium sized enterprises in the creation of **local 'agroecological business models'** that can make appropriate inputs and technologies available in the market
Erosion of traditional cultural values and institutions and traditional knowledge (TK)	Promote policies that strengthen indigenous cultures and local organisations **and protect the knowledge and rights of farmers and pastoralists** to save and improve seeds and share benefits from the use of traditional crop and livestock varieties

particular by securing their rights of access to and use of natural resources.

Large agri-business and food companies show no interest in agroecological practices because inputs and technologies cannot be easily standardised and patented. Due to the strong influence of the corporate sector on agricultural research governance and on food policies, farmers – and especially those in developing countries where lack of funds and expertise in public research institutions are additional constraints – lack access to agroecological inputs, tools and technical advice. Promoting a local agroecological business model for the production and commercialisation of appropriate inputs and technologies (such as light no-till planting machineries, organic fertilisers, biological pesticides, seeds for cover crops and so on) could encourage more farmers to engage with agroecology. In addition, if agroecological production systems become more widespread, local demand for environmental services and agroecological inputs could increase the number of rural employment opportunities, and these are likely to be safer and less seasonal than those offered by industrial agriculture.[42]

On the other hand, it is also critical to protect the knowledge and rights of farmers and pastoralists in order to secure their continued access to traditional crop varieties and livestock breeds and provide appropriate rules and incentives to make sure that any benefit from the commercial use of this knowledge (e.g. for plant breeding) will be shared with them.

These policy changes are particularly challenging because they require an underlying cultural and philosophical shift in the perception and the valuation of what is commonly regarded as 'efficient'. The 'more is better' mantra characterises our current production and consumption systems; challenging it may not be easy as its assumptions influence all sectors of the economy and society. In agriculture, for instance, productivity has been traditionally measured through crop yields and returns to labour, with little or no attention to overall resource efficiency, risk reduction and non-commodity outputs. Nonetheless, recently a number of local actors and international organisations have been questioning this model and recognising the multi-functional roles of agriculture. Some initiatives, such as the UK-based Ecosystem Services for Poverty Alleviation (ESPA) and UNEP's Economics of Ecosystems and Biodiversity (TEEB), indicate the willingness to turn this recognition into operational metrics.

Build constructive complementarities between agroecological and conventional farming

Farming systems based on large-scale units and intensive use of chemical inputs are unlikely to be abandoned, especially in countries where agricultural commodities contribute to large shares of GDP and international exports. In these circumstances, the possibility to adopt aspects of agroecology at one or more stages of the farming process could help reduce the negative environmental and social impacts of this production model. Although such reduction might not be significant, it would still represent a step towards greater sustainability. However, the biases that some agroecological movements have against 'conventional' agriculture (see above) often deter them from engaging more effectively with conventional farmers. Such biases can also mean they overlook opportunities for reaching farmers who are less radical, are willing to reduce expenses for purchasing inputs, want to employ different approaches on different parts of their farm or mix agroecological practices with other practices.

The capacity to understand and engage with such 'hybrid' farming systems is important, especially as the rapid pace of urbanisation and rural-urban migrations are currently transforming rural landscapes. The diversification of the rural economy, changes in land tenure systems (including possibly an increasing concentration of arable land into larger holdings) and the reduced availability of agricultural labour are likely to deeply affect prevailing agricultural production models. The impacts of climate change make the task of addressing these dynamics, and the way they affect agriculture, even harder.

At the same time, these transformations open up opportunities for innovative policies, unexplored research streams and new technological solutions. In a context of new challenges and opportunities, these innovations may well consist of the adoption of environmentally sound practices, such as agroecology. However, new opportunities will also stem from mixing different approaches and technologies. In order to provide realistic solutions to the challenges facing food and the agricultural systems, the long-standing debate between 'conventional' and 'alternative' may need to be reframed and become less polarised. If policymakers and practitioners can stop perceiving agroecological practices as alternative they might be more likely to mainstream them in agricultural policies and practices.

Looking forward: consolidating the evidence for agroecology

4

The existing evidence for the benefits of agroecology is highly context specific. Studies are difficult to compare or aggregate as they use different parameters and analytical tools, and they rarely assess economic viability. Some comprehensive studies are available, but they date back to the 1990s or before; while this does not affect the validity of their conclusions, the factors influencing farmers' choices may be very different nowadays, especially considering the socio-economic transformations that characterise peasants and rural societies in Asia and Africa. New, consolidated evidence that supports agroecology is needed.

New studies should rely on multi-dimensional analyses that measure not just crop yields, but also other outputs, such as feed available for livestock, mulching crops, provision of ecosystem services, and so on. While this has been attempted in the past, the challenge today is to find common metrics to evaluate and compare environmental services, agricultural by-products and other externalities along with more classic measures of agricultural productivity. New studies should also assess more consistently how agroecological farming contributes to farmers' incomes and compare it with alternative on and off-farm livelihood opportunities.

The way farmers balance constraints and potential benefits, and the incentives needed to overcome these tensions, have not been adequately addressed. New evidence is thus needed on profits, returns to labour and resource efficiency of agroecological practices, as well as on the motivations and the drivers of choices that induce (or prevent) farmers' adoption.

The extent to which different combinations of agroecological practices contribute to resilience and sustainability of farming depends on how farmers balance a number of trade-offs – between production and environmental objectives and among different environmental objectives. This in turn depends on their values and priorities, but also on the technical advice and the institutional support they receive. For indigenous farmers, it may not be so much a question of trade-offs but of strengthening cultural values and local institutions that promote traditional practices.

Analysing the drivers of farmers' choices thus requires a flexible analytical framework, context-specific indicators and a focus on farmers' capacity to *innovate*, rather than *uptake innovations*. It should also be framed on a longer-term perspective, considering the socio-economic dynamics that are changing rural landscapes, such as land tenure security, availability of agricultural labour, economic diversification and so on. To take such variability into account, the debate between agroecology and conventional farming should be reframed in a more constructive way, in order to assess potential complementarities among different, even though less sustainable, farming systems.

A better understanding of the drivers of farmers' agroecological choices, as well as of the underlying incentives and obstacles, is the first step towards the mainstreaming of agroecological principles in agricultural policies and practices. Another important step is to assess whether tensions exist between farmers' objectives and the social benefits that policymakers increasingly expect from the agricultural sector (e.g. urban food security, landscape conservation, soil protection, etc.), and how to balance them. To this end, it is important to analyse the exogenous constraints to the adoption of agroecological practices and the policy options to overcome them (Table 2). Overcoming these constraints may imply innovative tools and approaches such as participatory innovation systems, economic incentives for early adopters, payments for environmental services and rewards for landscape conservation. Relevant policy changes may also concern land tenure, natural resources management as well as support to farmer organisations, local business development and markets for agroecological products.

While obtaining high and stable yields is important to all farmers, agroecological practices seek to optimise, rather than maximise, production (and profits). Measuring achievements in terms of yield optimisation and environmental benefits may prove complex in practice. Not only does it require new measurement tools, it also requires a fundamental cultural and philosophical shift – not just by farmers but by society as a whole – in what we mean by 'productive' and 'efficient'. The type of policy analysis and the measurement needs outlined here seek to contribute towards this evaluation shift and could provide a useful starting point for refining an analytical framework and more detailed, context-specific tools that can better inform farmers and policymakers about the many benefits of agroecology. This would ultimately help mainstream agroecology as a means to support sustainable livelihoods, promote food sovereignty and strengthen climate resilience.

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Notes

1 Pretty *et al.*, 2011

2 Altieri, 1995.

3 Altieri, 1995.

4 The concept of agro-ecosystem, introduced by the ecologist Odum in 1969, well reflects the expanding scope of agroecology throughout this period. The agro-ecosystem represents the interaction of ecological, technological and socio-economic factors.

5 Wezel, *et al.*, 2009.

6 Gliessman, 2007.

7 Altieri, 1995.

8 Sources: Reijintjes, et al., 1992; Gliessman, *et al.* undated; De Schutter, 2010; Koohafkan *et al.*, 2012.

9 Francis (2003) defines agroecology as the 'integrative study of the ecology of the entire food systems, encompassing ecological, economic and social dimensions, or more simply the ecology of food systems'. Similar definitions describe agroecology as 'an integrative discipline that includes elements from agronomy, ecology, sociology and economics' (Dalgaard *et al.*, 2003) and 'the science of applying ecological concepts and principles to the design and management of sustainable food systems' (Gliessman, 2007).

10 UNCTAD, 2013.

11 Dalgaard *et al.*, 2003; Méndez, 2010; Wezel, *et al.* 2009.

12 McDonald's Corporation, 2009.

13 As an example, the Centre for Agroecology and Food Security at Coventry University and the International Food Security Network discuss the benefits of agroecology mainly in relation to the production dimension at the agro-ecosystem scale and treat food systems and policy issues separately. See their respective reports: Wibbelmann, *et al.*, 2013; and Wijeratna, 2012.

14 Altieri, 1995.

15 De Schutter, 2010.

16 Sources: Altieri, M.A. 1995 and 1999; Wibbelmann, *et al.* 2013; De Schutter, 2010; Gliessman, 1998; Kremen and Miles, 2012; Pretty, 2006.

17 This paradigm considers farming only as an input-output equation to maximise crop yields. Such farming models are based on yield maximisation; monocropping and genetic uniformity; extensive use of synthetic inputs sourced off the farm such as chemical fertilisers, herbicides and pesticides; use of modern mechanised procedures; large-scale irrigation schemes or mechanised irrigation; heavy soil disturbance; and factory-style practices for raising livestock. Industrial agriculture based on these production systems is also characterised by large-scale farming and economies of scale; strong vertical integration; and corporate concentration at the extreme ends of the value chain. Many small-scale farmers in developing countries do not have access to irrigation and machinery but they often rely on this yield-oriented, mono-cropping model and, as long as they can afford them, on external inputs.

18 Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. Food sovereignty is founded on six interlinked and inseparable principles: it 1) focuses on food for people; 2) values food providers; 3) localises food systems; 4) puts control locally; 5) builds on knowledge and skills; and 6) works with nature. Food sovereignty uses the contributions of nature in diverse, low external input agro-ecological production and harvesting methods that maximise the contribution of ecosystems and improve resilience and adaptation, especially in the face of climate change; it seeks to 'heal the planet so that the planet may heal us'. Source: Declaration of the Forum for Food Sovereignty, Nyéléni 2007, available at: www.nyeleni.org, accessed October 2013

19 Altieri and Nicholls, 2012.

20 Wibbelmann, *et al.*, 2013.

21 Examples of ecosystem services include biodiversity; soil and water quality; nutrient management (nitrogen fixation); soil water-holding capacity; control of weeds, diseases, and pests; pollination services; carbon sequestration; energy efficiency and reduction of atmospheric warming potential; resistance and resilience to climate change; and crop productivity

22 United Nations Secretary-General, 2013; UNCTAD, 2013; UNEP, 2012; De Schutter, 2010; McIntyre, *et al.* 2009; Wijeratna, 2012; CGIAR-WLE, 2013.

23 LaSalle and Hepperly, 2008.

24 Altieri and Koohafkan, 2008; Holt-Gimenez, 2001.

25 Swiderska *et al*., 2011.

26 Rosset *et al*., 2011.

27 Bourgeois, 2013.

28 Chappell and La Valle, 2009.

29 Altieri, *et al.,* 2012.

30 United Nations Secretary-General, 2013.

31 In their book *The Conversion to Sustainable Agriculture* (2010, CRC Press, USA), Gliessman and Rosemeyer effectively describe this continuum by defining four levels – or four steps – in the transition from 'conventional' to agroecological practices.

32 The Montpellier Panel is a panel of international experts from the fields of agriculture, sustainable development, trade, policy, and global development working together to enable better European government support for national and regional agricultural development and food security priorities in Sub-Saharan Africa.

33 Altieri and Nicholls, 2012.

34 IFAD, undated.

35 Altieri, *et al*., 2012.

36 Social capital includes 'social assets' such as trust, reciprocity, formal or informal organisations and co-operatives, accountable institutions and so on.

37 C.f. Ostrom, 1990.

38 Parmentier, 2014.

39 Altieri and Nicholls, 2012.

40 Sources: Alonge and Martin, 1995*;* UNCTAD, 2013; UNEP, 2012; De Schutter, 2010; von der Weid, 2000; Wibbelmann, *et al.* 2013*;* Stassart *et al*., 2012; FAO-SARD, 2007; Altieri, 2002.

41 IATP, 2013.

42 Pretty, Toulmin and Williams, 2011.

In a context of a changing climate and growing concerns for more healthy food systems, agroecology is gaining momentum as a scientific discipline, sustainable farming approach and social movement. There is growing anecdotal and case study evidence of its multiple benefits, from climate resilience to farm productivity. Yet its promotion in public agricultural policies, research and extension is still limited.

This paper explores why this is. It calls for consolidating the evidence base for agroecology through multi-dimensional tools that not only measure yields, but also its many other benefits: economic, environmental and social. Mainstreaming agroecology will require a fundamental cultural and philosophical shift in how we as a society define 'productive' and 'efficient' agriculture.

IIED is a policy and action research organisation working to promote sustainable development – development that improves livelihoods in ways that protect the environments on which these are built. Based in London and working on five continents, we specialise in linking local priorities to global challenges. In Africa, Asia, Latin America, the Middle East and the Pacific, we work with some of the world's most vulnerable people to ensure they have a say in the decision-making arenas that most directly affect them – from village councils to international conventions.

International Institute for Environment and Development
80-86 Gray's Inn Road, London WC1X 8NH, UK
Tel: +44 (0)20 3463 7399
Fax: +44 (0)20 3514 9055
email: info@iied.org
www.iied.org

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