Mainstreaming Agroecology: Implications for Global Food and Farming Systems

Discussion Paper

Foreword by
HRH the Prince of Wales

Coventry University

The Centre for
Agroecology and Food Security

Creating resilient food systems worldwide

garden organic

About this discussion paper

In 2010, the Centre for Agroecology and Food Security (CAFS) was established to undertake applied research and education on agroecology as the underlying paradigm of sustainable agriculture. This approach is required not only to ensure that all the peoples of the world are fed, but also for humanity to avoid destroying the life support system and renewable resources upon which it depends.

Whilst the term 'agroecology' has been increasingly used in international circles over the past two decades, it is less used and not well-understood in the UK, even within the alternative agricultural movements. Therefore this discussion paper was written to inform not only the CAFS multidisciplinary team, but also the very broad audience of people and organisations working for change in the farming production, research and policy arenas.

The discussion paper is based on an extensive literature review undertaken by researcher Marco Wibbelmann, and includes contributions by other staff and affiliates of CAFS. It was edited by Karen Brock of Green Ink.

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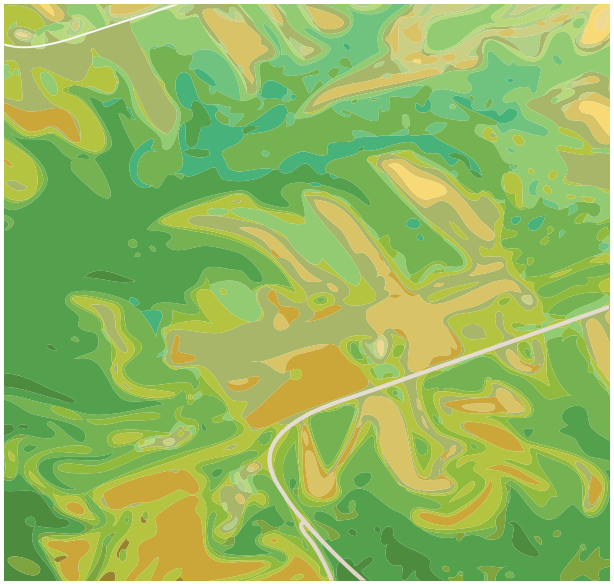
Foreword by HRH the Prince of Wales

CLARENCE HOUSE

When I first became Patron of the Henry Doubleday Research Association, some twenty-five years ago now, it was because I appreciated the importance of sound academic research into the principles of ecologically-friendly gardening and farming practices. I am delighted that, over the past quarter of a century, the organization, now known as Garden Organic, has continued to drive this agenda with numerous initiatives, including a new partnership with Coventry University to establish a centre for Agroecology and Food Security. I am greatly encouraged that this first report, "Mainstreaming Agroecology", is such a serious contribution to the movement. It sets out a pathway for how the Agroecological approach can make an evermore significant contribution to the world's food security. I hope this report will be read by all of those involved in food production and provision and would like to congratulate everyone at the Centre for Agroecology and Food Security for making such an assured start.



Executive Summary

The challenge of feeding the world's growing population without further damaging the natural resource base is becoming increasingly urgent, and must be met in ways that also allow adaptation to and mitigation of climate change. Agriculture provides not only food, but also fuel, fibre and a wide range of ecosystem services. This paper discusses the principles and practices of agroecology, and how mainstreaming them can potentially meet the challenges facing agriculture and food production.

The academic discipline of agroecology emerged over a century ago. Subsequently, in response to the social and environmental problems caused by the global industrial agricultural and food system, it has become the foundation of both a set of land management practices and a vibrant social movement. The science of agroecology is the study of living organisms and their inter-relationships in the context of agriculture and land use, and can be seen as the scientific basis of sustainable agriculture.

Agroecology not only defines, classifies and studies agricultural systems from an ecological and corresponding socio-economic perspective, but also applies ecological concepts and principles to the design and management of sustainable agro-ecosystems (Altieri, 1995). This means that it is very useful as a theoretical and practical approach to increasing the sustainability of current agri-food systems.

Agroecology has come to greater prominence since the publication of the 2009 International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) which advocated the use of agroecological approaches in sustainability initiatives. The following year, the United Nations (UN) Special Rapporteur on the Right to Food also highlighted agroecology as a viable approach for working towards food security (De Schutter, 2010).

The increasingly high profile of agroecology is reflected in the growing body of evidence on high-performing agroecological management practices. For example, a recent study (Pretty, Toulmin and Williams, 2011) examined 40 initiatives employing agroecological production methods in 20 countries, involving 10.4 million farmers. These included agroecological approaches to aquaculture, livestock and agroforestry, conservation agriculture, and crop variety improvements with locally appropriate cultivars and cropping systems. Analysis of project outcomes demonstrated not only an average crop yield increase of 113%, but also numerous environmental benefits, including carbon sequestration and reductions in pesticide use and soil erosion.

Agroecological practitioners design food production systems which aim to maintain the functions that natural systems provide, both internal and external to production, and which are robust, productive and equitable. This means integrating instead of segregating, closing systems and relying on local inputs, increasing biological and genetic diversity, and regenerating instead of degrading.

Agroecosystems managed according to these principles look very different from industrial agricultural systems, and are based on a different paradigm. Increasing the use of agroecological approaches in order to enhance the sustainability of food production would demand social and institutional changes in agricultural communities, the commercial framework

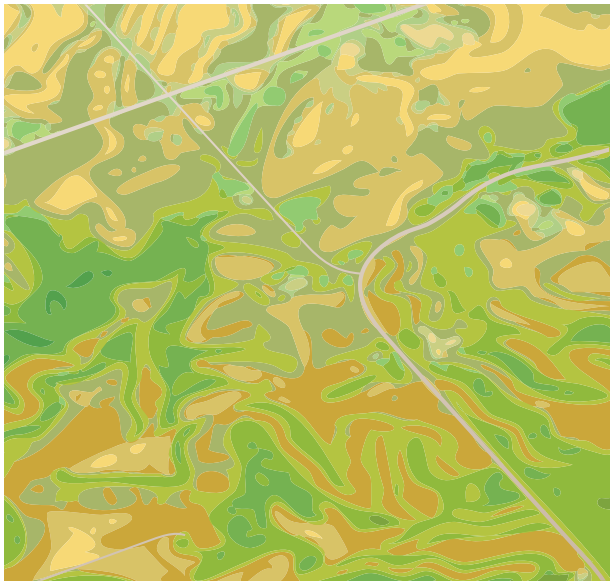
of agriculture, the wider food system, and policies for agriculture, development and trade.

The UN Special Rapporteur on the Right to Food identifies scaling up agroecological approaches as one of the main challenge of our time, noting both a need for increasing the areas cultivated using agroecological practices and an enabling framework for farmers using these practices (De Schutter, 2010). There are significant barriers to achieving this. They include the economic viability of agroecological approaches in competition with industrial approaches, an international economy dominated by neoliberal narratives, and the vertical, integrated structure and entrenched political interests of agri-businesses.

Although informed citizens and markets are powerful mechanisms for shaping resource use and production, and for stimulating creativity and innovation by communities, concerted government action is needed to speed up the spread of agroecological production, especially while some countries are still moving their agricultural sectors in the opposite direction. Supportive policies will be required if crop and livestock production systems are to be managed as ecosystems, with management decisions fully informed of environmental costs and benefits.

This discussion paper concludes with an agenda for change to support the wider use of agroecological approaches in the arenas of research, policy, and knowledge management and agricultural extension. In summary,

- **Agricultural policy** should focus on building a progressive, knowledge-based agricultural sector which fosters the participation of all stakeholders to deliver strong support, extension and education services for agroecological technologies.
- **Economic policy** should create market conditions – including financial and regulatory mechanisms – that are favourable to rural and urban agroecological production, and develop improved markets for ecosystem services to provide incentives for their conservation and support for farming communities.
- **Cross-sectoral policies** addressing food, markets and rural and urban development should include the development of robust frameworks for assessing and evaluating existing food production systems that focus on their ecological integrity and socio-economic benefit, and use these as a basis for evidence-based policy.
- **Knowledge management and agricultural extension** should prioritise exchange of knowledge on agroecological management practices between all stakeholders by building regional, national and international information resources and networks.
- **Research** should address the implications of agroecological management in different cultural and environmental settings, both urban and rural, and further develop agroecological production techniques.



1. Introduction: Meeting the challenges of food and farming systems with agroecological approaches

How can today's concerns about food, fibre and fuel production be addressed by agroecological approaches?

This discussion paper examines how today's concerns about food, fibre and fuel production can be addressed by agroecological approaches. Agroecology not only defines, classifies and studies agricultural systems from an ecological and socio-economic perspective, but also applies ecological concepts and principles to the design and management of sustainable agroecosystems (Altieri, 1987; 1995). It has significant potential for increasing the sustainability of current agri-food systems.

Since the middle of the twentieth century, major breakthroughs in crop breeding have seen the introduction of high-yielding modern varieties of staple crops (Evenson and Gollin, 2003). Although adoption of these varieties has not been uniform, it has – together with technological improvements and the expansion of cultivated land – more than doubled physical agricultural output (Dale and Polasky, 2007).

Industrial agricultural practices quickly came to be defined as the new benchmark for agricultural performance (Evenson and Gollin, 2003). These practices include high inputs of agrochemicals and fossil energy, intensification, specialisation, monocultural production, mechanisation, intensive livestock production and large-scale production units (Tivy, 1990). Production economics, tariffs and subsidies were the principal drivers of the widespread adoption of these practices, with producers seeking to reduce unit production costs and increase yields in order to remain competitive (Hendrickson, Liebig and Sassenrath, 2008).

Industrial agriculture has had enormous negative consequences for environmental and human health and has led to a decline in the nutrient content of food.

As well as increasing yields, however, industrial agriculture has had enormous negative consequences for environmental and human health. Industrial practices have resulted in vast tracts of degraded land, loss of plant and animal species diversity, increased susceptibility to disease, and loss of livelihoods (FAO, 1997; Conway, 2001; UNEP, 2012). These problems are accentuated on marginal land, where poor soils cannot sustain monocultures of annual crops, and vulnerability to floods and droughts are high (McNeely and Scherr, 2001). Environmental degradation is also expensive: even a decade ago, agricultural losses due to land degradation were about $550 million annually (Tansey and Worsley, 1995).

The practice of industrial agriculture has also led to a dramatic decline in the nutrient content of food. For example, mineral levels in fruits and vegetables in the UK fell by up to 76% between 1940 and 1991 (McCance and Widdowson, 1940–1991), and a similar trend has been seen in the USA (Davis, Epp and Riordan, 2005). This decline is attributed to the unintentional selecting-out of high-nutrient crop varieties when breeding crops for high yield potential, the use of shallow-rooting annuals which are unable to tap into soil nutrients at deeper levels, and the failure to return a full complement of nutrients to the topsoil.

With over 38% of global land area under crop and pasture cultivation (Tilman, 2002), the magnitude of these impacts of unsustainable management is clear. But under the industrial agricultural model, negative impacts

The hidden costs of the food system are not included in the price of food, but are instead paid for by government and society.

are often externalised and exert no self-correcting pressure on practice, because food producers have little incentive to reduce them (Clay, 2004). The hidden costs of the food system – for cleaning up environmental damage and restoring human health – are not included in the price of food, and are instead paid for by government and society. In 1996, the health costs of the food system were estimated at $81–117 per hectare in Germany and $343 per hectare in the UK (Pretty et al., 2000).

In the past, the industrial production model has been supported by national policies, but more recently there has been an increasing trend towards policies designed to induce markets to reflect environmental costs. This can be seen in shifts in the European Union (EU) Common Agricultural Policy (CAP) and US agri-environmental policy which are associated with the provision of public goods and amenity services though land management (Baylis et al., 2008). Targeted policies are used to compensate farmers for the lower productivity that results from reducing externalities. In the EU, this is achieved through using rural development and direct income transfer to farmers, while the US focuses on reducing negative externalities such as soil erosion. In both cases, many of the amenities targeted by the programmes are being demanded by the population.

On a global scale, tensions between agriculture and environmental conservation (Brussaard et al., 2010) are compounded by hunger and poor nutrition, caused not only by insufficient food but also by lack of secure supply and fair distribution (Magdoff, 2007). This challenge is usually viewed from the top-down perspective of how to feed the world's growing population, currently projected to reach 8–10 billion by 2050 (United Nations Population Division, 2012). An alternative perspective asks how to enable populations to feed themselves, and indicates that there are divergent views on how this challenge is to be met.

As environmental problems with industrial agriculture have become more evident, adjustments have been made to the prevailing model. This has resulted in approaches to industrial agriculture which have adopted the rhetoric of sustainability, referred to as 'sustainable production' and 'sustainable intensification'. Advocates of these approaches argue that yield trends can be maintained by increasing the efficiency of nitrogen, phosphorous and water use whilst maximising the net benefits that society receives from agricultural production (Tilman et al., 2002; Royal Society, 2009). These approaches advance simplistic production output models by including fibre and fuel as co-products of food production, re-considering the increasing scale of livestock production (Alvis, Jackson and Allen, 2012), and recognising the importance of ecosystem services and ecologically-based management practices.

Such attempts to include some sustainable practices in industrial agriculture do little to address the fundamental, structural problems of this model. Critics argue that modified industrial agricultural practices are unsustainable in the broadest sense, and are still associated with the deterioration of the natural resource base, disruption of ecosystem integrity, declining biodiversity, impaired ecosystem services and the undermining of social equity (Bundell, 2010). In addition, they point to genetic and ecological limits – such as the availability of water – which are predicted to naturally cap yield increases (Jägerskog and Jønch-Clausen, 2012).

Attempts to include some sustainable practices in industrial agriculture do little to address the fundamental, structural problems of this model.

The discipline of agroecology has emerged as a different paradigm to address the social and environmental problems of the global industrial agriculture and food system. Based on the principles of sustainability, integrity, productivity, equity and stability (Conway, 1987; Marten, 1988), its scientific foundations are in the ecological and social processes underlying sustainable food production, rather than the chemical and economic processes that underpin industrial agriculture. This makes it a vital tool in developing viable, sustainable alternatives to industrial agriculture and food production.

The discipline of agroecology has emerged as a different paradigm to address the problems of the global industrial agriculture and food system. It is based on the principles of sustainability, integrity, equity, productivity and stability.

This discussion paper is a contribution towards the multi-disciplinary dialogue that is needed to analyse the principles of agroecology more widely. It draws on thinking from several disciplines, drawing threads through them all to tie the relevant themes together.

Section 1 defines agroecology, examines its relationship with other key concepts in the field of sustainable agriculture, and outlines some of the positive outcomes that have resulted from agroecological management practices. Section 2 looks in more detail

at agroecological practices, examining the biophysical and socio-economic properties of agroecosystems. Section 3 focuses on the socio-economic and political barriers to mainstreaming up agroecology. Section 4 presents an agenda for increasing the adoption of agroecological practices, and Section 5 concludes.

1.1 What is agroecology? Definitions and key concepts

The term agroecology has diverse definitions (see Table 1). A review entitled "Agroecology as a science, a movement and a practice" illustrates the range of ways the term is used (Wezel et al., 2009). Agroecology has had varying meanings over time and across cultures, ranging from the highly specific applications of ecological methodologies by agronomists in the first half of the twentieth century, to the social meaning invested in the term through its adoption by the Agroecological Movement of Latin America in the first decade of the twenty-first.

Wezel and Soldat (2009) locate the scientific roots of agroecology in Germany and the USA in the 1930s, noting that the sciences of ecology and plant ecology had been established in German-speaking countries since the mid-nineteenth century. But while its scientific foundations remain a crucial part of the identity and meaning of agroecology – Altieri (1987) notes for example that the narrowest definition of agroecology remains the study of purely ecological phenomena in crop fields – a key concept in contemporary agroecology is that agricultural systems cannot be studied independently of the human communities that depend on them. Social dynamics are therefore relevant and integral to agroecology, so the discipline includes analysis of themes such as policy, extension and knowledge transfer. Some authors (Dalgaard, Hutchings and Porter, 2003) use the labels 'hard' and 'soft' agroecology to distinguish between the optimisation of measurable resource and production constraints and less tangible human and social capital. Agroecological management practices also strive to be sensitive to the constraints and resources of local communities (Tomich et al., 2011).

TABLE 1. Selected definitions of agroecology

Altieri, 1987: 6	"A discipline that defines, classifies and studies agricultural systems from an ecological and socio-economic perspective."
Altieri, 1995: 4	"The application of ecological concepts and principles to the design and management of sustainable agroecosystems."
Francis et al., 2003: 2	"The integrative study of the ecology of the entire food systems, encompassing ecological, economic and social dimensions."
Dalgaard, Hutchings and Porter, 2003: 39	"An integrative discipline that includes elements from agronomy, ecology, sociology and economics", "the study of the interactions between plants, animals, humans and the environment within agricultural systems."
Wojtkowski, 2004: 10	"The interactions among natural processes in artificial systems designed to meet human goals."
Gliessman, 2007: 18	"The science of applying ecological concepts and principles to the design and management of sustainable food systems."

Partly as a result of this integration of the social aspects of agroecosystems, the principles embodied by agroecological management have also come to have political meaning. Today, the primary concepts of agroecology and agroecological management practices resonate with arguments for food security, food sovereignty and sustainable rural development. Furthermore, the multidisciplinary identity of agroecology means it has come to be associated with a systems approach to knowledge, and has sometimes been associated with a movement away from reductionist enquiry based on positivism and experiments (Bawden, 1991) toward integrative, iterative and holistic approaches to research.

Wezel and Soldat (2009) show that the dominant trend in the meaning of agroecology is one of increasing spatial scale over time, from the plot field level in the 1930s to the broader agri-food, socio-economic and political system in modern usage. They also note that the most common published use of the term is in the phrase 'agroecological zone', where it is used to refer to a set of local biotic and abiotic conditions for crop production. It also commonly occurs alongside the terms 'sustainability', 'biodiversity' and 'organic farming'.

Although agroecology has its own identity, it is closely related to other disciplines. Since the rhetoric of sustainable agriculture has become more mainstream, some caution is warranted in interpreting how the term agroecology is understood by those who use it (Scherr and McNeely, 2008).

There is however some unity of meaning, in that most authors recognise that the "rationale for agroecology is currently the need to develop sustainable systems of food

production" (Dalgaard, Hutchings and Porter, 2003: 40). In this light, agroecology may be thought of as presenting an ideal that agriculture should strive for, balancing the needs of communities and the integrity of ecosystems.

This discussion paper uses Altieri's long-standing definitions (1987, 1995) to describe agroecology as "a discipline that defines, classifies and studies agricultural systems from an ecological and socio-economic perspective, and applies ecological concepts and principles to the design and management of sustainable agroecosystems."

The first part stresses the theoretical and practical underpinning of the science, while the second derives implications for development and policy from it. While agroecology is defined this way, it is important to note that it is not isolated from broader social, political and economic forces, and that it therefore has corollaries in the entire agri-food system (Francis et al., 2003).

Weiner (2003) argues that ecology will become the major science of agriculture in the twenty-first century. He notes that there are many sciences of agriculture – including crop science, food science, chemistry, veterinary science and weed science – but that most current biological problems in agriculture occur at the levels of populations, communities and ecosystems. He considers that these levels are addressed by ecology rather than other scientific disciplines, and therefore that ecology will by necessity become the central science of agriculture. He argues that, fuelled by these problems, ecology – and by implication, agroecology – will mainstream itself. However, given the power of agri-business, the increasing pressure of problems alone may not be enough to mainstream agroecology; instead, significant policy and institutional support is likely to be necessary.

Agroecology is a discipline that defines, classifies and studies agricultural systems from an ecological and socio-economic perspective, and applies ecological concepts and principles to the design and management of sustainable agroecosystems.

1.2 Agroecology and like-minded approaches to sustainable agriculture

Agroecological concepts and principles embrace a wide range of practices and have broad scope for implementation. This means that they have considerable resonance with other concepts, principles and practices in the field of sustainable agriculture that also offer alternative structures to the mainstream paradigm of industrial agriculture. A brief overview of other key approaches in sustainable agriculture illustrates some of the similarities and differences between them and agroecology.

- **Agricultural ecology** (Cox and Atkins, 1979; Tivy, 1990) is one of the academic foundations of agroecology. Unlike agroecology, agricultural ecology does not address the socio-economic or political elements of agroecosystems, focusing instead on developing an ecological understanding of biophysical agricultural processes such as soil fertility and nutrient use and cycling. Agroecology differs from agricultural ecology because of its emphasis on practice, its identification with principles and objectives, and its incorporation of aspects of sociology and economics (Dalgaard, Hutchings and Porter, 2003).

- In contrast with agroecology, the practices of **certified organic agriculture** are codified in a clearly defined and transparent set of standards. This has the advantage that certified organic producers can receive a price premium in the marketplace and be trusted as being part of a body that shares and controls a transparent set of standards. There are however also advantages to avoiding codification: it keeps some options open, protects the breadth of the social movement associated with agroecology, encourages freeform thinking, and avoids attempts to push sustainably produced products into a high-value niche market.

- The **alternative agriculture movements** embrace individuals and organisations following agroecological principles for food and non-food production. For example, the International Federation of Organic Agricultural Movements itself includes stakeholders who follow organic principles but do not necessarily practice certified organic agriculture, meaning that they cannot sell their products with the organic label; examples include Garden Organic, which has guidelines for domestic and community organic growing (Garden Organic, 2010). An alternative approach to marketing has been developed that avoids the costs of certification: under the 'participatory guarantee system,' producer networks agree on shared principles and practices and peer control, and make these transparent to the consumer. Practitioners in the alternative agriculture movements use a range of principles, including 'permaculture', 'eco-agriculture', 'biodynamic agriculture', 'natural farming' and 'alternative agriculture' – all of which can be inspired and influenced by agroecology (Vandermeer, 1995). Key common principles centre

on the maintenance of soil fertility and integration of ecosystem functions. The differences between these approaches and agroecology lie in their ideological heritage and the relative value and importance that is ascribed to different practices.

- **Multifunctional agriculture** has become a key concept for reflecting the many land uses and ecosystem services that agriculture provides beyond the production of food and fibre (McIntyre et al., 2009). It is concerned with the provision of public goods and services by agricultural landscapes (Renting et al., 2009) and is a fundamental concept in the EU CAP. Multifunctional agriculture is closely allied to agroecology, and the two concepts have been used in conjunction to consider the spatial arrangement and structural design of agroeco-systems for multifunctionality (Lovell et al., 2010).

- The **sustainable rural livelihoods** framework (Scoones, 2009) has been widely used in development research and project planning. It splits livelihood assets into five categories of capital – natural, financial, physical, human and social – and argues that access to them is mediated through transforming structures and processes at local and non-local levels. Amekawa (2011) explores the relationship between sustainable rural livelihoods and agroecology, presenting the synthesis as an approach to rural development, and demonstrating the complementary nature of the two perspectives.

- The concepts of **food security** and **food sovereignty** are also closely aligned with agro-ecology. Advocates of food sovereignty argue that hunger is due to power imbalances in the food system leading to poor food access and distribution rather than low productivity, and that food security can be better achieved by local production than a reliance on imports (Bundell, 2010). Agroecological practices can be viewed as a way to achieve this food security, especially for the rural poor (Altieri, 2004).

- **Urban and peri-urban agriculture** are increasingly put forward as a key strategy for sustainable urban development and food security in cities (Smit, Ratta and Nasr, 1996) where seven out of ten people are projected to be living by 2050 (WHO, 2010). In common with agroecology, much urban agriculture aims at the efficient use of local resources, many of which are scarce in the urban environment (FAO, 2012), and often emphasises soil conservation and the recycling of water and waste (Deelstra and Girardet, 2000). It also shares agroecology's focus on sustainable food security (Hampwaye, Nel and Ingombe, 2009) and on bringing food producers and consumers closer together (Fernández, 2006).

1.3 Agroecological practices and positive outcomes for sustainability

Agroecology came to greater prominence following the 2009 International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), an international multi-agency initiative which asked how agricultural knowledge can contribute to equitable and sustainable development. The IAASTD report notes the social and environmental costs of improvements in agricultural productivity and states that they must be addressed by policy (McIntyre et al., 2009), concluding that multifunctional agriculture and agroecological approaches should be promoted by sustainability initiatives. The year after the IAASTD report was published, the United Nations (UN) Special Rapporteur on the Right to Food also highlighted agroecology as an appropriate approach to moving towards food security (De Schutter, 2010).

This rise to prominence is based on wide success of agroecological management practices, documented in several studies, including the example shown in Box 1. A similar earlier study examined 286 projects using resource-conserving technologies, covering 37 million ha across 57 less industrialised countries (Pretty et al., 2006). Here, average yield improvements across projects were 79%, with improvements in water use efficiency and carbon sequestration, as well as reduced pesticide use.

BOX 1. Increased productivity and environmental benefits from agroecological approaches

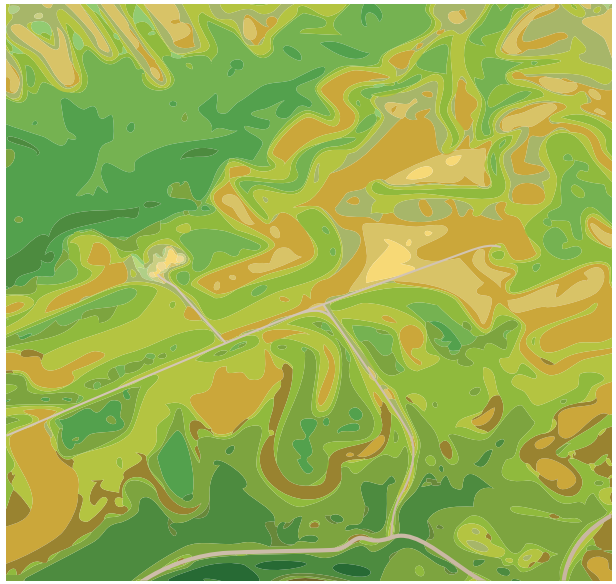
A recent study examined 40 initiatives employing agroecological production methods in 20 countries. These covered 12.6 million ha and involved 10.4 million farmers, and included agroecological approaches to aquaculture, livestock and agroforestry, conservation agriculture, and crop variety improvements with locally appropriate cultivars and cropping systems. Analysis of outcomes demonstrated not only an average crop yield increase of 113%, but also numerous environmental benefits, including carbon sequestration and reductions in pesticide use and soil erosion.

Source: Pretty, Toulmin and Williams (2011)

Altieri (2004) documented agroecological technologies employed in Latin America with yield increases ranging from 20 to 330% and improved food security, dietary diversity and productivity. He notes that the projects did not necessarily introduce new technologies, but often reintroduced traditional techniques or supported the adaptation of existing techniques to changing circumstances. Apart from the direct benefits that these ventures provided to participants, Altieri argues that they also created a local knowledge base and networks that helped perpetuate agroecological practices.

Some individual agroecological practices, such as zero-till cultivation and integrated pest management, have been widely adopted in particular parts of the world. A political and institutional integration of agroecological practices can be found in Cuba (Wright, 2009; Nelson et al., 2009). Recent documentation of case studies of agroecology from Bangladesh, Cambodia, Indonesia and Pakistan offers tools to develop affordable, dynamic, low-carbon and locally-adaptable models of agricultural development (Wijeratna, 2012).

In addition to these examples, many innovative and practical initiatives implemented by NGOs, community groups and farmers do not necessarily get exposure in formal academic literature. Further, as Tomich et al. (2011) note, a significant portion of the literature on agroecology has been generated in Latin America and is in Spanish and Portuguese. As such, initiatives that demonstrate critical experiences, proofs and lessons have frequently been obscured from the view of mainstream debate in the fields of agriculture and sustainable development. Improved access to these experiences and validation of results would strengthen the uptake of agroecological management practices.



2. Agroecological practices: Managing agroecosystems for sustainable food production

Agroecological practitioners design food production systems that try to support the functions of natural ecosystems, both internal and external to production. Magdoff (2007) describes the properties of ecosystems as efficiency, diversity, self-sufficiency, self-regulation and resilience. Supporting these properties in agroecosystems means management practices that focus on integrating instead of segregating, closing systems, increasing biological and genetic diversity, and regenerating instead of degrading.

Agroecosystem management according to these biophysical principles looks very different from industrial agricultural management, and goes hand in hand with social changes which emphasise equity, local marketing systems and broad-based participation in decision-making about food production. An example of agroecosystems management illustrating the inter-relationship between these ecological and socio-economic aspects is shown in Box 2.

2.1 Biophysical properties and characteristics of agroecosystems

Agroecological practices seek primarily to maintain the ecosystem processes that perform central functions, rather performing them with substituted inputs, mechanisation and labour.

Ecosystems are composed of complex relationships between plant and animal species and underlying environmental and geophysical processes. The conversion of natural ecosystems to agroecosystems explicitly alters abiotic processes, such as nutrient

BOX 2. Grassroots agroecology scheme tackles poverty and hunger in Bangladesh

The Food Security for Sustainable Household Livelihoods project supported the spread of agroecological practices in six remote districts of Bangladesh between 2004 and 2009. Village-level groups of men and women experimented, tested and adopted agroecological practices including:

- home-made organic fertilisers and plant-based insecticides
- mixed cultivation and intercropping
- fish–rice culture and pond fish culture
- homestead and backyard vegetable gardening.

As well as working on the biophysical aspects of their agroecosystems, the groups also focused on socio-economic initiatives including:

- improving their access to local common property resources such as fishponds, tree nurseries, orchards and collective land
- participating in a network of community-based rice seed traders
- establishing a village-level biodiversity centre to preserve and distribute genetic resources such as turmeric, ginger, neem and aloe vera
- establishing women-only rice grain banks to ensure seed and food supply during lean periods.

Through its integrated ecological and socio-economic approach, the project had both positive impacts on crop and livestock productivity and positive social outcomes, particularly for women. One female participant observed that "we have found the courage to come out of our houses."

Source: Wijeranta (2012)

cycling and the hydrological regime, and biotic interactions, such as community composition and trophic structure. These alterations disrupt other ecosystem processes, which sustain life.

Agroecological practices seek primarily to maintain the ecosystem processes that perform central functions, rather performing them with substituted inputs, mechanisation and labour. They achieve this through managing a series of biophysical properties and characteristics.

Soil processes and nutrient sourcing

Building soil structure and improving soil health is central to agroecological management practices.

Soil is the foundation of agriculture. It acts as a nutrient medium and plant anchor, a holder of water and air, and a structure for microbial life. A poor soil structure can cause problems with workability, water infiltration and retention, nutrient leaching and vulnerability to erosion. Of all components of the agroecosystem, the condition of the soil is the most crucial and can, if healthy, offer the most direct benefits to the farmer. Soil generation is generally a slow process, and the declining soil quality experienced in many regions of the world severely limits productivity (FAO, 2002; Rosegrant and Cline, 2003). A contemporary economic incentive for improving soil health is that synthetic fertiliser application is subject to diminishing returns (Tivy, 1990; Cassman, 1999) and increasingly high input rates are required to achieve the same levels of growth.

Building soil structure and improving soil health is central to agroecological management practices. Soil nutrients are managed by closing resource loops through the use of green manures and cover crops, mulches, compost and the incorporation of below-ground biomass in roots. Tillage is carefully considered; it is usually necessary to aerate the soil, to improve water percolation and control weeds, but it can also degrade soil structure, increase erosion and accelerate the mineralisation of organic compounds (Silgram and Shepherd, 1999), and therefore needs to be carefully managed.

Microbes make an enormous contribution to soil quality. Singh, Pandey and Singh (2011) demonstrate this in a comprehensive review, with specific reference to sustainable agriculture, highlighting the role of microbes in making nutrients soluble, competing with and controlling plant pathogens and pests, and stabilising soil. As with above-ground biodiversity, soil microbial diversity is linked with ecosystem stability and productivity (Franklin, 1993). Management practices have been shown to impact heavily on soil microbial composition; in particular, soil disturbance and low soil organic matter depress microbial biomass and diversity (Izquierdo et al., 2003; Pimentel et al., 2005) and pesticides disrupt microbial communities and function (Van der Werff, 1996). Such findings inform agroecological cropping practices, for example to favour intercropping and rotation in order to maintain the stability of microbial populations.

The relationship between different components of soil and yield is extremely complex. One review, for example, reports on studies which found that intensive industrial cropping including tillage caused a decline of soil organic carbon (Azeez, 2009), while another study found that intensive cropping increased soil

organic carbon and resulted in greater crop yields as root biomass increased (Benbi and Brar, 2009). In agroecological management, soil organic carbon is fortified by the incorporation of organic matter and minimisation of soil disturbance.

Agroecological management sources nutrients locally wherever possible. Robertson and Swinton (2005) suggest that nutrient requirements must be met externally in the absence of substantial internal sources and where a significant proportion of the crop is removed from the field. Strategies for locally-produced nutrients include using rotations with leguminous cover crops or green manures and incorporating animal manure, plant residues or compost made from waste materials; these can be easier to implement on smaller farms. Utilisation of nutrients is facilitated by agroecological management practices that improve soil quality to encourage organisms such as those responsible for the mineralisation of nitrogen and arbuscular mycorrhizae, which are particularly important for phosphorus uptake. Addition of biochar has been shown to decrease nutrient leaching considerably (Laird et al., 2010) and suggests one option for managing nutrients, as well as a possible way of reducing atmospheric CO_2 levels (Shackley and Sohi, 2011).

Agroecological principles advocate closing resource loops to avoid the export of nutrients. Increased segregation of farming systems – both in terms of their functions and in terms of their segregation from society – is one of the reasons that resource cycles are difficult to close. For example, the spatial separation of feed and animal production that characterises industrial agriculture leads to net exports of nutrients from production systems through the creation of open resource loops (Magdoff, 2007; Archer et al., 2008; Hendrickson, Liebig and Sassenrath, 2008). It also creates significant environmental problems, particularly water pollution. Agroecology's emphasis on closing resource loops and maximising the use of on-farm inputs implies the reintegration of livestock and agriculture to optimise energy and nutrient transfers.

Closing resource loops does not however have to be limited to agricultural operations; it also implies making use of consumer wastes. There are several potential routes for integrating different sectors with food production in order to close resource loops. These include the use of biochar, green compost or human urine and faeces as a resource in agriculture (Malkki, 1999), but also the production of renewable energy from waste, for example by using anaerobic digestion in farm-scale installations.

Water use and conservation

The conservation and efficient use of water are basic principles of agroecology.

Water imposes one of the greatest limitations on crop growth (Tivy, 1990), and the conservation and efficient use of water are basic principles of agroecology. Water availability is critical in determining which crops will grow, how much they will produce, and the efficient use of fertilisers. Irrigated agriculture has made enormous contributions to global agricultural output, but, if poorly managed, has negative consequences which include altering hydrology, changing habitats and the salinisation of agricultural land. Despite the importance of irrigation, more than 60% of the world's food is estimated to come from rainfed agriculture (FAO, 2002).

Innovations in irrigation technology, adding sprinkler, drip and underground irrigation to predominantly rainfed systems, are still ongoing. Some evidence suggests that improvements in water use efficiency through harvesting and agroecosystem design can significantly improve yields (Rosegrant and Cline, 2003).

Agriculture is a major mediating factor in water cycles, and management has significance beyond crop growth. Run-off and soil erosion can be reduced by maintaining permanent soil cover, which is easily reconciled with the use of mulches and green manures as part of agroecological management strategies. This also improves water penetration into the soil, and together with a good soil structure can reduce the leaching of nutrients into groundwater and streams.

Agroecological management can also involve the manipulation of vegetation structure and associations to create microclimates, for example improving the water use efficiency of shade-adapted crops. Living fences act as windbreaks, decreasing evapotranspiration, but can also reduce runoff and provide forage and biomass. Many agroecological land management systems use physical features to improve water retention, especially in Latin America where terracing and contour planting are widespread.

There is also evidence that organic farming practices impart improved drought tolerance; in one study, corn yields were 30% higher in drought years with organic

than with than with conventional methods (Pimentel et al., 2005). In the UK, a recent comparison of paired farms taking organic and conventional approaches to grassland management showed significantly higher infiltration rates for certified organic management (Sunderland et al., 2012). The authors also predicted a 30% reduction in peak flooding levels in a catchment with organic management.

Agroecological principles are appearing increasingly frequently in international water and food security policy narratives. A recent UN Environment Programme report (Boelee et al., 2011) calls for a shift in water management from 'water for food' to 'water for multifunctional agroecosystems', while 'Feeding a Thirsty World', a major report by the Stockholm Water Institute, discusses the potential of vegetarianism and global dietary changes as a means of coping with declining water availability (Jägerskog and Jønch-Clausen, 2012).

Biodiversity and agro-biodiversity

Agroecological methods aim to sustain or improve functional diversity to in order to create more stable, resilient and productive agroecosystems.

Many farming practices used in intensive agricultural production – including greater specialisation and the routine use of pesticides and fertilisers – have a negative impact on biodiversity, affecting the stability and functioning of agroecosystems. For example, the specialisation of farms and the trend to increasing size has resulted in loss of farmland habitats, and moves to make farming more efficient have resulted in the removal of hedges, ponds and other structures. The result is a more uniform habitat with less diverse vegetation structure, fewer niches and less opportunity for species to move between habitats.

The biodiversity of an agroecosystem includes all the living species on a site, including the livestock, crops and natural components of the ecosystem, but it also encompasses the genetic and phenotypic variation within these species (Tilman, 2001). In most ecosystems, greater biodiversity is desirable, as the most diverse ecosystems tend to be those which provide greater stability, resilience to disturbance and are the most productive in terms of total biomass. Greater biodiversity contributes to the functional diversity of the ecosystem: the range and value of the species which contribute to and influence ecosystem processes. The rate and dynamics of ecosystem processes such as primary production, total plant biomass and nutrient cycling are influenced by both the biodiversity and the functional diversity of an ecosystem.

Agroecological methods aim to sustain or improve functional diversity to in order to create more stable, resilient and productive agroecosystems. The contribution of biological diversity to ecosystem functioning in agricultural production systems can be substantial. In arable systems, genetic and species diversity are both important (Hajjar, Jarvis and Gemmill-Herren, 2008). By contributing to the long-term stability of agroecosystems and helping to provide continuous biomass cover, crop genetic diversity aids the ecosystem in sequestering carbon and helps prevent soil erosion.

Spatial and temporal diversity of cropping is an important characteristic of agroecological management practices. It allows crop plants to exploit complementary niches, alleviating requirements for single nutrients and exploiting different non-competitive growth habits. Soil fertility can be enhanced by the use of nitrogen fixing species, or recruitment of beneficial soil microbial and fungal communities, which provide conditions that facilitate the growth of other species.

Agroecological methods of pest control are based on an understanding of pest ecology and lifecycles, optimum planting times and crop selection, and maintenance of biodiverse agroecosystems rather than external inputs. Complex agroecosystems tend to have relatively high levels of associated biodiversity, which can then be exploited in the control of insect pests, especially if they include wild vegetation and are close to natural stands. Designing pest control regimes to work with natural ecosystems can significantly reduce the risk of outbreaks.

Biodiversity is often distinguished in agricultural land use as either planned or associated. Planned diversity includes the temporal and spatial organisation of crops, while associated diversity is constituted by the incidence of wild species. The push–pull system of pest control is one example of an agroecological management practice that makes effective use of planned diversity to control pests, by using attractive and repellent plants to disrupt pest lifecycles.

Agro-biodiversity is also vital for combating environmental stress and variability, as well as being valuable for future plant breeding efforts. According to the FAO (2004) agro-biodiversity is a vital sub-set of biodiversity

and is the result of both natural selection processes and the selection practices of farmers, herders and fishers over millennia. Modern intensive farming tends to rely only on a few highly-bred species to provide the most of the food we eat. Agroecology aims to improve agro-biodiversity by conserving and using a wider range of breeds and varieties suited to local conditions.

In a US Department of Agriculture report, Rubenstein et al. (2005) lay out why crop genetic resources are largely a public good, and how to value them in an economic appraisal. Particularly in less industrialised countries, agroecology emphasises the role of farmers in conserving crop genetic diversity as a strategy for managing risks (Gauchan et al., 2005), but crop genetic diversity also plays a significant role in agroecological management in industrialised countries.

Climate and atmosphere

Agroecological practices, which favour the protection of soil carbon and carbon sequestration in vegetation biomass, hold huge potential for climate change mitigation.

Agriculture can act as both a source and a sink for carbon emissions and therefore plays an important role either contributing to or mitigating climate change. Major agricultural sources of carbon emissions include use of fossil fuels, the use of fertilisers and the loss of organic matter in soils resulting from intensive cultivation practices. Estimates vary, but if land use change is included in the calculation, 30% of total emissions of anthropogenic greenhouse gases can be attributed to agriculture (Paustian et al., 2006).

Bellarby et al. (2008) report that 89% of the potential mitigation from agriculture comes from carbon sequestration. Agroecological practices, which favour the protection of soil carbon and carbon sequestration in vegetation biomass, hold huge potential for climate change mitigation. For instance, zero-tillage cultivation may result in reduced wind and water erosion and building of soil, which increases water retention capability, organic matter and soil microbes, leading to increased carbon sequestration. Carbon is also sequestered in above-ground woody biomass, with considerable improvement in sequestration rates coming from changes in land use, for example from arable to agroforestry. Intercropping trees in cropping and grazing systems is a long-standing recommended agroecological management practice (Pretty and Bull, 2001). In some areas, government-supported carbon offset schemes can be used to generate income for using agroecological techniques, as shown in Box 3.

BOX 3. Carbon Farming Initiative – support for agroecological practices

The Carbon Farming Initiative is a voluntary Australian Government carbon offset scheme. It is designed to help farmers earn additional income from reducing emissions and sequestering carbon through changes to agricultural and land management practices including reforestation, manure management, protecting soil carbon and use of biochar. Through these activities, participating farmers will be able to generate credits that can be sold to individuals and businesses that want to offset their own greenhouse gas emissions.

Source: Australian Government Department of Climate Change and Energy Efficiency (2013)

De Schutter (2010) gives a comprehensive set of other benefits that agroecology can deliver to climate change adaptation. Among them are resilience to adverse weather events like hurricanes, landslides, erosion, droughts and floods, limiting risks from new invasive pests, weed and diseases favoured by climate change, and the decoupling of agriculture from its reliance on fossil fuels (De Schutter, 2010).

Assessing and valuing agroecosystem properties and characteristics

Assessing and valuing the performance of agroecosystems and agroecological management practices against a range of criteria is an important consideration for the widespread adoption of agroecological management.

As described above, agroecological management aims to strengthen the sustainability of agroecosystems and food production. Assessing and valuing the performance of agroecosystems and agroecological management practices against a range of criteria is therefore an important consideration for the widespread adoption of agroecological management.

The dominant contemporary method for valuing the natural environment is the concept of ecosystem services (Millennium Ecosystem Assessment, 2005). This attempt to price the different services provided by ecosystems fits well with the current economic system

and has helped to frame environmental issues for economists and policy-makers (Costanza et al., 1997). Agroecosystem performance may benefit from a similar approach, notwithstanding that critics argue for a new economic paradigm to complement the agroecological paradigm.

One of the core indicators of the performance of agroecological systems is their productive capability, not only in terms of crops and crop by-products, but also of other outputs like biodiversity and social cohesion, which are much more complex to value. While an extensive literature examines ecological and agro-environmental indicators and the quantification of changes in ecological systems (Dale and Polasky, 2007), agroecology aspires to measure agroecosystem performance against social as well as bio-physical indicators.

2.2 Socio-economic characteristics of agroecosystems

Equity is at the root of agroecosystems approaches to the social and economic aspects of food production.

Agroecosystems cannot be understood as separate from farmers, their communities or the social and economic contexts in which they are located. The socio-economic components of agroecosystems include population density, gender dynamics, labour availability, social organisation, prices and markets, knowledge, and technology.

Altieri (2004: 2) notes that "traditional agroecosystems and associated plant diversity are the result of a complex co-evolutionary process between natural and social systems, resulting in strategies for ecosystem appropriation". Industrial agriculture and the globalised food system have disrupted this co-evolution, increasing the physical and social distances between producers and consumers, and their respective environmental contexts (Bacon et al., 2012).

Equity is at the root of agroecosystems approaches to the social and economic aspects of food production. For some, equity is achieved when an agroecosystem meets demands for food without increasing the social costs of production; for others, it applies to the equal distribution of incomes within producing communities (Altieri, 1995).

Agroecology shares many socio-economic principles with food sovereignty, a concept that is framed by explicit opposition to the dominance of the global food and agriculture system by transnational corporations. It identifies food as a right and not a commodity, and argues that the people who produce, distribute and consume food should be at the centre of decisions on food systems and policies (Pimbert, 2009a).

Agroecology and food sovereignty advocates share a concern for the conservation of indigenous knowledge, the right of consumers to sufficient and healthy food, and the right of food producers to a livelihood. Both emphasise the importance of localised food systems which bring producers and consumers closer together, and of building the knowledge and skills food producers need to conserve, develop and manage localised food production and harvesting systems.

The principles of agroecology have implications for how agroecological farms engage with the commercial framework of agriculture and the wider food system (Jones, Pimbert and Jiggins, 2012).

Trade and markets

The principles of agroecological management imply a strong emphasis on local marketing and trade of inputs and products.

The principles of agroecological management imply a strong emphasis on local marketing and trade of inputs and products. Inputs should be sourced on the farm where possible. Where this is not feasible, agroecologists advocate strengthening decentralised, local trade in inputs. This requires not only co-ordinated efforts at the farm scale and between farms (Sutherland et al. 2012), but also at the regional level, between agri-businesses and commercial support services. Emphasising regional markets would encourage the disaggregation of production activities, meaning relatively smaller farms and greater regional heterogeneity.

The most common purchased inputs on agroecological farms are seeds, plants and organic fertilisers for crops, animals, and fodder for livestock production (Offermann and Nieberg, 2000). Regional sourcing of these inputs would strengthen social capital through encouraging knowledge transfer and sharing of experiences which are relevant to local climate and resource conditions. Regional markets are well-placed to cater for the local requirements of the dominant types of agricultural production, providing for example locally-appropriate

crop genotypes. The regional market model for agricultural resources would also facilitate the sharing of benefits from participatory plant breeding and on-farm seed multiplication (Assefa et al., 2011; Pretty, Toulmin and Williams, 2011), and research has shown that local food markets also have an important role to play in conserving genetic diversity in less industrialised countries (Goland and Bauer, 2004; Duram and Oberholtzer, 2010).

Supporting local marketing of agricultural products means bringing consumers and producers closer together to create localised food systems. A variety of models have emerged for achieving this. Box 4 discusses the example of Community Supported Agriculture (CSA) in the UK, but others include box schemes and farmers' markets.

Farm size

Agroecological farms are often relatively small, and farm size is an important part of discussions about sustainability.

Agroecological farms are often relatively small, and farm size is an important part of discussions about sustainability (Rosset, 1999; Altieri, 2004). D'Souza and Ikerd (2006) evaluate the properties of small farms compared with larger intensive operations and conclude that from a sustainability perspective, farms in the future – in common with other knowledge-based enterprises – will need to become smaller to remain competitive. There is ongoing debate on the nature of relationship between farm size and productivity of outputs like crop yield and biodiversity (Gabriel et al., 2010). Heltberg's (1998) discussion of this relationship includes considerations of the labour, land and credit market imperfections that favour larger intensive farms. Small farms already make a sizeable contribution to national food production, and hence food security, at the same time as providing considerable benefits to rural and subsistence communities (Vorley, Pozo-Vergnes and Barnett, 2012) and the size of the farm is arguably not as important as how it is managed in terms of productivity.

BOX 4. Community Supported Agriculture – a model for local food systems

Community Supported Agriculture schemes are run as partnerships between farmers and the local community. Early CSA projects were set up by farmers seeking a community of people to buy shares of the harvest at the beginning of the growing season. As the CSA movement has grown globally, a range of different models have emerged, from whole farm CSAs to urban food growing projects. For growers, CSAs mean a more stable income, good connections to local communities and support for using sustainable methods of production.

StroudCo in Stroud, UK is an example of a CSA jointly owned by producers and consumers. The enterprise trades about 100 products including fruit, vegetables, meat and dairy products. Consumers order and pay in advance online, and producers receive a single collated order in advance and deliver once a week to a collection point in a school. Overall management is controlled by an elected board comprising half consumers and half producers. Consumer members of StroudCo are expected to do at least two hours unpaid labour per year.

Sources: Gouzin, Williams and Devereux (2013) and Saltmarsh, Meldrum and Longhurst (2011)

Food supply chains

Cooperatives and local farmers' organisations are an often-neglected means of representing farmers in food supply chains and are critical for the adoption of agroecological practices.

The relatively small size of agroecological farms means that they are more suited to regional food markets, so agroecological production also has implications for the food supply chain. Closing the distance between farmers and consumers can facilitate communication about and understanding of the features of a food system based on agroecological principles (Lockeretz, 1986; Borsari, 2011; Amate and de Molina, 2013). Consumers in an agroecological food system, for example, will experience more seasonal variability in their diet, as well as less processed food and reduced choice.

Lower volumes due to smaller size and lower proportion of land given over to single crops on agroecological farms may reduce efficiencies of scale, and can also be associated with higher capital costs for several processing streams and higher transaction costs. However higher total production associated with the growing of more than one crop in the field may outweigh this. Direct marketing may be well-suited to this kind of production, as it can cope with irregular supply and avoid the transaction costs implied by middlemen, but farmer cooperatives can also help to improve capital efficiency. Co-operatives and farmer organisations have been centrally important to representing the interests of farmers in food supply chains in less industrialised as well as industrialised countries. Pretty (1995) argues that the importance of local organisations and institutions has often been neglected, but that they are critical for the adoption of agroecological practices.

Although existing centralised supply chain systems and contract farming (Hendrickson, Liebig and Sassenrath, 2008) contrast starkly with alternative markets (Follet, 2009; Duram and Oberholtzer, 2010) it may also be desirable to incorporate agroecological production into existing food chains in order to benefit from opportunities of scale and efficiency, and to meet the requirements of consumers.

Labour

Agroecological practices are associated with higher labour requirements than conventional agriculture.

Agroecological practices are associated with higher labour requirements than conventional agriculture (Offermann and Nieberg, 2000; Pimentel et al., 2005) although this also depends on the choice of outputs and on the potential for on-farm processing. If agroecological production systems become more widespread, more rural employment will be created, and it is likely to be more stable and less seasonal than that offered by industrial agriculture. Demand for services associated with agroecological practices could also create rural employment opportunities, as illustrated by the example of the emergence of labourer networks skilled at producing the planting pits used in zero-till agriculture in Africa (Pretty, Toulmin and Williams, 2011).

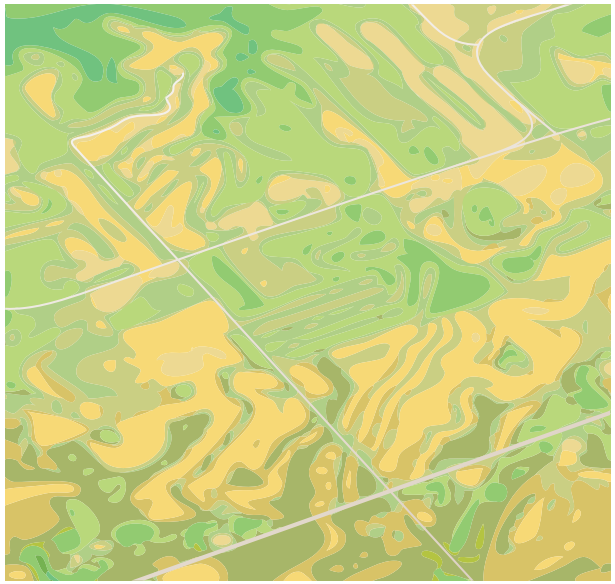
Availability of sufficiently flexible labour, especially in regions with rural–urban migration and an aging rural population, may be a challenge. Meeting this challenge would require greater integration between the agricultural and urban planning sectors, which would facilitate not only labour availability but also the development of local markets.

Extension and education

Extension practices and education in agronomy are often isolated from ecological concerns and agroecological knowledge.

The IAASTD Report notes that the agricultural knowledge, science and technology sector has little interaction with academic initiatives, particularly in ecology and the social sciences, and that this in turn inhibits the design of support and extension systems that meet sustainability goals (McIntyre et al, 2009).

Furthermore, extension practices and education in agronomy are often isolated from ecological concerns and agroecological knowledge (Cox and Atkins, 1979). This in turn has influenced the belief systems and mindsets of those working in agriculture so that there is an unwillingness to consider agroecology as a viable way forward, even with little evidence to the contrary.



3. Barriers to mainstreaming agroecology

A more widespread adoption of agroecology would lead to building agricultural sectors that conserve and enrich natural resources and contribute to equitable development. Achieving this would mean incorporating agroecological principles and practices into decisions about farming practices, consumption and agricultural policy, and would challenge the powerful entrenched interests of the industrial agriculture and food production systems. Such systemic change faces numerous barriers, ranging from the demographic and social structures which prevent some sections of the population from becoming involved in agriculture, to the behaviours and motivations of consumers and the ideologies and priorities of policy-makers.

3.1 Gender balance and demographics

Barriers to land ownership and access, particularly for women and young people, limit the widespread adoption of agroecological practices.

Women constitute 43% of the global agricultural labour force (FAO, 2011a). In less industrialised countries in particular, this presents challenges for wider adoption of agroecological practices. Women are often marginalised and suffer from lack of access to credit, land, education and decision-making power (Ajani, 2008). They often have less access than men to schemes and grants. The UN's Special Rapporteur on the Right to Food notes that gender issues are incorporated into less than 10% of initiatives to provide development assistance in agriculture, and concludes that one of the means of scaling up agroecology is to support the dissemination of knowledge about sustainable agricultural practices by relying on existing farmers' organisations and networks, and including schemes designed specifically for women (De Schutter, 2010).

In the industrialised world women are also marginalised in farming. The 2010 UK Farm Business Survey shows that numbers of female farmers are very low across different farming systems. The only exceptions are organic horticulture (43% female managers) and equine businesses (49 %) (Authors' own data).

Hendrickson et al. (2008) describe demographics as one of three key factors limiting the adoption of integrated farming systems in the US. This is also widely recognised in the EU, and attempts have been made to address the problem by involving young people in agriculture through various programmes. This is hampered to a major degree by the barriers to land ownership and access, including the increasing costs of agricultural land. The trend of rural depopulation has a powerful effect on the human capital needed increase the adoption of agroecological approaches, and this is exacerbated by low agricultural wages which are not conducive to labour movements into rural areas.

3.2 Integration, concentration and specialisation in agri-business

Extensive vertical integration and consolidation in the food industry can restrict farmers' freedom to adopt new approaches.

Decisions related to production economics are one of the primary obstacles to implementing agroecological practices. Extensive vertical integration and consolidation in the food industry can restrict farmers' freedom to adopt new approaches. In the USA in 2004, for example, 21 companies dominated food processing, with the four largest in each sector controlling between 45 and 81% of the market (Clay, 2004). An expert panel in the USA found that the most significant factors influencing the structure of agricultural systems were low margins and globalisation, both of which encourage concentration and specialisation (Archer et al., 2008). The same panel found that vertical integration and greater economies of scale contributed to a decrease in the number of products produced per farm from five to one in this century. Globally, processed food products are based on just a few crops including sugar, palm oil, maize and soya.

These trends limit the options of farmers who need stable and reliable markets for their products and who are cut off from local markets that could potentially exhibit these characteristics. In addition, farmers have seen the proportion of total expenditure on food that they receive decline from 38 to 8% over the century (Gliessman, 2007). This is partly explained by the increased value added in the supply chain through processing, packaging and convenience, but it also reflects a loss of producer power, with large mark-ups on producer prices even for goods that require no processing.

3.3 Economic viability of agroecological approaches

The negative impacts of industrial farming are often externalised and paid for by social sectors such as health and the environment. Because agroecological systems attempt to incorporate the costs of mitigating these impacts, economic viability in competition with industrial agriculture can be hard to achieve.

The economic viability of agroecological approaches is a major barrier to their wider uptake. The negative impacts of industrial farming are often externalised and paid for by social sectors such as health and environment. Because agroecological systems attempt to incorporate the costs of mitigating these impacts, economic viability in competition with industrial agriculture can be hard to achieve.

Although agroecological farms can increase productivity by reducing the cost of inputs and machinery, the costs of labour are also often high in industrialised countries. According to Scherr, McNeely and Shames (2008), however, many 'eco-agriculture' systems are more profitable than the alternatives. They present 28 case studies from Asia, Africa, America and Europe that demonstrate positive economic benefits, and another five cases where 'eco-agricultural' management practices had a neutral impact on incomes (McNeely and Scherr, 2001). Often, profitability was realised through targeted marketing where organic or other ethical labels could achieve a price premium for a certified product and service.

Although economic constraints and competition with intensive systems in industrialised countries is becoming more severe, there is a current worldwide growth in direct sales and local food sourcing. This is still however dwarfed by markets for goods produced within the industrial food system.

3.4 Consumer motivation and behaviour

Consumer demand is sensitive to economic context, and willingness to pay for sustainable production is currently not sufficient to deliver agroecological production on a large scale.

In free markets, the adoption of sustainable farming practices is influenced by consumer demand for its products. However, this demand is shaped by food companies that spend billions on advertising campaigns to promote their products, hardly any of which are produced agroecologically. At the same time, the concept of consumer demand is worth interrogating, given that consumers were not asked if they wanted industrially-produced food in the era when industrial agriculture was becoming established.

Consumer demand is also sensitive to the economic context, as illustrated by the recent drop in market

share for many organic products following the 2008–2012 recession in the UK (Soil Association, 2011; 2012). This may indicate that willingness to pay for sustainable production is currently not sufficient to deliver agroecological production on a large scale. However, whilst demand for organic produce has dropped, demand for 'local produce' has accelerated and supermarkets have lost nearly 10% of their share within the organic market to other food distribution types (Soil Association, 2011; 2012). The Institute for Grocery Distribution (2012) reported that UK shoppers remained keen to support their local economy and community by supporting local producers and retailers, despite the economic downturn, a trend which has also been identified at the European scale (European Commission, 2012). As such, the agroecological principle of encouraging localised food systems is in line with consistent consumer interest in buying local, particularly for social and economic reasons. The UK is also the only country in Europe which has seen a recent drop in organic sales; one reason for this is the dominance of supermarkets in the UK food system.

A report from the UK Government (Defra, 2008) discusses pro-environmental consumer behaviours and identifies the stratification of social groups according to environmental concerns. It found a relatively small appetite for radical lifestyle changes, noting instead many small behaviour changes to improve current lifestyles, such as changing wasteful behaviours and developing green shopping habits. A market study of organic consumers in the UK found that demand is not only related to environmental or ethical considerations, but that health and nutrition are equally important factors choosing organic products (Soil Association, 2010).

A report by the US Department of Agriculture (Blisard et al., 2002) highlights changes in the consumption patterns of US consumers. It shows that increasing ethnic diversity in the population leads to the consumption of more diverse foods. There is also however a demand for homogeneity and food uniformity, although this could be artificially imposed by internal retailer standards. Today's consumers are willing to spend more on processed food, convenience and service, even though there is some evidence that demand for environmental quality grows with income (Archer et al., 2008).

Price is generally considered as the main driver of purchasing decisions. This emphasises the need for a value-based strategy for motivating environmentally positive behaviours (Crompton, 2008). The concept of the "citizen consumer" – an individual who realises their values and personal responsibilities through consumer decisions – has been put forward as a mechanism to drive ethical consumption and use market forces to effect positive change (Lockie, 2009). This combines a liberal model of citizenship, which emphasises the ability of individuals to monitor and regulate their own behaviour, with the ecological model of food citizenship, which is expressed through participation in social arrangements based on solidarity and coordinated action.

Agroecological production promotes different food systems, and their relationship to consumers can be examined in this regard. Food produced by agroecological practices will need to be reconciled with consumer demands for convenience and highly processed food. Communication and knowledge brokerage will certainly need to be part of longer-term strategies to engage consumers, but the stronger rural and community values that should result from increased use of agroecological approaches will also reciprocally effect production.

It is worth noting that several studies have emphasized that 'reconnecting' consumers and producers can promote behaviour change, not only in relation to food, but also towards other environmental issues. Cox et al. (2008) and Hayden and Buck (2012) found evidence of changes in consumption and lifestyle amongst participants in CSA schemes such as those discussed in Box 4.

Marketing and media are major influences on consumers, often driving unsustainable consumption trends, although some marketing has also adopted environmental and sustainability rhetoric in response to changing demands. Marketing and commercialisation can therefore also help to popularise agroecological practices, especially if tied to commercialising agroecosystem amenity values such as access to diverse countryside or active participation in the way food is produced, processed and distributed. As well as fostering producer–consumer relationships, closer urban–rural integration would help to appreciate the identification with agroecological landscapes.

Diet – in particular, reduced consumption of meat – is another aspect of consumer behaviour which could support agroecological production systems. For example, if a 'Scandinavian diet' which relies on five cereals were more widely adopted, it could enable mixed crop rotations with increased diversity of cereals. The challenge here is how to influence dietary change, which is driven by culture as well as marketing. Bringing consumers and producers together may help in this regard: a recent study of CSAs in England (Saltmarsh,

Meldrum and Longhurst, 2011) found that 70% of CSA members said that their cooking and eating habits had changed, primarily through using more local and seasonal food.

3.5 Policy context

Policies are needed to create incentives and capabilities for the adoption of agroecological practices.

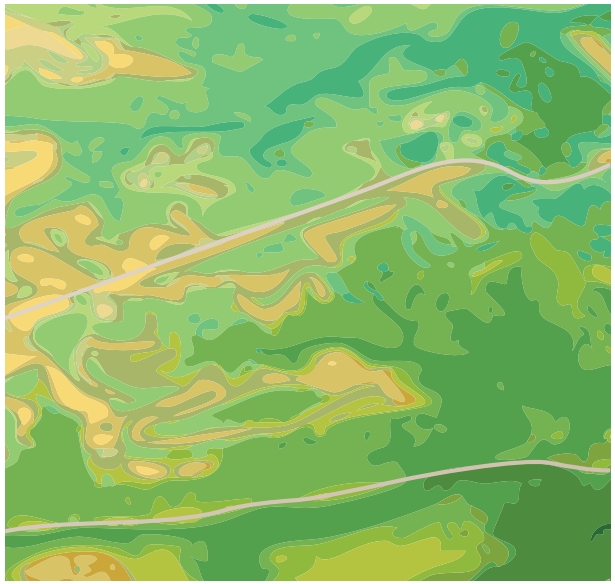
Increased market volatility in 2008 and 2010 and the ensuing export bans and restriction imposed by some countries in an attempt to protect domestic food supplies (FAO, 2011b) acted as a global wake-up call to reconsider the importance of food security in politics. Since then, there has been a renewed focus on food policies that include but also look beyond ensuring a robust agricultural sector. In UK, for example, there has been considerable attention paid to the fact that only 60% of UK food is home-produced, and that about 40% of total food purchased is wasted (Barling, Sharpe and Lang., 2008; House of Commons, 2009).

Policies are needed that mediate the tendencies of corporate food producers to drive global farming decisions (Robertson and Swinton, 2005) through creating incentives and capabilities for the adoption of agroecological practices. This is not necessarily an easy balance to achieve. In the EU, for example, while removal of production-linked subsidies rapidly reduced the region's production surplus, markets currently do little to decrease environmentally damaging practices. Statutory regulations are in place which are intended to create a basic level of sustainable agricultural practice, but no inspection system is in place to police these standards. Certified organic production, which shows the greatest market promise for agroecological management practice, can currently best be described as a well-established niche (below 10% market share in most countries) with a large potential for future growth.

Supportive policies will be required if crop and livestock production systems are to be managed as ecosystems, with management decisions fully informed of environmental costs and benefits. James (2006) contrasts two approaches to sustainability in agriculture. In the first, market forces guide agricultural activities, while the second sees economics balanced with environmental and social objectives. This second approach does not however easily reconcile with the evident social inequities and the asymmetrical distribution of power and interests in global markets. Neither does it make sufficient allowance for the interests of those whose welfare is harmed or whose liberties are curtailed by the economic pursuits of others.

It has long been proposed that land managers become stakeholders responsible for environmental stewardship (Bromley, 2000). This view is now being adopted at the political level in the EU and the Organization for Economic Cooperation and Development (Losch, 2004; Marsden and Sonnino, 2008) through the increasing acceptance of the idea of multifunctionality, which recognises the services of agroecosystems beyond provisioning. The implications are that farmers should be rewarded for the maintenance and provision of these services (Tilman et al., 2002). Pricing externalities and incorporating them into production costs means creating markets for environmental services. This will be a major challenge because environmental services have long been viewed as public goods, and this approach requires them to be measured and quantified (Dale and Polasky, 2007).

From a rural development perspective, in many places higher rural labour requirements are desirable and could contribute significantly to the revitalising of rural economies, which remains on the agenda of many development agencies and governments. Not only do agroecological approaches use more labour, they also tend to use less mechanised equipment and therefore less fuel, which is likely to become more important as rising fuel costs contribute to higher food prices as they did in 2011 (FAO, 2011c). The partial substitution of manual labour for mechanisation may facilitate the scaling up of the productivity gains found in smaller-scale farms using agroecological practices. Policy-makers can contribute to rural development by supporting agroecological farming through facilitating land, labour, infrastructure and knowledge needs. Most important is access to information and extension founded on participatory approaches. The regionalisation of all aspects of farming, including research and extension agencies, and farmer organisations, is crucial.



4. Priority areas for policy, research and practice

Based on ecological sciences and guided by practical requirements for sustainable development, agroecology contributes to the design of agricultural systems that are robust, productive and equitable and which preserve the integrity of ecosystem services. Many remarkable projects have demonstrated the potential of agroecological land management, and these are supported by a strong academic foundation in the natural and social sciences.

The pressures facing agricultural and ecosystem health are sufficiently critical to merit action. Economic arguments for the conservation of our natural resources and sustainable reform of the agricultural sector are convincing, and take equal precedence with those which emphasise intrinsic values and ethical responsibilities.

There will be significant differences between farming transitions in different countries, with specific requirements for and barriers to change. International development policy should acknowledge the diverse capabilities and requirements of different countries, and this should be reflected in priorities. Just as a single agroecological practice will not be universally appropriate, no single policy will be relevant everywhere. In some regions, food security and stability or land tenure and market access may be most significant, while in others seriously declining ecosystem services may present the more immediate priority. In all cases, policy-makers will face the challenge of balancing a range of needs and priorities, so robust guidelines for managing trade-offs must be in place.

Markets are powerful mechanisms for shaping resource use and production, and for stimulating creativity and innovation by communities. But concerted government action will also be necessary to scale up agroecological production, especially while some countries are still moving to reform their agricultural sectors in the opposite direction. This concluding section therefore highlights priority areas for policy, knowledge management, agricultural extension and research.

4.1 Agricultural policy

Agroecology has strong roots in traditional, small-scale and subsistence agriculture. Many of the practices are therefore tailored for the available labour and resources of small-scale farms. Making these practices viable in different economies is a challenge for policy. Sustainability must be balanced with productivity and adequate accounting of whole system performance. Agroecology should be endorsed as way of achieving food security by further establishing its capability to meet growing food demands sustainably.

- Build a progressive, knowledge-based agricultural sector which fosters the participation of all stakeholders to deliver strong support, extension and education services for agroecological technologies.
- Secure gender-equitable rights of access and use for land, water, forests, common property resources and seeds.
- Protect the knowledge and rights of farmers and pastoralists to save seed and improve crop varieties and livestock breeds, for example by banning seed

patents and inappropriate intellectual property right legislation.

- Support small farm agriculture where appropriate, and support co-operatives to assist small farmers to trade more effectively through facilitating their access to markets.

- Prioritise the use of local resources to meet the requirements of an agroecological farming sector.

- Align agricultural policy more closely with rural and urban planning processes, and prioritise infrastructure investment.

4.2 Economic policy

In order to create demands for agroecological production, current economic frameworks favour the establishment of market mechanisms. Although some of the expense of including the cost of the external environmental impacts of agricultural production in product prices can be taken up by distributors in food supply chains, much of it will be borne by consumers, either via taxation or food prices. Accounting for the value of and revenue from environmental services and the costs of stewardship or remediation is essential, because the economy as a whole may benefit from more widespread agroecological production through, for example, increased tourism, public health, employment and stronger rural economies. These benefits may even offset any investment and payment for public goods provided by agroecological farming. The low input rate of non-renewable resources which characterises agroecological farming will make it far less susceptible than conventional agriculture to future input price increases.

- Create market conditions – including financial and regulatory mechanisms – that are favourable to rural and urban agroecological production.

- Restrict the concentration and market power of major agri-food corporations through new international treaties, competition laws and adoption of more flexible process and product standards.

- Manage supply to ensure that public support does not lead to over-production and dumping, lowering prices below the cost of production and harming farmers in all parts of the world.

- Develop improved markets for ecosystem services to provide incentives for their conservation and support for farming communities.

- Ensure that support for agricultural production is closely tied to stewardship of ecosystem function.

- Establish credible and accountable measurement systems to communicate the value of social and environmental services through prices and savings.

- Replace current economic growth measures with those that also account for external costs of production such as pollution, as well as external benefits such as rural development, ecosystem services, health and well-being.

4.3 Cross-sectoral policy

Governments have a responsibility to protect natural resources and ecosystem function which demands cross-sectoral approaches to policy. Policy-makers should recognise the non-monetary values of public goods that are difficult to value. Agreement should be sought at an international level on the valuation and incorporation of externalities in international markets, especially in view of trade liberalisation.

- Develop robust frameworks for assessing and evaluating existing food production systems that focus on their ecological integrity and socio-economic benefit, and use these as a basis for evidence-based policy.

- Develop approaches to land use planning that take agroecological principles into account and support agroecological practitioners in gaining access to land.

- Promote and encourage public–private and public–voluntary sector partnerships to deliver agroecological innovations in rural and urban areas.

- Support the regional integration of non-food sectors to close resource cycles, focusing in particular on recycling, waste and sewage processing.

4.4 Knowledge management and agricultural extension

Institutions are crucial for agroecological management, facilitating the provision of support, inputs and resources, conducting research, and disseminating knowledge. Effective implementation of agro-ecological management also requires oversight and monitoring by institutions, in particular of the performance and restoration of ecosystem services.

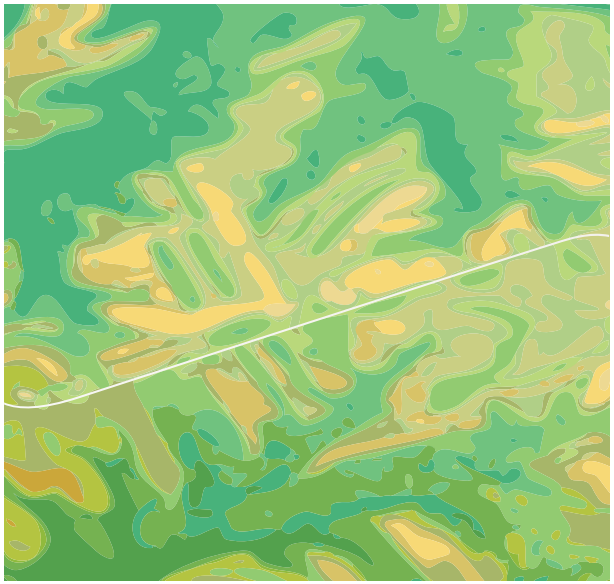
- Prioritise exchange of knowledge on agroecological management practices between all stakeholders by building regional, national and international information resources and networks.
- Regionalise extension and support services so that they engage with local farmers' organisations and cooperatives.
- Strengthen the capacity of local organisations to engage in farmer-led research and horizontal spread of agroecological innovations in rural and urban settings.
- Incorporate ecological and agroecological principals and multidisciplinary thinking and problem-solving into agricultural science curricula and research.
- Provide simple auditing systems for agroecological methods which strengthen producer sovereignty and autonomy.

4.5 Research

Agroecology has significant social and environmental benefits, but due to the different guises under which it has been practised around the world and the small scale of many agroecological farms, the potential implications of scaling up agroecological practices are not well understood. Agroecology has no codified set of practices and indicators of its performance are spread across a complex set of environmental and socio-economic domains.

Moreover, the determinants of innovation and factors that influence research choices – science policies, public–private partnerships, funding, and the cultural and cognitive routines of scientists – all combine to favour technological regimes that are well-suited to scientific reductionism and which marginalise more holistic approaches such as agroecology. Interactions between these determinants of innovation construct a technological regime and a lock-in situation that hinders the development of agroecological research (Vanloqueren and Baret, 2009). A more balanced allocation of resources in agricultural research and significant reforms in the larger framework that influences research priorities are needed to mainstream agroecological approaches based on the science of dynamic complexity and farmers' local knowledge (Pimbert, 2009b).

- Ensure that strategic research priorities and funding are re-directed to strengthen agroecological research and development.
- Support institutional and methodological innovations for inclusive forms of participatory research that allow researchers and non-researchers such as farmers and food consumers to define upstream strategic research priorities and co-produce agroecological knowledge.
- Address the implications of agroecological management in different cultural and environmental settings, both urban and rural.
- Further develop agroecological production techniques and disseminate knowledge of them to facilitate their more widespread use.
- Establish indicators for the objectives of agroecology, in particular the integrity, stability and autonomy of agroecosystems, and further develop indicators of ecosystem services and the trade-offs between them.
- Emphasise the use of economics and decision models to better understand how agroecological production can be structured through the use of market mechanisms, policies and consumer behaviours.



5. Conclusion

The UN Rapporteur on the Right to Food clearly outlines that the right to food is not a right to a minimum ration of calories, proteins and other specific nutrients, or a right to be fed. It is about being guaranteed the right to either feed oneself directly from productive land or other natural resources, or to purchase food (De Schutter, 2010). The current mainstream of industrialised farming and food provision has failed to deliver this right.

Although attempts are being made to make industrial farming more sustainable, they fail to address the fundamental problems with this system and are seen by many as 'tinkering around the edges.' As Wezel et al. (2009) have shown, agroecology's strength is that it is equally a science, a practice and a social movement. The social movement in particular is under no illusion that changes can be slow, because agri-business has had the power to maintain the industrialised agricultural production and food system in a static state for decades. This power includes control over access to land, large global marketing budgets, and influence on the political and research agendas.

De Molina (2013) addresses the relationship between agroecology, power and policy. He points out that while agroecology initially focused on small-scale farmers, other subjects – especially consumers and food policy – become relevant when dealing with food systems. The close relationship between agroecosystem dynamics and politics means therefore that political agroecology will have a crucial role to play in the agroecological transition.

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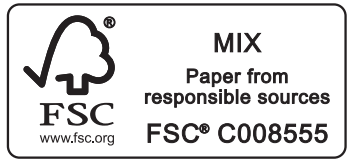

Coventry University

The Centre for Agroecology and Food Security

Creating resilient food systems worldwide

garden organic

The Centre for Agroecology and Food Security

The Centre for Agroecology and Food Security (CAFS) aims to meet the challenge of how to create resilient food systems worldwide. A joint initiative of Coventry University and Garden Organic, based in the West Midlands, CAFS undertakes applied research, postgraduate and professional education, and consultancy on agroecological farming and food systems both in the UK and internationally. Its four themes are:

- **Transition Technologies** – developing practical techniques that ensure both food nutritional security and ecosystems health
- **Stabilisation Agriculture** – building the ecological and social resilience of agriculture to withstand and respond to natural and man-made disasters
- **Fair Routes to Market** – enabling innovative and equitable approaches that allow access to the products of sustainable agriculture for all
- **Food and Communities** – exploring the social, cultural, economic and political dimensions of the relationship between people and the production and consumption of food.

The CAFS team comprises a multidisciplinary mixture of experts with over 30 years of global experience.