Ecological Farming

The seven principles of a food system that has people at its heart

May 2015

GREENPEACE

Contents

Acknowledgements

This report grew from the work of a great team of people working in Greenpeace, all over the world, on our Food for Life campaign. Without their contributions and ideas, writing this paper would have not been possible. There are many to thank, but I'd like to give my special gratitude to Iza Kruszewska, Alessandro Saccoccio, Jamie Choi, Paul Johnston and Zeina Alhajj, for their huge support and good humour.

To me, the biggest inspiration and hope for a better food system comes from the hundreds of farmers in India, Brazil, Kenya, Tanzania, Mexico, Spain… whom I have had the privilege to learn from during my work. Farmers are the backbone of our human civilisations, and deserve our biggest respect and support. However, many farmers and their families, especially smallholders, struggle for a safe and rewarding livelihood. This paper is dedicated to the millions of farmers in the world that grow our food with dignity and love, often getting too little in return.

For more information contact:
pressdesk.int@greenpeace.org

Written by:
Reyes Tirado, Greenpeace Research Laboratories, University of Exeter
reyes.tirado@greenpeace.org

Edited by:
Martin Baker, Daniel Kramb

Art Direction, Design and Infographics:
Sue Cowell / Atomo Design
www.atomodesign.nl

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Food *is* life. What we grow and eat sustains our bodies. It enlivens our culture. It strengthens our communities. It defines, perhaps more than anything else, what we are – as human beings.

Preface: Food for Life

Food *is* life. What we grow and eat sustains our bodies. It enlivens our culture. It strengthens our communities. It defines, perhaps more than anything else, what we are – as human beings.

And yet, the food system is broken. Consumers no longer trust what they eat. Many farmers are struggling with poverty. Malnourishment and obesity are blighting lives even where – on the surface – everything seems okay. And, millions of people around the world continue to go hungry, day after day.

What's more, the profit-driven, chemical-intensive, industrial-scale model of agriculture, which large parts of the world have subscribed to, is an enormous threat to the planet.

The most positive, life-sustaining human endeavour – the growing and eating of food – has been turned into a threat, with serious consequences for people and the planet.

Greenpeace's Food and Farming Vision aims to demonstrate that another way is possible.

Ecological Farming combines modern science and innovation with respect for nature and biodiversity. It ensures healthy farming and healthy food. It protects the soil, the water and the climate. It does not contaminate the environment with chemical inputs or use genetically engineered crops. And, it places people and farmers - consumers and producers, rather than the corporations who control our food now - at its very heart.

Greenpeace's Food and Farming Vision describes what Ecological Farming means, and how it can be summarised in seven overarching, interdependent principles – based on a growing body of scientific evidence on agroecology (Altieri, 1995, Gliessman, 2007).

We see this way of farming as a key – but by no means sole – ingredient of a wider new **Ecological Food System.** It is inextricably linked to rural and urban food consumption and waste, human health and human rights, equality in resource distribution, and many other elements of food production and consumption – and all these aspects need to be addressed.

Significant progress has been made over the last few decades. Concepts such as the "organic movement", the "locavore [locally produced food] movement", and "food sovereignty" have developed to challenge the damaging mainstream industrial agriculture model. Now is the time to go further. A new movement is forming around agroecology-based Ecological Farming, and it is gaining significant international support and momentum.[1]

Greenpeace sees itself as part of this **growing movement.** That is why this paper does not exclude other views about which aspects of agroecology should be the focus; its purpose is to highlight the issues where we see the biggest challenges and the most promising solutions.

Rural, social, and consumer movements, environmentalists, academics, and many others have been fundamental in creating support for agroecology. La Via Campesina, the Latin American Scientific Society of Agroecology (SOCLA), the Pesticide Action Network, and others are successfully working on different aspects of the issue. Meanwhile, academics and international institutions, such as the regional offices of the UN's Food and Agriculture Organization (FAO) and the CGIAR consortium - a global partnership that unites organisations engaged in research for a food secure future - keep adding evidence to a growing body of scientific research on agroecology.

We are convinced that there is a solid shared vision for Ecological Farming within this wide spectrum of approaches and focusses. If we work together, we can create a food system that protects, sustains and restores the diversity of life on Earth – at the same time respecting ecological limits.

It is a vision of sustainability, equity and food sovereignty in which safe and healthy food is grown to meet fundamental human needs, and where control over food and farming rests with local communities, rather than transnational corporations.

Together, we can return our food to what it was always meant to be: a source of life – for all people on the planet.

Reyes Tirado,
Greenpeace Research Laboratories,
University of Exeter

We are living with a broken food system. It needs to be replaced urgently for the benefit of all people, and the planet

01

Introduction

It needs no more than a few figures to see something is not right - almost one billion people go to sleep hungry every night. At the same time, the world produces more than enough food to feed all seven billion of us. Around one billion people are overweight or obese. A staggering 30% of the world's food is wasted.

Our problem today is not one of producing more food, but producing food where it is most needed and in a way that respects nature. The current industrial agriculture system fails to deliver this.

Meanwhile, the planet is suffering considerably. We are over-exploiting resources and reducing soil fertility, biodiversity, and water quality. Toxic substances are accumulating in our surroundings. Levels of waste are growing. And all this is occurring in the context of climate change and increased pressure on the Earth's diminishing resources.

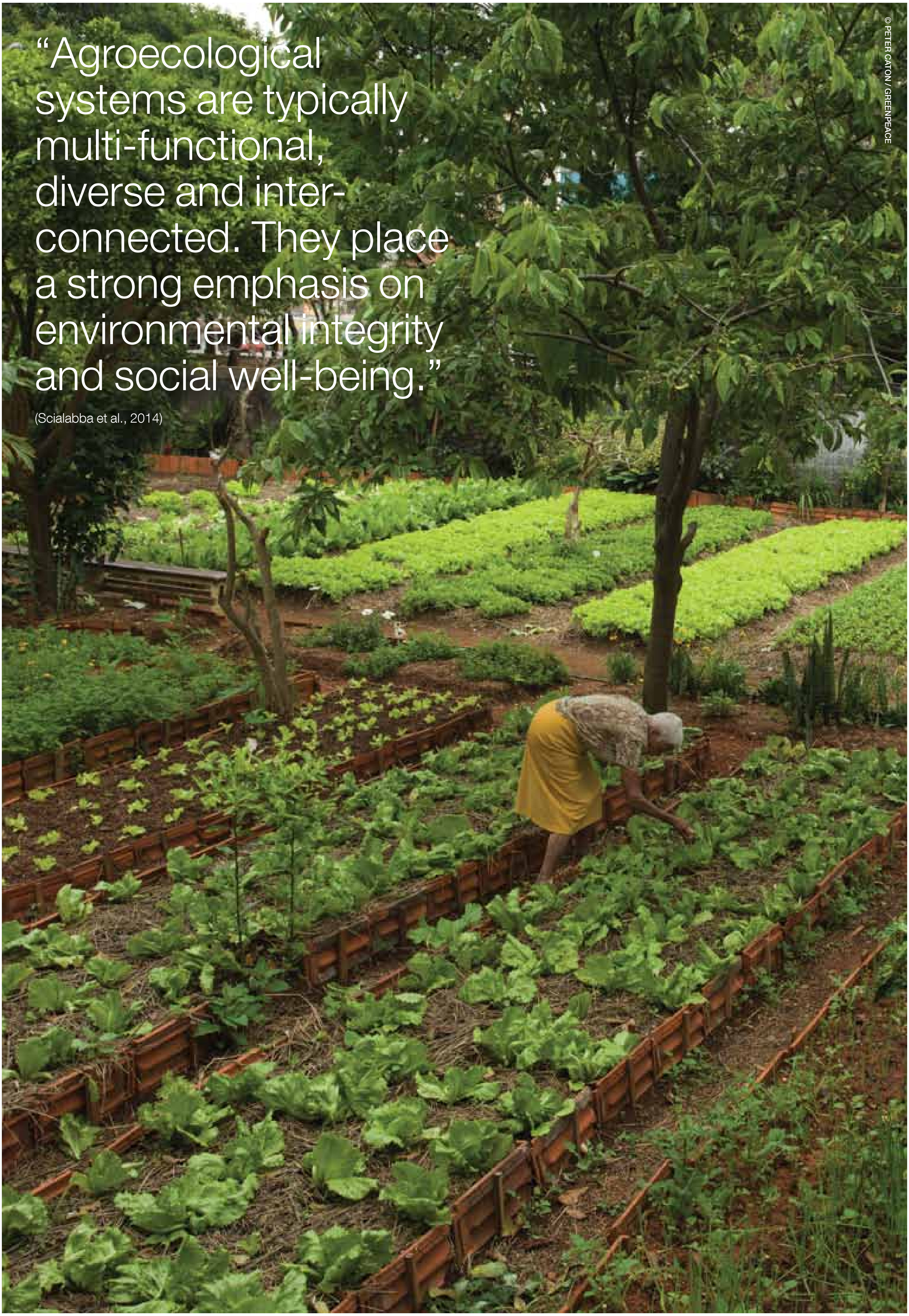
Our current agriculture system depends on the use of vast amounts of chemicals, as well as fossil fuels. It is controlled by a few large corporations, which congregate in a few parts of the world, mainly in rich, industrialised countries. It relies heavily on a few key crops, undermining the basis for the sustainable food and ecological systems upon which human life depends.

This agriculture system pollutes and harms the water, the soil, and the air. It contributes massively to climate change and harms biodiversity and the wellbeing of farmers and consumers. It is part of our wider – failing – food system, which is driving:

- increased levels of corporate control in some regions of the world, resulting in decreased power of farmers and consumers to exercise choice about how and where food is grown, and what is eaten,
- high levels of waste in food chains (ranging from 20-30%), mainly post-harvest losses in developing countries and retail/post-consumer waste in the developed world (FAO, 2011a),
- large areas of land and crops devoted to feeding animals (approx. 30% of all land and 75% of agricultural land), and to biofuels (approx. 5% of all crop's energy, (Searchinger & Heimlich 2015)),
- a global food system based on monocultures of a few cash crops, promoting unsustainable and unhealthy diets, often deficient in nutrients and causing problems of both undernourishment and obesity,
- contribution to major impacts on ecosystems, including:
  - dangerous climate change (about 25% of GHG emissions including land use changes (IPCC 2014)) and air pollution,
  - agriculture has now become a major contributor to water scarcity and water contamination in many regions of the world; agriculture uses 70% of freshwater resources,[2]
  - soil degradation, including widespread soil acidification due to overuse of chemical fertilisers or losses in soil organic matter,
  - losses of biodiversity and agrodiversity at all levels, from genetic diversity of crops at the farm level, to losses in species richness at landscape level.

In addition to addressing social equity issues,[3] such as the lack of equal access to resources for farmers - particularly women farmers, reducing systemic food waste, and switching to more healthy diets, we also need to shift from the current failing food production system to one that is compatible with Ecological Farming.

Greenpeace's Food and Farming Vision explains why Ecological Farming is the solution for a sustainable future and why we need to act now to hasten much-needed systemic change.



“Agroecological systems are typically multi-functional, diverse and inter-connected. They place a strong emphasis on environmental integrity and social well-being.”

(Scialabba et al., 2014)

02

Greenpeace's vision for Ecological Farming:
the seven principles

Ecological Farming is a food and agriculture system that follows the principles of **agroecology**.

Ecological Farming is not merely ecologically sound; it is also economically viable. It respects the societies and cultures it forms a part of. And, it is fair and systemic in its approach.

Ecological Farming is diverse. This is one of its greatest strengths – but it means the practices used in **Ecological Farming** are not universal, but they are locally specific.

Ecological Farming can be applied in smallholdings, as well as in large farms. **Ecological Farming** is diverse, knowledge intensive and low in external inputs and fossil fuels (Tittonell, 2013). It requires a systemic approach to agriculture from the field to the regional level, including diversity (soil, water, air and climate protection), but there is no universal prescription for what this approach should look like.

In spite of all its diversity, a set of general principles underlying **Ecological Farming** system can be identified. The next section outlines the seven principles that Greenpeace recognises as the focus of the changes we need to make to our food system.

Food sovereignty Ecological Farming supports a world where producers and consumers, not corporations, control the food chain. Food sovereignty is about the way food is produced, and by whom.

A handful of large corporations control large parts of our food system right now – informed by the demands of a disconnected commodity market. Food sovereignty takes this control, and places it in the hands of the people who produce, distribute, and consume food. It ensures that farmers, communities and people have the right to define their own food systems.

Food sovereignty acknowledges the role of women as the backbone of rural communities, and the historic role women have played in gathering and sowing seeds, as guardians of biodiversity and genetic resources. Addressing gender equity issues is part of the broad concept of Food Sovereignty about who controls the food we grow and eat.

Benefitting farmers and rural communities **Ecological Farming contributes to rural development and fighting poverty and hunger, by enabling livelihoods in rural communities that are safe, healthy, and economically viable.**

It is one of the most perverse incongruities of our current food system that the people who produce our food – farmers, farm workers and fisherfolk – often suffer most from poverty and a lack of access to food.

Evidence from Ecological Farming initiatives across the world shows that Ecological Farming – when sufficiently supported by policy instruments – can be a successful tool in providing stable financial benefits to smallholder farmers, in turn benefitting rural communities and advancing their rights to a rewarding and secure livelihood.

Smarter food production and yields **To increase food availability globally, and to improve livelihoods in poorer regions, we must reduce the unsustainable use of what we grow at the moment and we must reduce food waste, decrease meat consumption, and minimise the use of land for bioenergy. We must also achieve higher yields where they are needed – through ecological means.**

Feeding the world's population – which keeps growing and, on average, getting wealthier– is not (just) about quantity. The important question is where and how we grow more food, and where we make other changes. Yields need to be increased in regions where they are very low right now, due to poverty, lack of resources, soil degradation, and the inadequate use of water. In other parts of the world, we need to reduce meat consumption, the use of croplands for bioenergy, and food waste.

Right now, corporations and food policy makers are stubbornly sticking to an increase in yields as the global goal. This obscures the real challenge - we need to rethink how we use the food we are producing - right now, and in the future. In a better food system, ecological livestock systems would make use of the agricultural land and resources not required for human food needs, and at the same time drastically reduce the amount of animal products we produce and consume globally. Equitable distribution, however, would mean that some regions could still improve their diets with animal products.

Blindly increasing yields – at any price, anywhere in the world – is not a solution. Doing so in the US, for example, where a large proportion of the maize is grown for domestic fuel needs, does not help farmers in Africa or Asia. Ecological Farming would create a system where we increase yields where they are most needed – through ecological means.

Biodiversity **Ecological Farming is about nature's diversity – from the seed to the plate, and across the entire agricultural landscape. It is about celebrating the flavour, nutrition, and culture of the food we eat, improving diets and health.**

Our current model of agriculture promotes monocultures. Vast areas of land are given over to genetically uniform plants, with little biodiversity and no refuge for wild plants or animals. This way of farming minimises the services a functioning ecosystem can provide, and it badly affects our health through poorer diets and a lack of nutritional diversity.

Ecological Farming systems do the opposite. They place nature's diversity at their core. In doing so, they not only protect the natural habitats that are vital for biodiversity protection. They also take advantage of what nature offers in return: wild and crop seed diversity, nutrient cycling, soil regeneration, and natural enemies of pests, for instance.

Ecological Farming combines modern technology and farmers' knowledge to develop advanced diverse seed varieties, which helps farmers to grow more food in a changing climate, without risking biodiversity with genetically engineered crops, or harming it with pesticides.

Sustainable soil health and cleaner water **It is possible to increase soil fertility without the use of chemicals. Ecological Farming also protects soils from erosion, pollution, and acidification. By increasing soil organic matter where necessary, we can enhance water retention, and prevent land degradation.**

Ecological Farming pays central attention to nourishing the soil. It maintains or builds up soil organic matter (for example with compost and manures), and, in doing so, feeds the diversity of soil organisms. It also aims to protect wells, rivers, and lakes from pollution, and to make the most efficient use of water.

All this is vital in a world where agriculture is now the biggest user of fresh water, globally, and, in many regions, also the major contributor to water contamination, with nitrogen and phosphorus fertiliser pollution one of the major threats to the stability of life on the planet (Steffen et al., 2015).

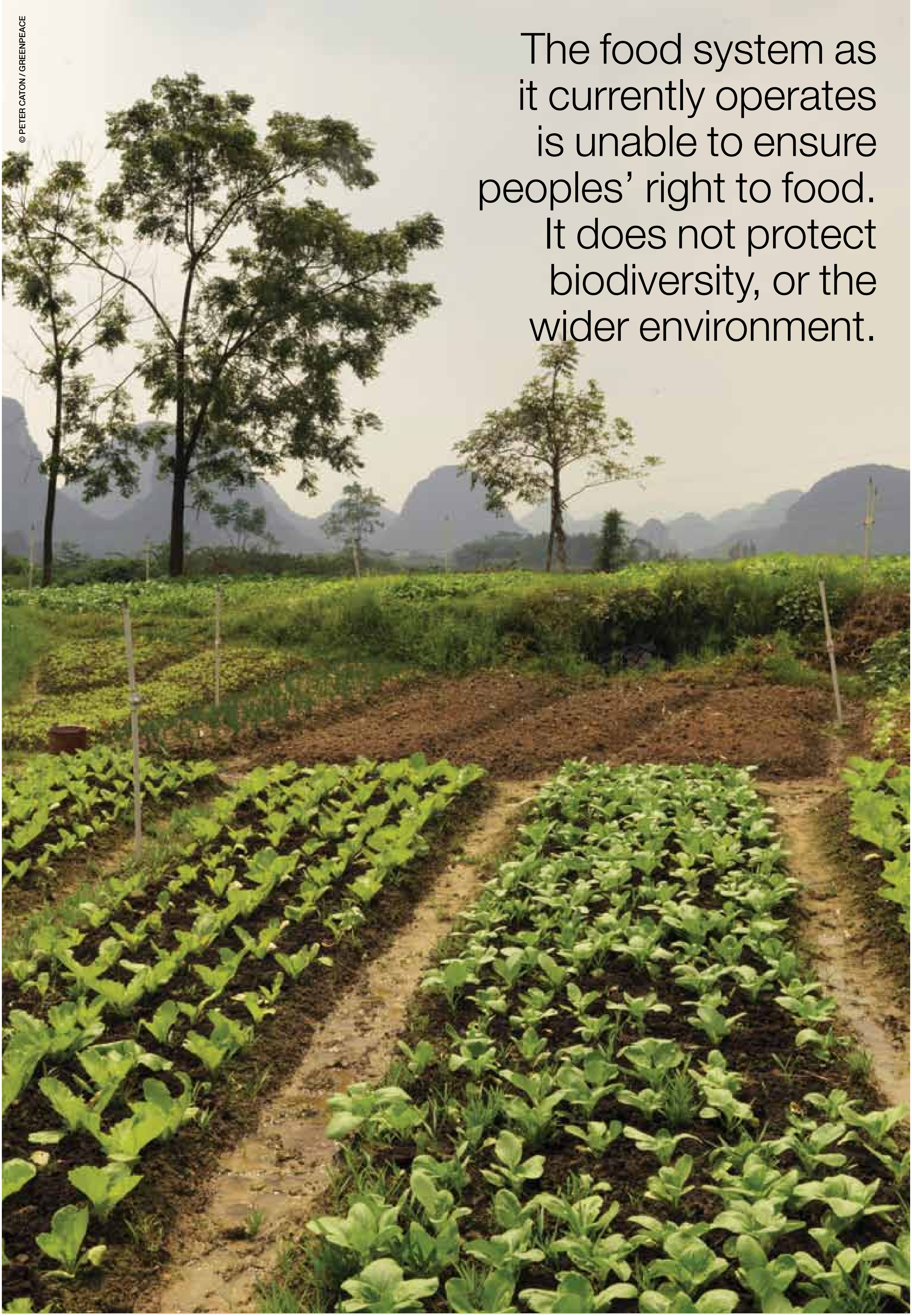
Ecological pest management **Ecological Farming enables farmers to control pests and weeds – without the use of expensive chemical pesticides that can harm our soil, water and ecosystems, and the health of farmers and consumers.**

Toxic chemical pesticides are a hazard for our health, and for the health of the planet. Unfortunately, the industrial farming model depends on large quantities of herbicides, fungicides, and insecticides for its very existence. Our current food system has locked farmers into a costly relationship with the corporations that sell these chemicals.

Resilient food systems **Ecological Farming creates resilience: it strengthens our agriculture, and effectively adapts our food system to changing climatic conditions and economic realities.**

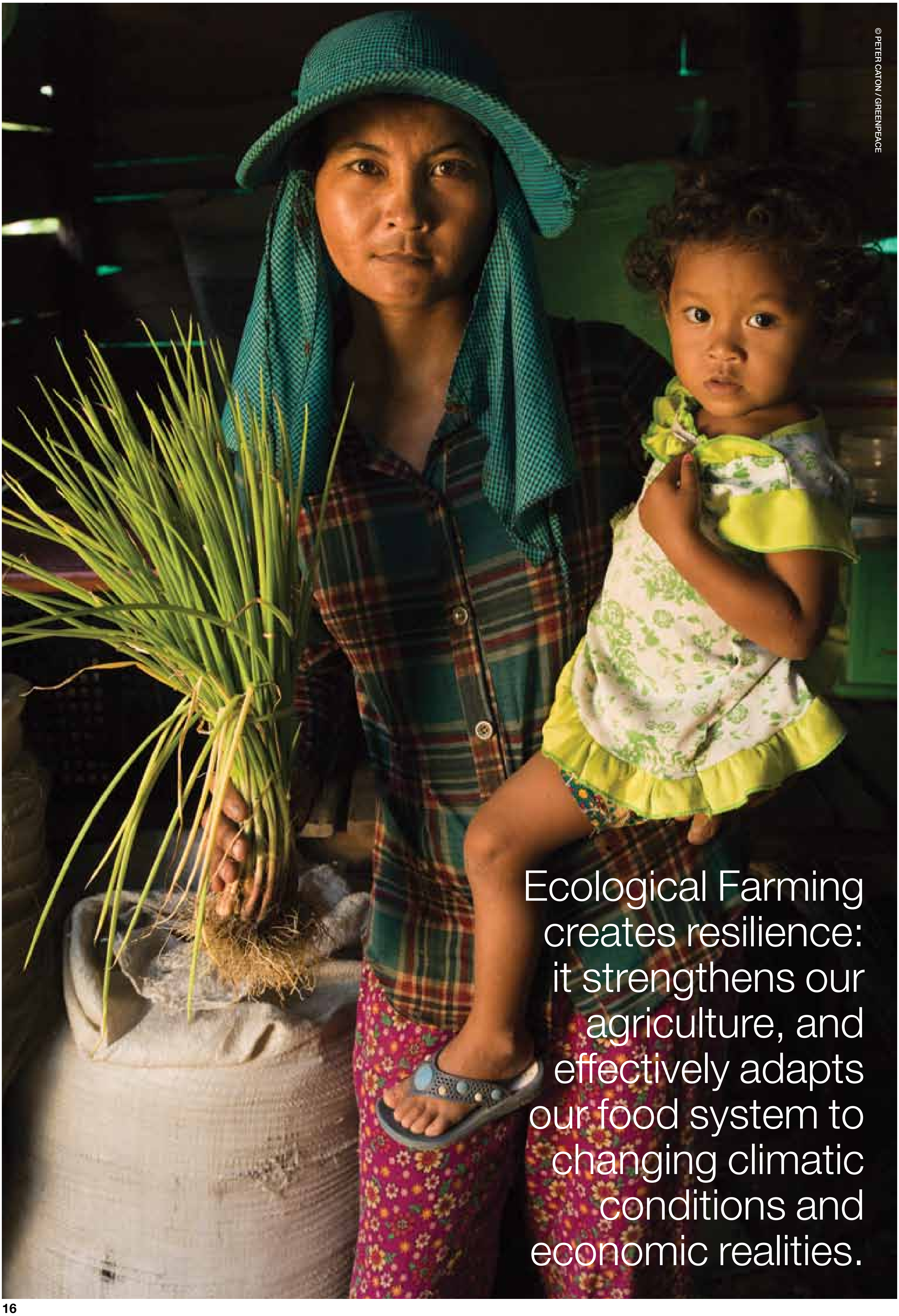
Embracing diversity – growing different crops at the field and landscape levels – is a proven and highly reliable way to make our agriculture resilient to increasingly unpredictable changes in the climate. Well-tended soil, rich in organic matter, is much better at holding water during droughts, and much less prone to erode during floods. Farmers can benefit in another way - if your farming is diverse, so is your stream of income – providing security in uncertain times.

A redesigned food system would provide large-scale carbon sinks and many other ways to reduce greenhouse gases in the atmosphere (climate mitigation). Nutrient cycling, biological nitrogen fixation, and soil regeneration would reduce carbon emissions. And while livestock plays a key role in agroecosystems, animal production and consumption would be changed radically. All this makes Ecological Farming one of the most powerful tools we have in the fight against climate change.



The food system as it currently operates is unable to ensure peoples' right to food. It does not protect biodiversity, or the wider environment.


Ecological Farming combines modern science and innovation with respect for nature and biodiversity. It ensures healthy farming and healthy food.


Ecological Farming creates resilience: it strengthens our agriculture, and effectively adapts our food system to changing climatic conditions and economic realities.

03

How the science supports Greenpeace's seven principles

1 Food sovereignty

"Agroecology is political; it requires us to challenge and transform structures of power in society. We need to put the control of seeds, biodiversity, land and territories, waters, knowledge, culture and the commons in the hands of the peoples who feed the world." Declaration of the International Forum for Agroecology, Nyéléni, Mali, 27 February 2015[4]

Our current food system primarily serves the needs, not of people or the planet, but of capital. Global markets – dominated by a small number of corporations – determine not only what kind of food is being produced, but also how it is being produced, and how it is being distributed. Major power imbalances mean that large investments in land, agriculture and food processing often marginalise or displace small-scale farmers. Ecological Farming offers better solutions.

The food system as it currently operates is unable to ensure peoples' right to food. It does not protect biodiversity, or the wider environment. Most investments being made under this framework, as well as the policies that regulate it, ignore small-scale farmers – even when decisions directly affect them. Consumers, too, are subject to the often opaque decisions of corporations. Corporate control means food is distributed on the basis of ability to pay, not on the basis of need. Being profit-driven, the current food system naturally promotes highly processed food over fresh food - right now, the former is much more profitable than the latter. This leads to the excessive consumption of unhealthy food in many parts of the world. The most obvious manifestation of this is an ongoing obesity crisis: there are now 1.5 billion overweight adults around the globe, 500 million of them obese (Finucane et al., 2011).

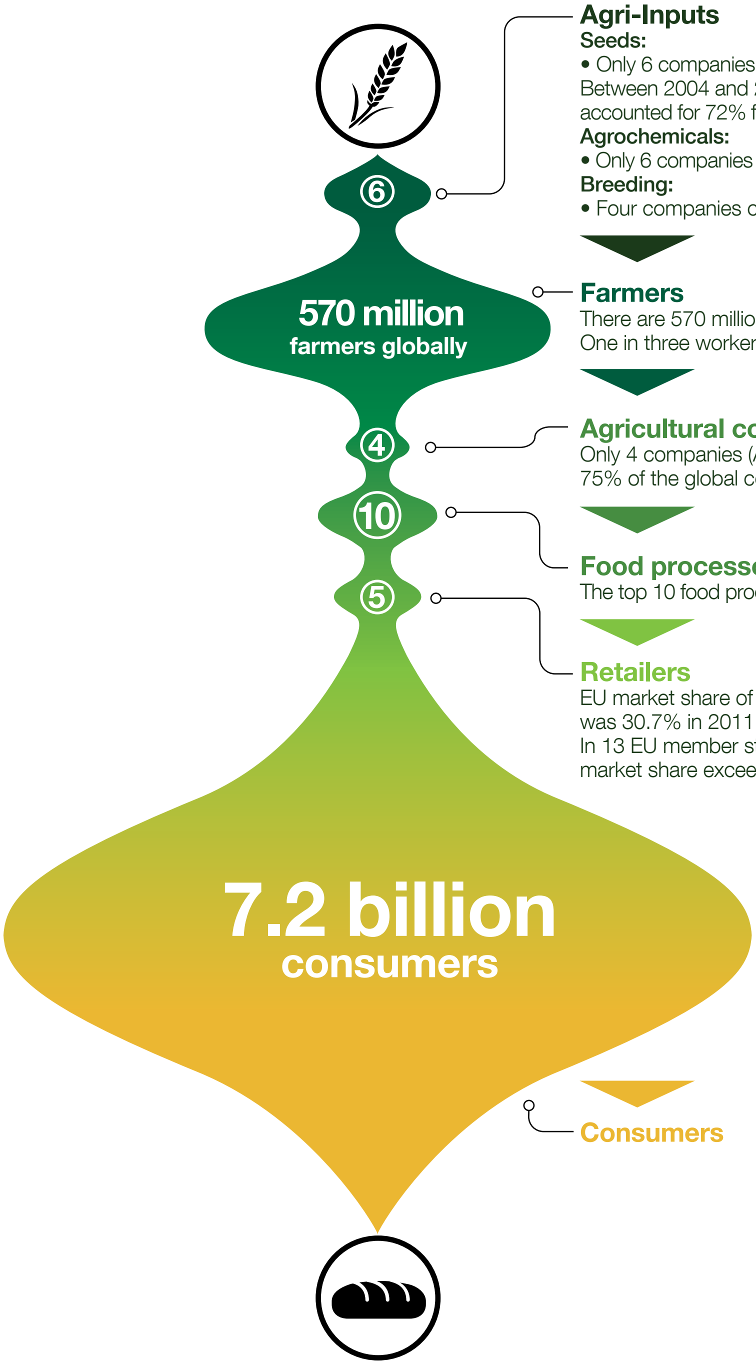
The goal of the current food system has been framed largely around the concept of food security – people's ability to have access to sufficient food. The growing movement behind food *sovereignty* argues that much more is needed to address the imbalances of the current food system.

Simply put, food sovereignty is about the right of people to define their own food systems. It is distinctive from food security, which is restricted to access and sometimes even includes food aid. While international development efforts to promote food security can help alleviate hunger, they alone are insufficient because they do nothing to address the inequalities and imbalances of power that exist in the food system, which enable corporations to squeeze maximum profit from both producers and consumers.

The framework of food *sovereignty* has been developed by global social movements, and the International Peasant Movement, La Via Campesina, has played a lead role in this.[5] In recent years, food sovereignty has become a shared vision for a world that upholds the right to food, where people can define their own food and agriculture systems. Ecological Farming is now widely accepted as one of its main pillars.

Figure 1: **The Global Food System**

A double bottleneck of corporate control between farmers and consumers



Agri-Inputs

Seeds:

• Only 6 companies controlled 66% of global seed sales in 2011. Between 2004 and 2008, 3 companies (Monsanto, Pioneer, Syngenta) accounted for 72% for all patent applications for plant varieties in the USA.

Agrochemicals:

• Only 6 companies controlled 76% of global agrochemical sales in 2011.

Breeding:

• Four companies control 99% of the global chicken breeding sector.

Farmers

There are 570 million farms globally.
One in three workers is employed in the agriculture sector globally.

Agricultural commodity traders

Only 4 companies (ADM, Bunge, Cargill, Dreyfuss) control 75% of the global commodity trade (grains and soya).

Food processors & manufacturers

The top 10 food processing companies control 28% of the global market.

Retailers

EU market share of top 10 retailers (in edible grocery sales) was 30.7% in 2011.
In 13 EU member states the top 5 retailers market share exceeds 60%

Consumers

Top 10 processors | **1** Nestlé | **2** PepsiCo | **3** Kraft | **4** ABInBev | **5** ADM | **6** Coca-Cola | **7** Mars Inc. | **8** Unilever | **9** Tyson Foods | **10** Cargill
Top 10 retailers in EU | **1** Schwarz Group (Lidl) | **2** Carrefour | **3** Tesco | **4** Edeka | **5** Aldi | **6** Rewe Group | **7** Auchan | **8** ITM (Intermarché) | **9** Leclerc | **10** Ahold | *Note that the top 5 retailers in the respective EU countries can be different from this list and it is, of course, not always the same top 5 in each country.*
Top 6 Seeds | **1** Monsanto | **2** DuPont | **3** Syngenta | **4** Vilmorin | **5** WinField | **6** KWS | **Top 6 Agrochemicals** | **1** Syngenta | **2** Bayer | **3** BASF | **4** Dow | **5** Monsanto | **6** DuPont | **Top 4 Breeding** | **1** Aviagen International Group (part of EW Group) | **2** Cobb-Vantress (part of Tyson) | **3** Groupe Grimaud | **4** Hendrix Genetics B.V.

Agroecology: The way forward

La Via Campesina focusses on "peasant agroecology as the fundamental building block in the construction of food sovereignty" originating from centuries of peasant and indigenous knowledge.[6]

Similarly, SOCLA[7] highlights corporate control of the food systems and aspects of access to land, seeds and water as crucial within the food sovereignty concept.[8]

Other organisations, like Pesticide Action Network, have focussed more on the specific impacts of industrial agriculture, in this case fighting chemical pesticides.

Finally, many academics within universities and international institutions like UN Food and Agriculture Organization (FAO) regional offices and CGIAR[9] centres are increasingly adding evidence to the significant body of science research pointing to agroecology as the only solution to the food and agriculture crisis we live in.

In 2007, over 500 representatives of organisations of small-scale food producers, workers, indigenous peoples and social movements from over 80 countries came together in Nyéléni, Mali, and came up with a declaration and action plan, outlining a set of principles of food sovereignty.[10] According to this, a food system based on food sovereignty

1) focusses on food for people,

2) values food providers,

3) localises food systems,

4) puts control at the local level,

5) builds knowledge and skills, and

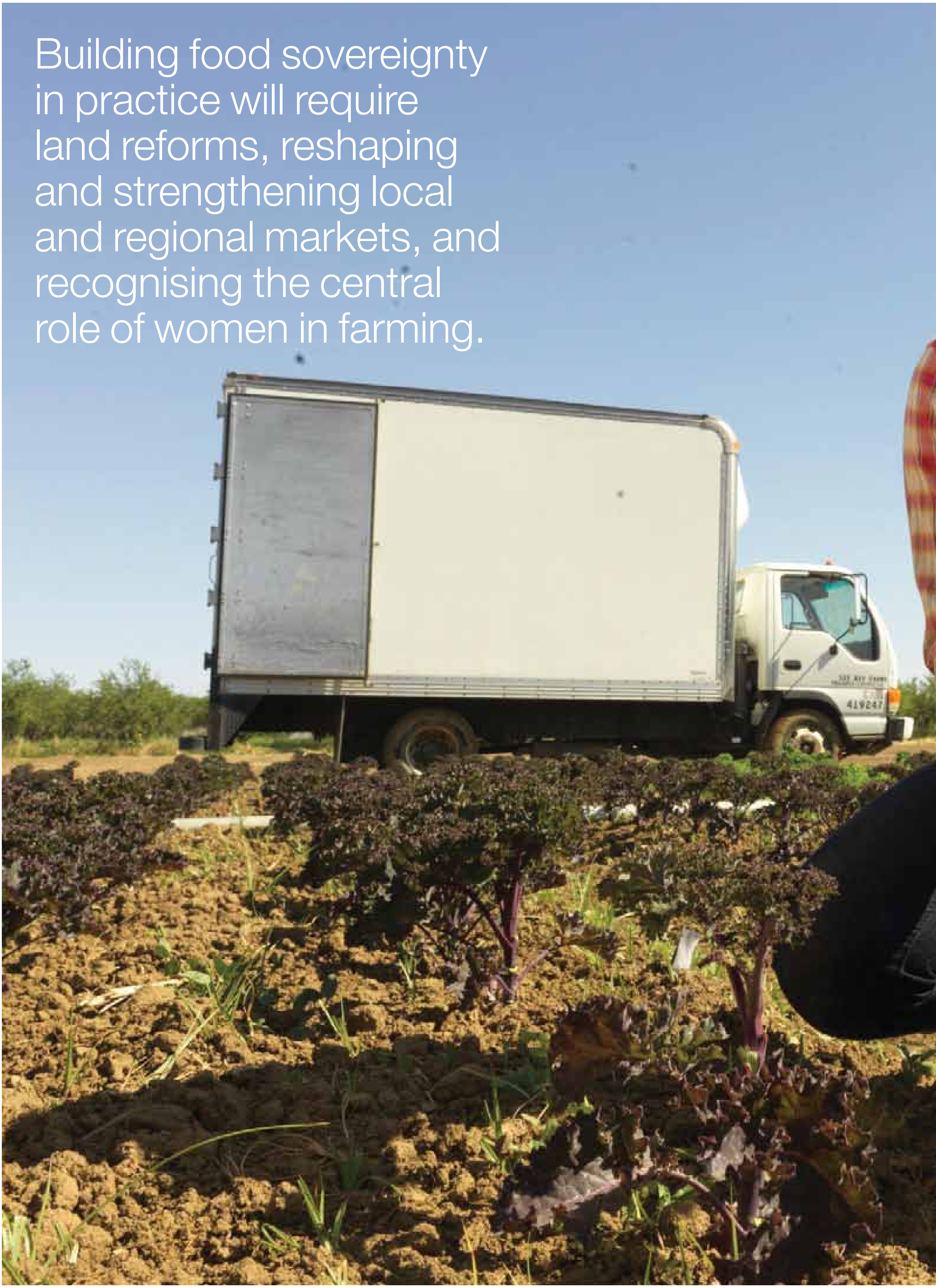
6) works with nature.

In 2008, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), developed by 400 global experts and approved by 58 governments, defined food sovereignty as: "the right of peoples and sovereign states to democratically determine their own agricultural and food policies".[11]

In 2014, *the Colloquium on Food Sovereignty* brought together some of the world's leading thinkers on the concept in Den Haag, the Netherlands. Experts on social sciences and representatives of food sovereignty movements from around the world[12] discussed the concept. During these discussions, food sovereignty was defined as: a concept, a process, a vision, a political frame, a praxis, a paradigm, a movement, a struggle, a dialogue, a living organism, a banner, an ideology, a counter-movement, and, a utopia. Depending on the context and the identity of the speaker, food sovereignty was being viewed as any of these, or even all of them together.

In February 2015, a new Declaration was issued in Nyéléni: the movement strengthened the International Planning Committee for Food Sovereignty (IPC), which coordinates global and regional efforts and sets strategic directions towards transforming and building agroecological food systems.[13] This was widely acknowledged to be **"a new and historic step forward".**

Building food sovereignty in practice will require land reforms, reshaping and strengthening local and regional markets, and recognising the central role of women in farming.



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Based on these, and many other discussions and conversations, food sovereignty is best described as an "open" concept, growing and evolving continuously. This lack of clarity is both its weakness and its strength.

Greenpeace stands by peasant communities all over the world who advocate food sovereignty, and calls on governments to help them reclaim control over the food system in order to realise their right to food through Ecological Farming.

Building food sovereignty in practice will require land reforms, reshaping and strengthening local and regional markets, and recognising the central role of women in farming. It will also require overcoming barriers such as unfair trade governance and climate injustice. The environmental aspect of food sovereignty, defined as "working with nature", is central to Ecological Farming. It is here that Greenpeace's work seems most easily aligned.

2 Benefitting farmers and rural communities

"Agriculture alone cannot solve poverty in places like sub-Saharan Africa, but it can contribute to alleviate the crude reality of thousands of rural families." (Tittonell, 2013)

It is one of the sad ironies of our current food system that the majority of those who suffer from hunger live in poor, rural communities in developing countries – with livelihoods dedicated to producing food (crops, livestock or fisheries) (FAO, WFP and IFAD, 2012). One clear conclusion can be drawn from this: the industrial, chemical-intensive agriculture system is deeply unfair, and unsustainable. Ecological Farming can help address this.

More food is being produced now than ever before in human history. Quantitatively speaking, it is enough to feed all 7 billion people living on the planet right now. But the picture is more complicated than that. Right now, **1.5 billion adults around the world are overweight**.[14] **30% of the food the world produces is being wasted** (FAO 2011a). At the same time, **there are almost 1 billion hungry people** (870 million in 2012, according to FAO (2012)).

Farmers with less than 2 hectares of land constitute more than 90% of the world's farmers, and cover some 60% of the agriculture land globally (De Schutter and Vanloqueren, 2011). These small-scale farmers have insufficient access to natural resources (land, water, etc.). They lack training (for instance on agroecological practices to increase yields). They do not have enough information on prices and the weather, and they lack storage and markets to sell to. In addition, they are largely powerless in almost all the political processes that affect them.

Against this background, Ecological Farming – based on biodiversity and utilising resources that are affordable and locally available – can increase production and improve livelihoods where such developments are most needed, while protecting the natural resource base needed to sustain life on the planet (UNEP and UNCTAD, 2008, De Schutter, 2010, Bommarco et al., 2013, Tittonell, 2013).

Research increasingly shows Ecological Farming to be the most promising, realistic and economically feasible alternative to the current destructive agriculture model. It is also ideally suited for poor and small-scale farmers, as they require minimal or no external inputs, use locally and naturally available materials to produce high-quality products, and encourage a whole systemic approach to farming that is more diverse and more resilient to adverse weather conditions, pests and diseases (UNEP and UNCTAD, 2008).

There is a long – and growing – list of examples of Ecological Farming systems in developing countries that contribute both to improving livelihoods by food production and nature conservation. Here are a few recent ones:

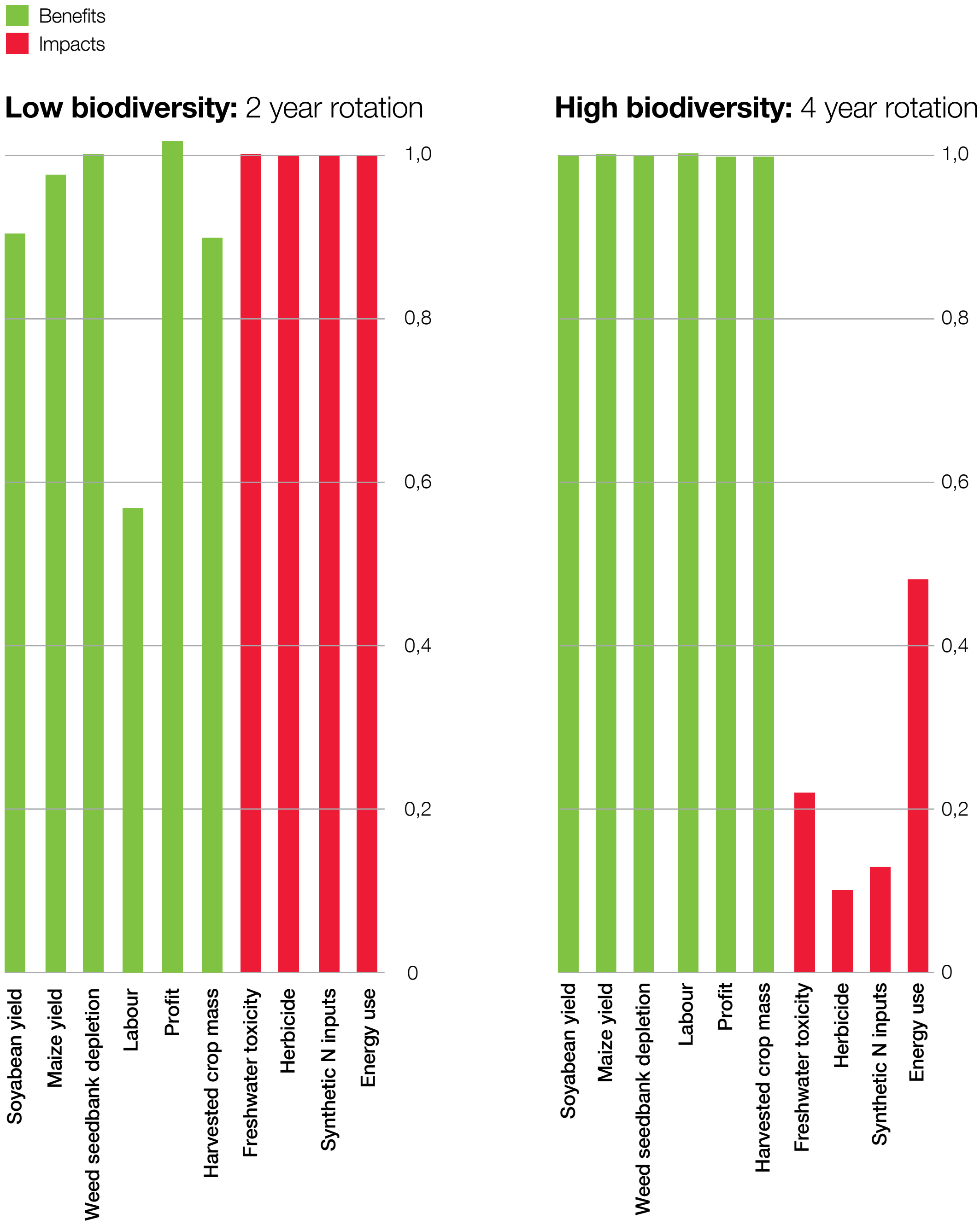
- In-depth analysis of 15 organic farming[15] examples in **Africa** has shown increases in per-hectare productivity for food crops, increased farmer incomes, environmental benefits, strengthened communities and enhanced human capital. Ecological agriculture can increase agricultural productivity and can raise incomes with low-cost, locally available and appropriate technologies, without causing environmental damage (UNEP and UNCTAD, 2008).
- In **Malawi** and **Kenya**, Ecological Farming interventions such as agroforestry with legume trees and the push-pull system of chemical-free pest protection, respectively, had strong effects on livelihoods and farmer income. (Push–pull systems repel insect pests from the crop ("push") and attract them into trap crops ("pull")). In Kenya, farmers practising ecological farming could earn up to three times as much as neighbours using chemical inputs; in Malawi they could earn up to one and a half times as much as neighbours using agro-chemicals. This is still the case even when agrochemicals are subsidised, as they are in Malawi (Greenpeace Africa, 2015).
- Recent analysis in tropical cocoa production in **Indonesia** and **Ecuador** shows how integrating high diversity and high productivity is possible, with large benefits for livelihoods and wildlife conservation (Clough et al., 2011, Waldron et al., 2012).
- A grassroots scheme to tackle poverty and hunger through ecological agriculture in **Bangladesh**, particularly targeting marginalised women, brought considerable benefits to 21,000 poor men and women in 6 remote districts. With Ecological Farming practices and better collective management, rice production rose 5-10%, vegetable and fruit production improved by 25-40%, poultry and livestock production improved by 30-40%, fish production by 20-30%, and average net returns grew by 20-30% because of higher value addition and from cost savings from spending much less on synthetic fertilisers and pesticides (Wijeratna, 2012).
- An example of the economic benefits of Ecological Farming is the success the Non-Pesticide Management programme in Andhra Pradesh (**India**) had in reducing the costs of cultivation and increasing the net incomes of farmers. The cost of cultivation was brought down significantly, with savings on chemical pesticides ranging between 600 and 6,000 Indian Rupees (US$ 15-150) per hectare without affecting the yields (Ramanjaneyulu et al., 2008).

In the developed world, studies increasingly show how farming with ecological methods, instead of chemicals, can balance productivity, profits and environmental health. For example:

- Recent findings from Iowa in the **US** show how longer, diversified crop rotations (integrating the raising of livestock, whose manure was used as fertiliser) produced more corn and soy with the same profits, while avoiding groundwater pollution with agrochemicals.[16]
- A region-wide analysis across **Europe** indicates that profits on organic farms are on average comparable to those on conventional farms (Offermann and Nieberg, 2000). A recent economic analysis of organic dairy farms in **Denmark** showed that the most environmentally friendly cattle system reduced local as well as global environmental impacts without an economic trade-off. Profits per farm were highest for the most ecological farms, which minimised imports of concentrated feed and outputs of polluting animal excrements. Their profitability was also more stable as they were less affected by milk and meat commodity price fluctuations (Oudshoorn et al., 2011).

Figure 2: **The benefits of increasing diversity in cropping systems**

Higher productivity, higher profit and higher environmental health

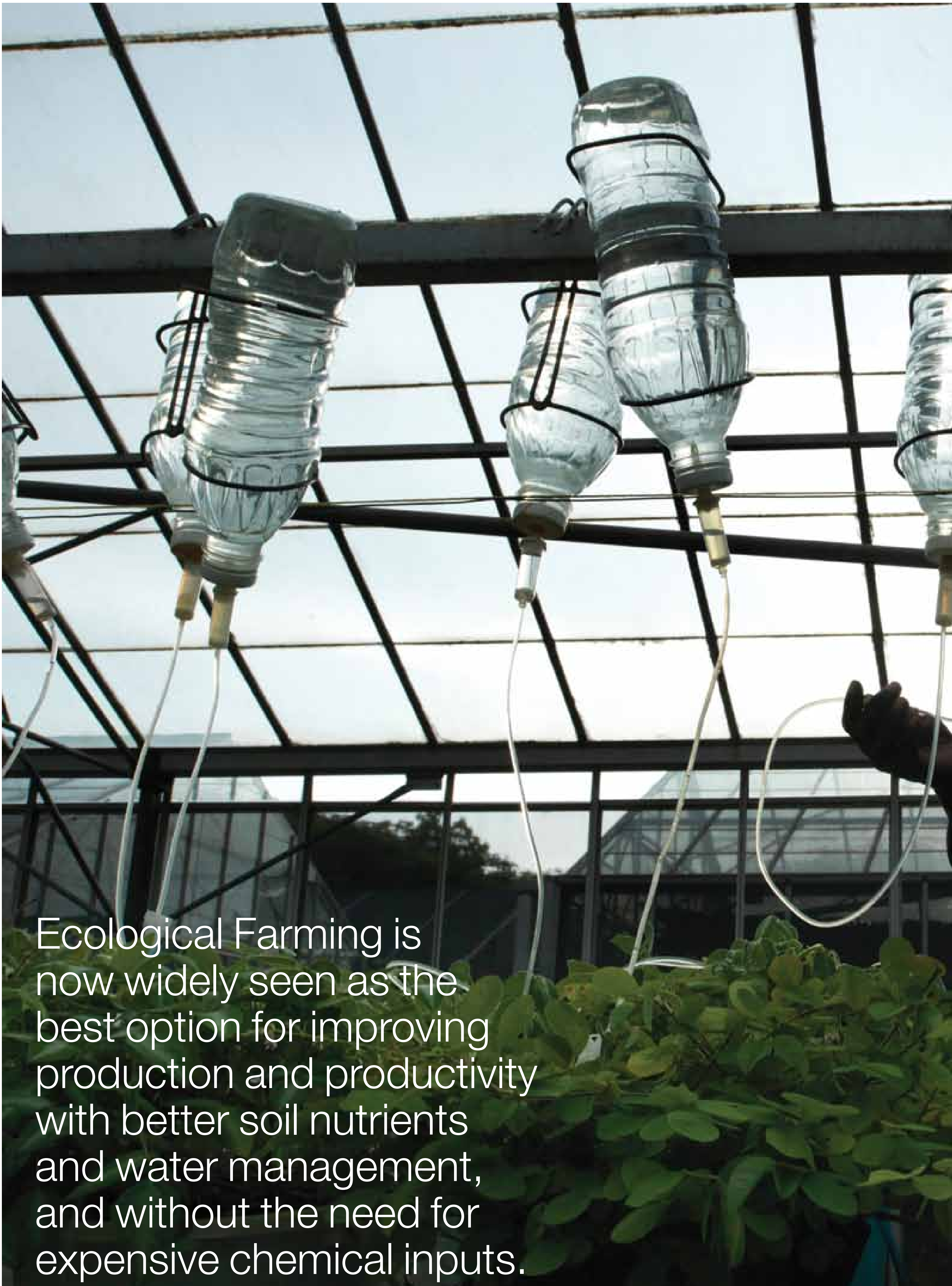


Comparative long-term performance of maize-soybean (2-yr) and maize-soybean-small grain/alfalfa-alfalfa (4-yr) cropping systems in Boone, IA, averaged over the 2003–2011 study period. Variable means are normalized on a 0 to 1 scale, with 1 representing the cropping system with the largest absolute value for that variable (N = 36 per cropping system). Performance metrics included: maize and soybean yield, rotation-level harvested crop mass, net returns to land and management, manufactured N fertilizer and herbicide application rate, fossil energy use, labor requirements, freshwater toxicity potential and weed seedbank decline (measured as exponential decay constant).

Adapted from: Davis, A. S., Hill, J. D., Chase, C. A., Johanns, A. M. & Liebman, M. 2012. Increasing Cropping System Diversity Balances Productivity, Profitability and Environmental Health. PLoS ONE, 7: e47149. [available under the Creative Commons CC0]

- Also in Europe, but under different climatic and agronomic conditions, another recent study in **Spain** showed that organic cereal production (wheat, sunflower with legume rotations) was 62% more profitable, assuming current organic premium prices, and 36% more profitable when selling products in conventional markets (Pardo et al., 2014). In this case, economic subsidies and price premiums for organic farmers play a role in increasing profitability.
- In a decade long study in Wisconsin (**US**), scientists have shown that farming with high diversity and with no pesticides or chemical fertilisers is more profitable than farming with monocultures and chemicals (Chavas et al., 2009).
- In the **US** Midwest, it has been demonstrated that for corn and soybean with extended crop rotations (green manuring), high crop yields can be obtained with reduced-input systems (organic and low external input) (Coulter et al., 2011).
- In apple orchards in the west of the **US**, organic farms produced sweeter and less tart apples, higher profitability and greater energy efficiency when compared with conventional and integrated farms (Reganold et al., 2001). Similarly, an analysis of strawberry farms in **California** showed that the organic strawberry farms produced higher quality fruit, as well as developing higher quality soils, which may have greater microbial functional capability and resilience to stress (Reganold et al., 2010).
- Ecological farming represents an opportunity to make a significant net saving for citizens. If the whole farming system of the **UK** shifted to organic farming, for example, environmental costs savings would be about £1 billion per year (1.5 billion US$) (Pretty et al., 2005).

The 2004-2008 International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, or 'Ag Assessment') was an intergovernmental process under the co-sponsorship of the FAO, GEF, UNDP, UNEP, UNESCO, the World Bank, and WHO and included a consultative process involving 900 participants, many of them prominent scientists, from 110 countries. The IAASTD represented a massive global effort to assess agricultural knowledge, science, and technology and the effectiveness of public and private sector policies and institutional arrangements, towards the goal of sustainable development. It concluded: "business as usual is not an option". One of their "options for action" was "policies that promote sustainable agriculture (....) stimulate more technology innovation, such as agroecological approaches and organic farming, to alleviate poverty and improve food security (IAASTD, 2009, Global Summary, Options for Action).



Ecological Farming is now widely seen as the best option for improving production and productivity with better soil nutrients and water management, and without the need for expensive chemical inputs.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3 Smart food production and yields

"…growing food exclusively for direct human consumption could, in principle, increase available food calories by as much as 70%, which could feed an additional 4 billion people…"
(Cassidy et al., 2013)

Taken together, the world's farmers produce enough food to feed all people on the planet. Yet, billions go to bed hungry every night. In some places, too much food is being produced – and wasted. In other places agricultural yields are so low that farmers can barely feed themselves. Many food and agriculture experts agree that our response to this complex situation needs to be smart, balanced, and locally specific. Ecological Farming has a crucial role to play in this.

Two questions are key: *where* our food is being produced, and *how* it is being produced. It is widely accepted, for example, that in parts of the world where yields are extremely low right now – in parts of Africa and Asia, where poverty is very high at the same time – improving yields in nutritionally relevant crops is vital, for food production, for human health, and for farmers' livelihoods. The current global goal – which can be simply stated as: increasing yields at any cost, anywhere in the world – needs to make way for targeted local solutions in these places (Garnett and Godfray 2012).

The *how* is just as important: many experts now agree that yield improvements can be "largely accomplished by improving the nutrient and water supplies to crops in low-yielding regions" (Foley et al., 2011). In other words, this can be done without the need for investment in expensive genetically engineered crops or chemical inputs. There is great potential to raise yields in poor regions, where they are very low and decreasing right now – with low-input technologies that are affordable and effective (Clough et al., 2011, Pretty et al., 2003).

Research increasingly shows the essential role Ecological Farming has to play in this.

For smallholders in resource-poor regions where higher yields are most needed, Ecological Farming is now widely seen as the best option for improving production and productivity with better soil nutrients and water management, and without the need for expensive chemical inputs (Pretty et al., 2006). Ecological Farming minimises many of the impacts associated with the use of synthetic inputs: water pollution, air pollution, greenhouse gas emission, soil pollution, biodiversity impacts such as further pollinator declines or effects on pest predators, soil degradation, losses in resilience, etc.

Our efforts to increase yields need to be seen in context: there will be upper limits to the process, and it will need to happen keeping in mind how important ecosystem services are for life on the planet (Rockström et al., 2009). It is also crucial for them to go hand in hand with changes elsewhere in the world. We need to:

- reduce unsustainable use of the food crops we currently grow,
- reduce food waste,
- adopt diets low in animal protein (reducing diversion of crops to animal food), and
- reassess the amount of land diverted to growing crops for bioenergy.

Recent analysis shows how choosing diets with half the content of animal protein could free up enough food to feed an additional 2 billion people. Currently, 36% of the calories grown in our food system are used to feed animals, not people (Cassidy et al., 2013). Further analysis suggests that changing crop allocation to directly feed people in four regions alone: the United States, China, Western Europe, and Brazil could provide enough calories to meet the basic needs of an extra 2.4 billion people (West et al., 2014).

Increasing food self-sufficiency and optimising food production where it is needed (local seasonal products where possible, urban farming, etc.) will also be key for efficient ecological food and farming systems.

Ecological farming aims at optimising all the ecosystem services that a landscape provides – not only agricultural production, but also water filtration, nutrient cycling, carbon sequestration and other functions (see Figure 2).

A recent study from the University of California, Berkeley, shows that farming with ecological practices – which build on biodiversity (rotations, polycultures, etc.) – is an effective way to increase yields and reduce the "yield gap" between organic farming[17] and conventional farming (Ponisio et al., 2015). The first important finding is that the difference between organic and conventional yields is less than some previous estimates: 19% lower yields for organic farming. Even more importantly, when biodiversity-based practices are applied in the best way, organic yields can be much closer to those achieved by conventional farming methods. In some cases, the difference was negligible (Ponisio et al., 2015).

These ground-breaking results prove how close Ecological Farming, i.e. diverse organic farming, is to delivering both high food productivity *and* high value for the planet – something that chemical-intensive farming will never be able to deliver.

In 2007, a meta-analysis of global yield data showed that, globally, Ecological Farming can, on average, produce about 30% more food per hectare than conventional agriculture. In developing countries, it can produce about 80% more food per hectare than conventional agriculture (Badgley et al., 2007). This global data set had some limitations, but this study still points to the huge untapped potential of ecological farming practices to increase yields where it is most needed.

Other analyses – inconclusive to a certain degree, due to very limited data from developing countries and excluding essential crops, such as rice in Asia – have shown yields of organic farms to be, on average, about 20% lower than those of conventional farms (Seufert et al., 2012, de Ponti et al., 2012). The 20% difference in yields also reflects a difference in investments between organic and industrial agriculture. Investments in agriculture have been estimated to be around 90-95% (or higher) in favour of industrial agriculture since the onset of the Green Revolution (Tittonell, 2013). This is a small estimated difference in yields given this extremely uneven playing field.

The 20% average difference in Seufert et al., 2012 across crops and regions also obscures important statistics:

- For fruits (orange, bananas, apples) and oilseeds crops, Ecological Farming produces as much as industrial agriculture on average.
- For staple crops in developing countries, the difference is about 10% (bearing in mind that the data set is very limited). The study includes no data for rice yields in Asia, which makes results about lower organic yields in staple grains very weak and inconclusive (rice being such an important grain crop globally). **Where data on rice yields in Asia is available there is no significant difference between organic and conventional rice yields (di Ponti et al., 2012).**

The Seufert et al., (2012) study found that, *"soils managed with organic methods have shown better water-holding capacity and water infiltration rates and have produced higher yields than conventional systems under drought conditions and excessive rainfall."* The fact that Ecological Farming performs better under rainfed conditions is extremely important in a world of changing climates and increasing water scarcity. It makes the approach highly relevant to small-scale farms, which are largely dependent on rainfall (Seufert et al., 2012).

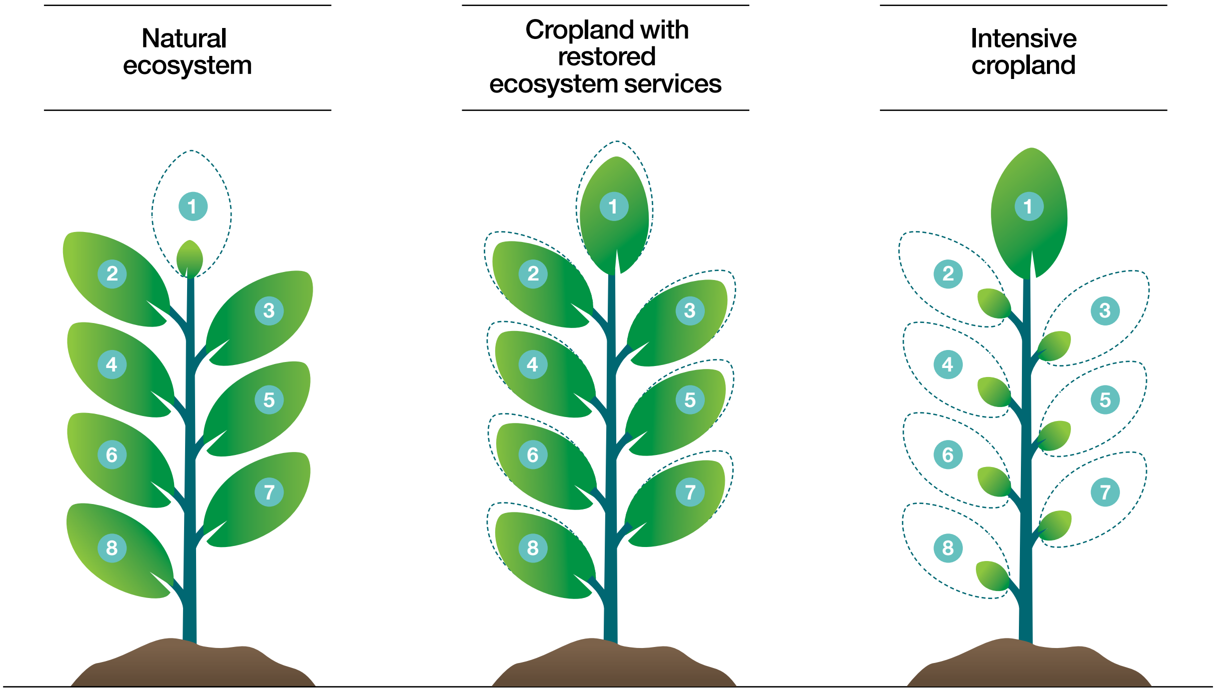
Our current food system continues to be skewed towards a narrow intensification approach. This approach to agricultural land use advocates maximising food production on a given piece of land, arguing that this will save other land (*land spared*) for biodiversity conservation. However, this approach disregards the impacts that land intensification with chemicals and monocultures has on biodiversity within and around farms, in addition to the highly unrealistic assumption that any land spared from farming will be saved for nature (Matson and Vitousek, 2006, Weinzettel et al., 2013, Bommarco et al., 2013).

Ecological Farming provides a balanced approach between optimising ecosystem services and food production. Figure 3 represents different options in a gradient from higher ecosystem services (land sharing) to higher food production (land sparing).

Greenpeace is not opposed to intensification of yields. On the contrary: increasing food production in low-yielding farms is good for farmers, good for food security and good for the planet, **but** only if it goes hand in hand with ecological practices. Ecological Farming is about both intensifying ecosystem services and food production from the same piece of land.

Figure 3: **Comparing Land Sharing vs Land Sparing:** Ecosystem Services vs Food Production

Ecological farming - cropland with restored ecosystem services - can deliver both high food production and at the same time, ecosystem services that ensure a healthy planet



1 Food/biomass production 2 Forest production 3 Preserving habitats and biodiversity 4 Water flow regulation
5 Water quality regulation 6 Carbon sequestration 7 Regional climate and air quality regulation 8 Infectious disease mediation



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Conceptual framework for comparing land use and trade-offs of ecosystem services, with an hypothetical gradient from nature conservation to land sharing, or "nature-friendly farming", and land sparing.
The provisioning of multiple ecosystem services from the same piece of land under different land-use regimes can be illustrated with these simple "plant" diagrams, in which the functioning of each ecosystem service is indicated by the size of the leaf; the bigger the leaf, the more effective the ecosystem service (this is a qualitative illustration, the size of the leaf is not normalised with common units.) For purposes of illustration, we proposed three hypothetical landscapes in a gradient from nature conservation (left) to an intensively managed cropland where crop production is maximised but other services are compromised (right), and a cropland with restored ecosystem services (middle). The natural ecosystems are able to most effectively support many ecosystem services (e.g. nature conservation), but not food production. The intensively managed cropland, however, is able to produce food in abundance (at least in the short run), at the cost of diminishing other ecosystem services (land sparing). However, a middle ground—a cropland that is explicitly managed to maintain other ecosystem services—may be able to support a broader portfolio of ecosystem services (land sharing) including food production.

Source: Foley JA, DeFries R, Asner GP, Barford C, Bonan G, Carpenter SR, Chapin FS, Coe MT, Daily GC, Gibbs HK, Helkowski JH, Holloway T, Howard EA, Kucharik CJ, Monfreda C, Patz JA, Prentice IC, Ramankutty N & Snyder PK (2005). Global consequences of land use. Science, 309: 570-574. Reprinted with permission from AAAS.

4 Biodiversity and diverse seed systems

"At a time where fortification is widely promoted as the most effective solution to address micro-nutrient deficiencies, we should not forget that nature provides an almost infinite variety of food species which are disregarded and therefore pushed into oblivion and extinction by the prevailing food production system" Florence Egal, Food Security, Nutrition and Livelihoods, Nutrition Division, FAO

Biodiversity is a key element for life on Earth. No healthy, functioning food and farming system can do without it. Yet, the diversity of the food we eat has decreased enormously in the past decades. Right now, half of the world's calories from plants come from rice, wheat and maize – a staggering amount given that humans used to grow more than 7,000 crops for food.[18] Ecological Farming aims to reclaim this diversity.

It is increasingly recognised that crop diversity plays a crucial role in food security, nutrition and human health, and many experts now agree that biodiversity in agriculture could help reverse the effects of two major contradictory human health burdens nowadays: malnutrition and obesity[19] (Fanzo et al., 2013, Frison et al., 2011, Frison et al., 2006). For example, recent efforts using local indigenous vegetables, often neglected and under-utilised (e.g. spider plant, amaranth, African nightshade) show that they hold untapped potential to improve profitability, nutrition and health in Africa (Ojiewo et al., 2013).

Scientists have shown that diversity provides a natural insurance policy against major ecosystem changes, be they in the wild or in agriculture (Diaz et al., 2006, Chapin et al., 2000, McNaughton, 1977). Biodiversity needs to be maintained from the seed to the plate, and across the landscape level, in order to maximise ecosystem services and support productive and nutritious farming systems in changing environments (Figure 3).

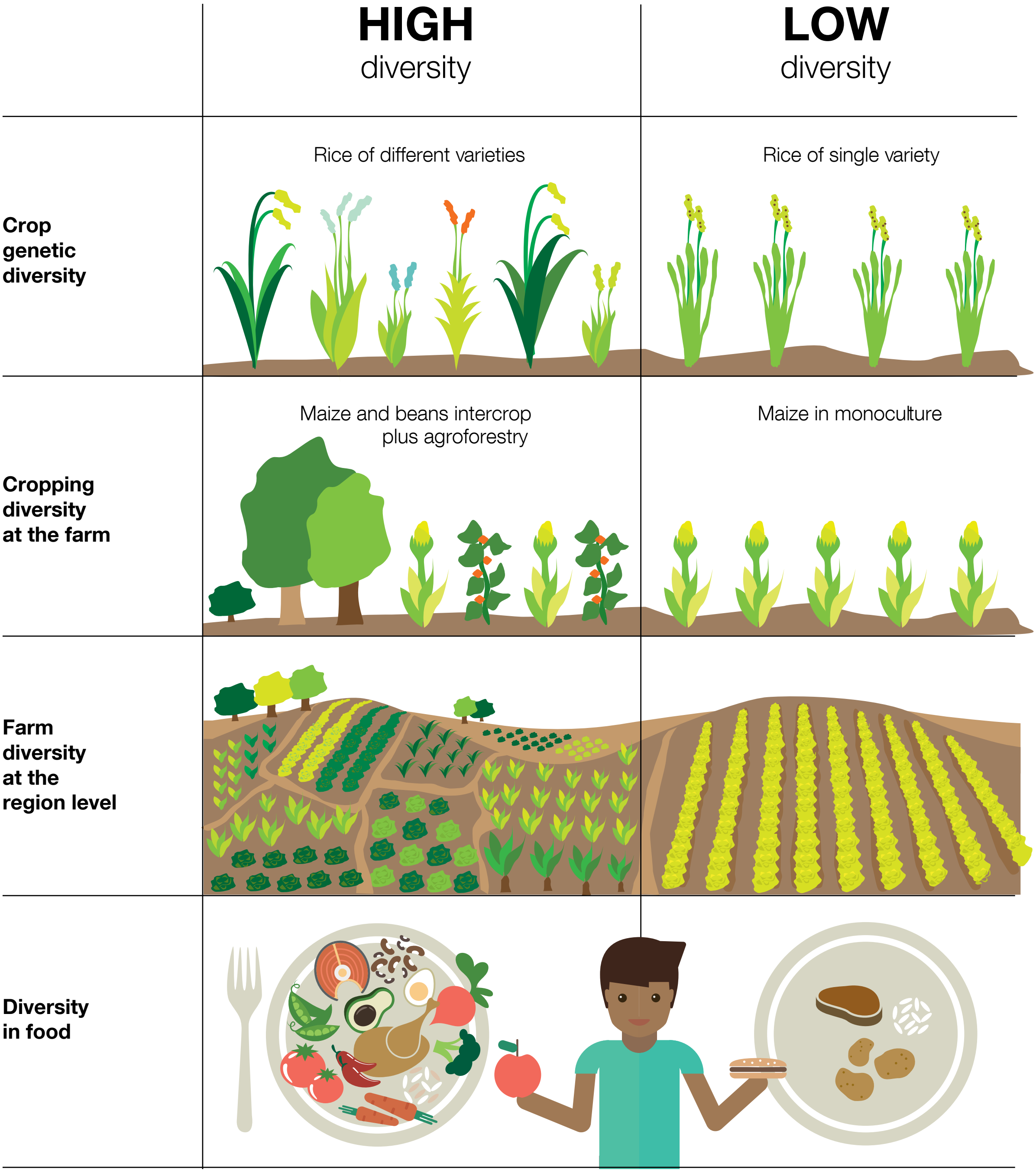
- Mixing different crops and single crop varieties in one field is a proven and highly reliable farming method to increase resilience to erratic weather changes within a farm (Costanzo and Bárberi, 2013). In addition, regional crop diversity (local varieties and landraces) holds the key to adaptation capacity to specific stresses (Denison, 2012). For example, in rainfed wheat fields in Italy, high genetic diversity within fields was found to reduce the risk of crop failure during dry conditions. In a model scenario, where rainfall declined by 20%, the wheat yield would fall sharply. But when wheat diversity was increased, this decline was reversed and yields were higher than average (Di Falco and Chavas, 2006, Di Falco and Chavas, 2008).

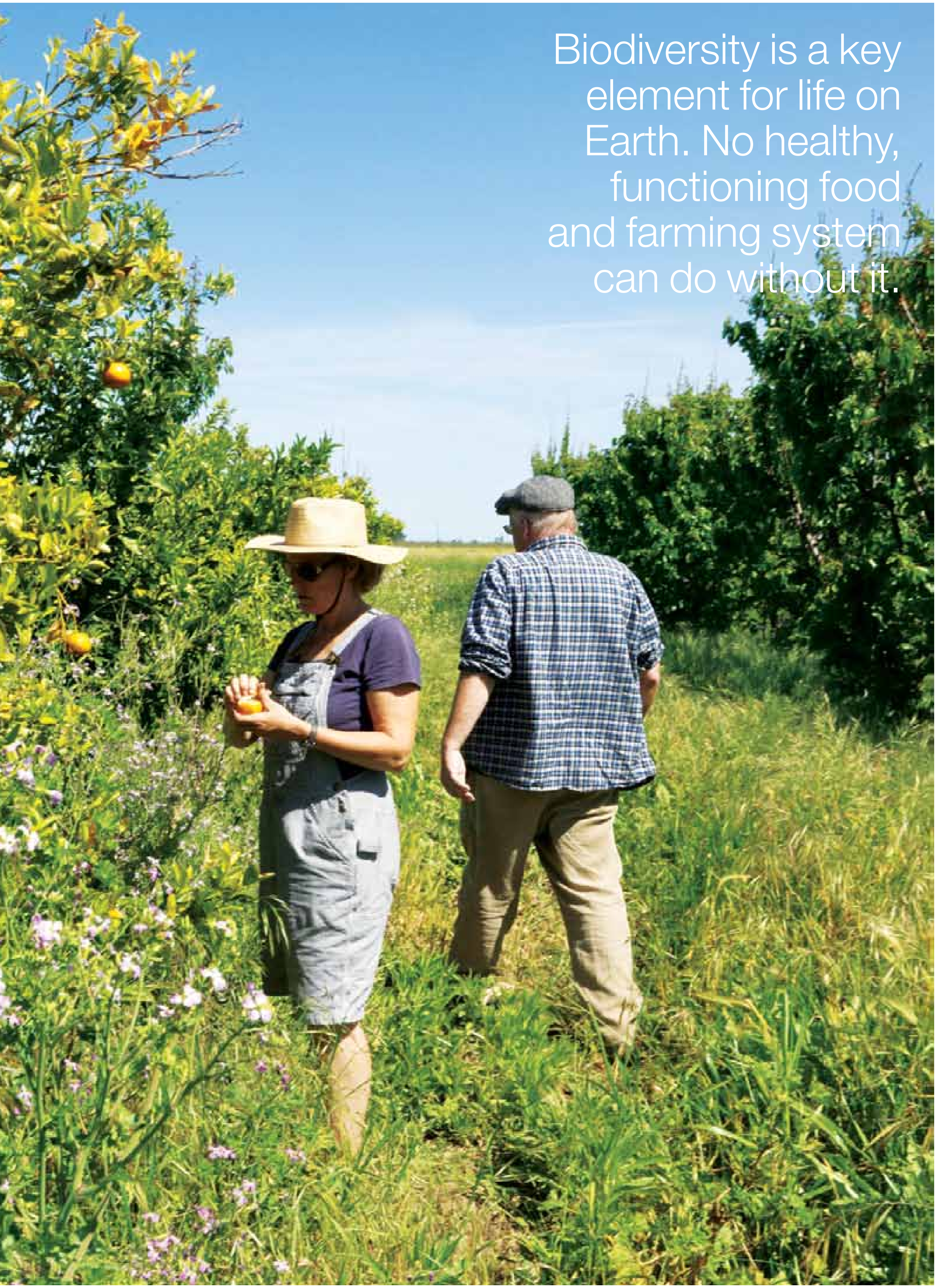
For single varieties of crops, the best ways to increase stress tolerance are modern breeding technologies that do not entail genetic engineering, such as Marker Assisted Selection (MAS).[20] In contrast, the vast majority of genetically engineered (GE) crops are either herbicide tolerant, resistant to specific insects or both (Quist et al., 2013). They are not designed to increase food security in a changing climate. GE crops narrow the genetic base of agricultural crops by producing "one-size fits all" varieties, when in fact, genetic diversity is seen as key to increasing resilience to climate change (Jacobsen et al., 2013, Lin, 2011).

A recent long-term review of the effects of organic farming on biodiversity (species richness) has shown that organic farms support 34% more plant, insect and animal species than conventional farms. This has been a consistent finding over the last 30 years (Tuck et al., 2014). For pollinators such as bees, the number of different species was 50% higher on organic farms. This is of vital importance, since bees and other pollinators maximise global food production through pollination services (however, pollinators are currently in decline due to loss of habitat, disease and pesticide use). More data is still needed for farms in developing countries, but the authors of the study conclude that, overall, the positive effect of organic farming on biodiversity is relatively even more profound in areas with widespread intensive agriculture (Tuck et al., 2014).

Figure 4: **Biodiversity at different levels**

From genetic crop diversity at the farm to landscape diversity at the regional level and nutritious diverse diet at the plate level





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The benefits of a diversification strategy are illustrated by a wealth of recent scientific data. In the last couple of years, more studies have contributed to the strong evidence showing that biodiversity is the most important driver of productivity and ecosystem function:

- Biodiversity seems to affect ecosystem productivity and functioning at least as much as other human drivers of environmental change, such as fire, fertilisation, droughts, grazing livestock or CO2. For example, when the diversity of a grassland is increased from 1 to 16 species, this results in a greater crop production than fertilising it with 95 kg of Nitrogen per hectare (Tilman et al., 2012). There is great potential to use biodiversity within agricultural systems, instead of external inputs, to increase productivity and provide ecosystem services such as water filtration, nutrient cycling, and beneficial insects.
- Another recent analysis shows how long-term chemical fertilisation causes biodiversity loss – leading to lower productivity. Adding nitrogen to grasslands initially increased biomass production, but because it also resulted in species loss it led to declines in productivity over time (Isbell et al., 2013).
- In Michigan (US), agronomists compared corn yields over three years between fields planted as monocultures and those with various levels of intercropping. They found the yields in fields with the highest diversity (3 crops, plus 3 cover crops) were over 100% higher than those cropped in continuous monocultures. Crop diversity improved soil fertility, reducing the need to use chemical inputs while maintaining high yields (Smith et al., 2008).
- Growing maize intercropped with fava beans (a legume) in poor soils low in phosphorus yielded more (43% more for maize, and 26% more for the fava) than growing them in monoculture. It appears that maize plants benefited from root interactions with the fava beans, which improved their access to soil phosphorus and nitrogen. Intercropping greatly improved soil fertility and crop yields in maize-fava farming (Li et al., 2007).

Protection of water from agricultural pollution and its conservation and efficient use within farming landscapes is essential for global biological diversity conservation. Pollution from agriculture is now considered the largest source of water contamination in many regions. The dead zone in the Gulf of Mexico, widespread eutrophication across the world oceans, and China's massive water degradation, are all, to a large degree, the result of industrial agriculture (Sutton et al., 2013, Sebilo et al., 2013, Grizzetti et al., 2011, Watts, 2010).

Agriculture is also the largest user of fresh water in the world. Many regions are experiencing water scarcity, while more droughts and erratic rainfall patterns are expected from future climate change impacts (IPCC, 2007, 2014).

Ecological Farming aims to protect water resources, and use them more effectively, through better and more efficient irrigation (e.g. decentralised solar pump irrigation in Africa (Burney et al., 2010)) and choosing appropriate crops. It improves the farming system to make the best use of the water available. Examples for this include developing soils rich in organic matter, water harvesting and agroforestry (Rockström and Karlberg, 2010).

5 Sustainable soil health and cleaner water

"Soils managed with organic methods have shown better water-holding capacity and water infiltration rates and have produced higher yields than conventional systems under drought conditions and excessive rainfall." (Seufert et al., 2012)

"Every citizen needs to know nitrogen. Because until they do, the politicians will not be empowered to make decisions." Mark Sutton[21]

Every farmer knows that healthy soils – well conditioned and with adequate nutrients – are essential for growing crops. However, our current agricultural system has badly harmed the ability of our soils to sustain a healthy condition. Heavy reliance on chemicals for fertilisation does not maintain soil fertility in the long term. It is costly, and it badly damages the environment. Ecological Farming provides a better way.

Plants accumulate essential soil nutrients, such as nitrogen and phosphorus, as they grow. When we take away the harvest, the nutrients travel with the crop- away from the farm soils. These nutrients need to be replenished in the farm soil in order to continue the cycle of crop and harvest. This happens, for example, when farmers put back crop residues, manures from their livestock, and waste from their kitchens as compost.

However, in the current industrial system – where food is highly processed, livestock is disassociated from arable land, and food commodities travel across the world – this cycle of extraction and replenishment is broken. This gives rise to the myth that chemical fertilisers are essential to grow enough food. This is simply not correct.

Chemical fertilisers perpetuate the broken unsustainable nutrient cycle within the current industrial agriculture system, which relies on two main sources of nutrients for soil health: chemical factories and mining operations.

Industrial nitrogen fixation produces synthetic nitrogen using large quantities of fossil fuels. **Mined nutrients**, such as phosphorus and potassium, are extracted from geological deposits via large-scale mining and processing operations – causing considerable environmental destruction. This approach has increased crop production in the past in certain regions – but at immense environmental and human costs.[22] These can no longer be neglected (FAO, 2011b).

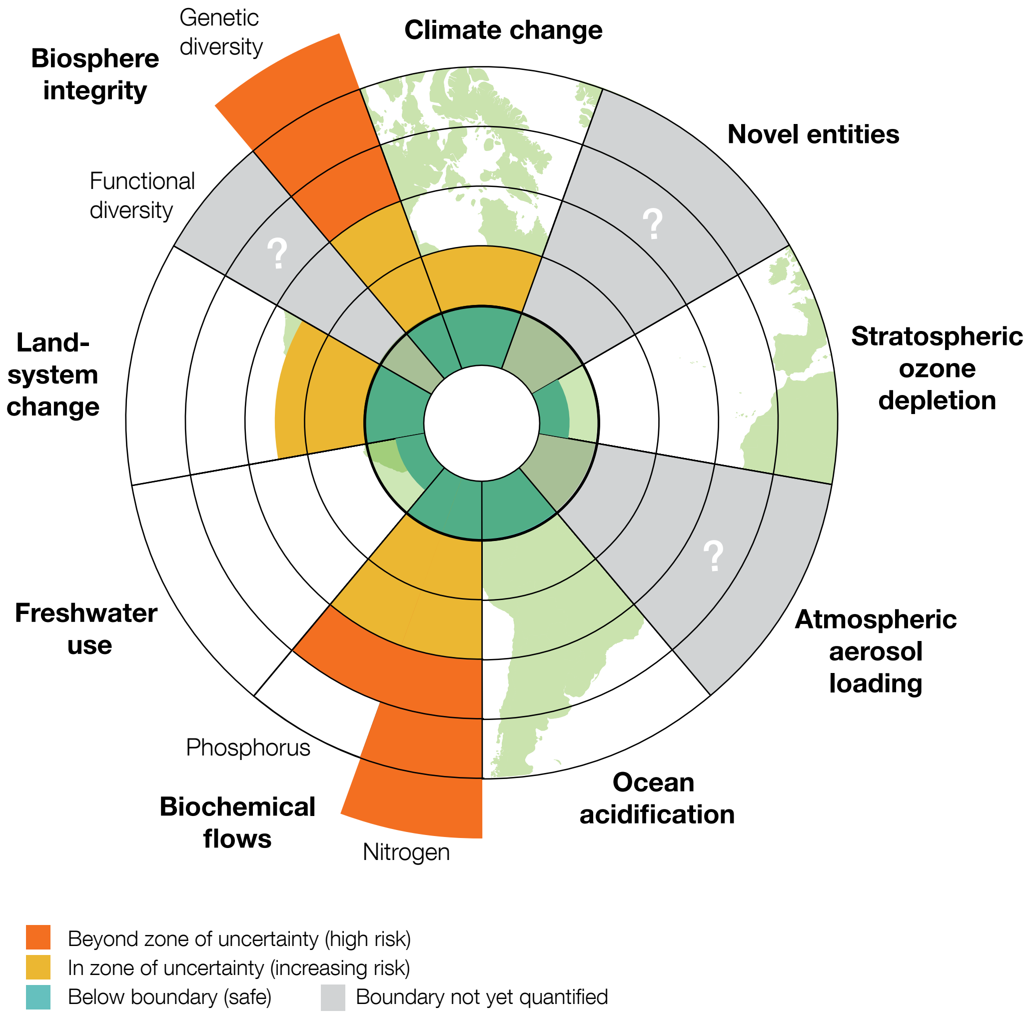
In the last few years a strong scientific consensus has emerged on the central role our unsustainable dependence on chemical fertilisers plays in global environmental problems, mostly through synthetic nitrogen and phosphorus fertilisers. Three recent issues highlight the need to rethink this dependence:

1) It is now widely accepted that the impact of nitrogen and phosphorus fertilisers on the planet has breached the **safe planetary boundary for life on Earth** by a very high margin (Rockström et al., 2009, Carpenter and Bennett, 2011, Steffen et al., 2015). The disruption of nutrient cycles is one of the major impacts affecting the health of the planet: dead zones in the Gulf of Mexico, massive toxic algal tides on China's coasts, and widespread contamination of drinking water in rural areas – all these environmental issues can be related to pollution with chemical fertilisers – with serious impacts on livelihoods.

2) Nitrogen and phosphorus application greatly exceeds nutrient limitation in agriculture lands, all over the planet. **Over-fertilisation is widespread**. Even the classic case of widespread phosphorus deficiencies in African farming systems does not hold true anymore. There are nutrient surpluses accumulating in some

Figure 5: **Planetary boundaries: key factors that ensure a livable planet for humans**

Of nine worldwide processes that underpin life on Earth, four have exceeded "safe" levels – human-driven climate change, loss of biosphere integrity, land system change and the high level of phosphorus and nitrogen flowing into the oceans due to fertiliser use.



Planetary boundaries showing changes that are shifting Earth into a "new state" that is becoming less hospitable to human life, as updated by the newest research published in Science in 2015. Pollution with nitrogen and phosphorous fertilisers, together with Biosphere Integrity (Biodiversity), are the two planetary boundaries under the high-risk zone for disruption of life on Earth (Steffen et al., 2015). The 'novel entities' boundary refers to "new substances, new forms of existing substances, and modified life forms that have the potential for unwanted geophysical and/or biological effects" (e.g. microplastics, nanoparticles or genetically engineered organisms) (refs. 68-71, Steffen et al., 2015). Graphic © theguardian.com (2015).

zones. Phosphorus surpluses exist in around 60% of African soils, mostly across East Africa in livestock operations and around cities. Elsewhere, soils are not being managed correctly to grow more food where it is needed, for example in rural areas, where around 20% of African soils have significant phosphorus deficits (MacDonald et al., 2011, Elser and Bennett, 2011). Poor soils everywhere, including Africa, could be improved by redistributing organic nutrients that currently go to waste and investing in agroecological practices that build long-lasting soil fertility.

3) The scientific community is calling for action on the nutrient issue: in 2013, the UNEP, together with an extensive group of global scientists, put together a comprehensive review, "Our Nutrient World: The challenge to produce more food and energy with less pollution" (Sutton et al., 2013). With it, **UNEP launched a "strong plea for action"** on nutrient management, calculating that the savings from reducing nitrogen consumption by 20 Mt per year by 2020 would amount to savings of US$ 170 billion per year (including implementation costs, with additional fertiliser savings for farmers and benefits for health and the environment).

The intensive use of chemical fertilisers has been related to serious degradation of soil health in extensive regions in China, with widespread effects on major cropping areas essential for future food security (Guo et al., 2010, Darilek et al., 2009). In some regions, soil acidification limits the potential for increasing food production, with large possible consequences for future food security (Guo et al., 2010). Soil erosion also has multiple consequences for nutrient cycles and soil health, and it threatens future food security and human survival in many parts of the world (Quinton et al., 2010).

There is a better alternative: Ecological Farming methods can help reverse the trend of declining soil fertility and land degradation that many farmers in developing countries are facing. Problems such as soil erosion, acidification and organic matter depletion can benefit from agroecological practices that nurture soil fertility and biodiversity (Eyhorn, 2007, Mäder et al., 2002, Fließbach et al., 2007, Tittonell et al., 2012).

Ecological farming considers soil as a living, essential, component of farming. The nutrients that plants need can come from three main sources and contribute to overall soil health:

1. **minerals** naturally occurring in farm soils, due to their geological history,
2. **organic sources** that are brought back to farming soils (manure from animals, residues from crops, composted waste from domestic sources),[23]
3. **biological nitrogen fixation**, from fixation of N_2 from the air, via legumes or other plants or micro-organisms with this capacity.

Below, we outline the scientific evidence that supports the 4 guiding principles of ecological soil fertility.

1 Ecological Farming relies on organic fertilisers, and on farming with diversity. It avoids the use of chemical, synthetic fertilisers, particularly nitrogen and phosphorus. However, under certain exceptional circumstances, mineral nutrients may be needed to restore soil fertility of degraded lands in the short term.

A meta-analysis of data from 77 published studies shows that nitrogen-fixing legumes used as green manures can provide enough biologically fixed nitrogen to replace the entire amount of synthetic nitrogen fertiliser currently in use, without reducing food production (Badgley et al., 2007).

In Africa, legume trees intercropped with maize, can add enough nitrogen to sustain maize yields as high as those produced with the use of chemical fertilisers. In addition, intercropping with trees and incorporating their biomass improves soil health, improving water infiltration, reducing runoff and soil losses. It can also enhance the uptake of other nutrients (phosphorus, potassium) (Akinnifesi et al., 2010).

2 Ecological Farming aims to return all manure and other food residues back to productive farm soils. To ensure a balanced return of nutrients to productive croplands and pastures, farming soils need to incorporate manure and other wastes (including human wastes, with well-designed and safe eco-sanitation). Closing nutrient cycles will require avoiding large imports/exports of nutrients from/to remote regions, for example by reconsidering the massive movement of livestock feed across the world (Galloway et al., 2007). Ecological Farming means either mixed farming (crops and livestock) or pastoralism (crofting, agro-pastoralism) in regions unsuitable for cropping. An Ecological Farming system will also require a drastic reduction in livestock production and consumption – currently the biggest inefficiency in use of nutrients within our food system.

A recent comprehensive global model estimates that **redistribution and adjustment of livestock to meet local human needs, plus a reliance on biological nitrogen fixation by legumes, could fulfill the needs of nitrogen for crop production to feed everyone on Earth without chemical fertilisers**, while greatly reducing nutrient losses and pollution (Billen et al., 2013). Ecological livestock management considers manure not as a waste but as a valuable input that needs to be returned to soils. Right now, inefficient use of manure within agriculture systems means that, for example, only about half of the phosphorus in manure used on agricultural lands is recovered in the crop (Cordell et al., 2011, Bouwman et al., 2011).

Greenpeace's position on ecological livestock is one guided by the essential role that animals play in agriculture systems. **Ecological livestock integrates farm animals as essential elements in the agriculture system; they help optimise the use and cycling of nutrients and, in many regions, provide a necessary farm work force, an additional form of income, and a form of insurance. Ecological livestock relies on grasslands, pasture and residues for feed, minimising the use of arable land and competition with land for direct human food production, and protecting natural ecosystems within a globally equitable food system.**

Right now, about half of the people living on the planet, 72% of them in Asia, do not have access to adequate sanitation facilities (Mihelcic et al., 2011). This is considered one of the biggest health risks associated with waterborne infectious and parasitic diseases, killing and sickening thousands of children every day in many regions of the world. In addition, lack of sanitation pollutes watercourses and limits access to safe drinking water for about 800 million people on the planet.[24]

This lack of existing sanitation and sewerage facilities in many places provides an opportunity for creating truly sustainable systems with nutrient recovery for farming as an explicit goal (SEI, 2005).

Nutrient recovery with ecosanitation can be very efficient: up to 90% of the phosphorus and nitrogen in urine and faeces could be potentially recovered and used to fertilise agricultural lands and improve crop yields (Andersson et al., 2013). With appropriate safety precautions, recycled nutrients from excreta can substitute costly chemical fertilisers. For Sub-Saharan Africa this could replace the entire amount used currently (SEI, 2005).[25]

Biomass is a limited resource

How should it be used? As manure for bioenergy, or to increase soil fertility? To feed animals, or to cover the soil?

In some cases, synergistic uses are possible. In decentralised domestic biogas plants, for example, manure is used for gas production; the remaining nutrient-rich waste improves soil fertility. Elsewhere, there are simple guidelines that can be followed. After the harvest, for example, priority should be given to the use of resources that first enhance food availability and maintain soil fertility over the use for energy security, especially where other sources of energy are available, for example solar power.[26]

In general, solutions are often context specific and local communities should decide on the on the use of biomass that work best for them.

3 **Ecological Farming maintains or increases soil organic matter in agriculture soils.** This is a crucial step in maintaining or improving soil fertility; optimising water use; creating resistance to drought stress; and preventing erosion.

Plants need nutrients to grow. They also need a well-conditioned soil to hold enough water and facilitate root growth. It also helps them to maintain healthy micro-organisms, which support plant growth and improve the availability of nutrients. As many farmers will attest: a good soil is life.[27]

Soil also has a crucial role to play in regulating the planet's climate: it stores more carbon than the atmosphere and vegetation combined (Averill et al., 2014).

Ecological Farming practices often work to increase content and stability of carbon in the soil, often preventing erosion and other causes of soil degradation (Thomas, 2008, Ajayi et al., 2007). For example, in a 21-year-long study on European farms, soils that were fertilised organically showed better soil stability, enhanced soil fertility and higher biodiversity, including activity of microbes and earthworms, than soils fertilised synthetically (Mäder et al., 2002).

In another example, fertilisation with manure (compared to fertilisation with chemical fertilisers) in apple orchards in the US, increased the amount of carbon stored in the soil, increased the diversity and activity of soil microbes, and decreased the losses of nitrates to water bodies, while keeping nitrous oxide losses to the atmosphere at similar levels (Kramer et al., 2006).

4 **Ecological Farming increases efficiency in nutrient use to minimise losses of nitrogen and phosphorus – working with biodiversity.** It aims at the best possible and most efficient use of resources.

A recent comprehensive study analysing years of global research on nitrogen uptake by crops shows that diversified farming practices can both enhance the uptake of nitrogen by the crop and reduce its losses and subsequent pollution (Gardner and Drinkwater 2009). This study shows that diverse rotations in a farm system can reduce losses of nitrogen from the system (i.e. its retention in soil and crops) by 30%.

Diversified farming seems more effective in reducing pollution sources than practices based on chemical fertilisers (e.g. changing chemical forms, reducing chemical nitrogen application rate). Importantly, yields were not different between crops fertilised with chemical or organic fertilisers, and much more organic nitrogen remained in the soil in the second year after application. This suggests that organic fertilisers may build up in the soil, avoiding losses to the environment and enriching soils over time.

The use of organic fertilisers, where cheap and locally available, makes Ecological Farming more secure and less vulnerable to the accessibility of external inputs and price fluctuations. Recently, this has been shown in agroforestry systems in Malawi, where farmers enjoyed a better financial return from their farms when they opted for fertilising with legume trees instead of with chemical fertilisers (Greenpeace Africa, 2015).

6 Ecological pest protection

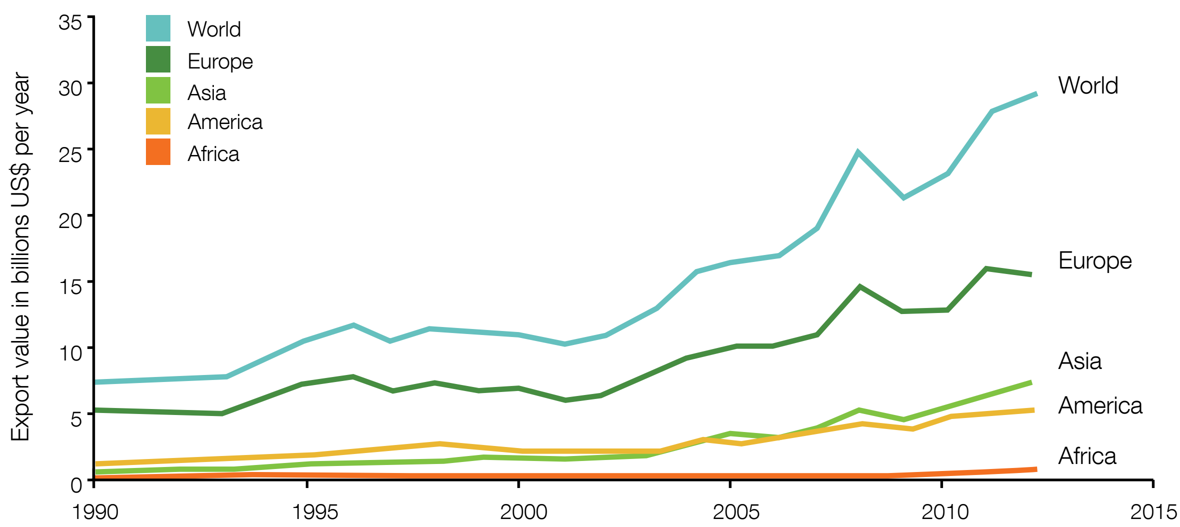
"Diversified landscapes hold the most potential for the conservation of biodiversity and sustaining the pest control function" (Bianchi et al., 2006).

They harm the ecological balance of our environments. They have many negative impacts on non-target organisms. They are involved in the decline in populations of bees and other pollinators. They kill insects that could be beneficial for natural pest control in the farm. Yet, pesticides continue to be at the heart of our current agricultural system – despite growing evidence that Ecological Farming can provide good pest controls.

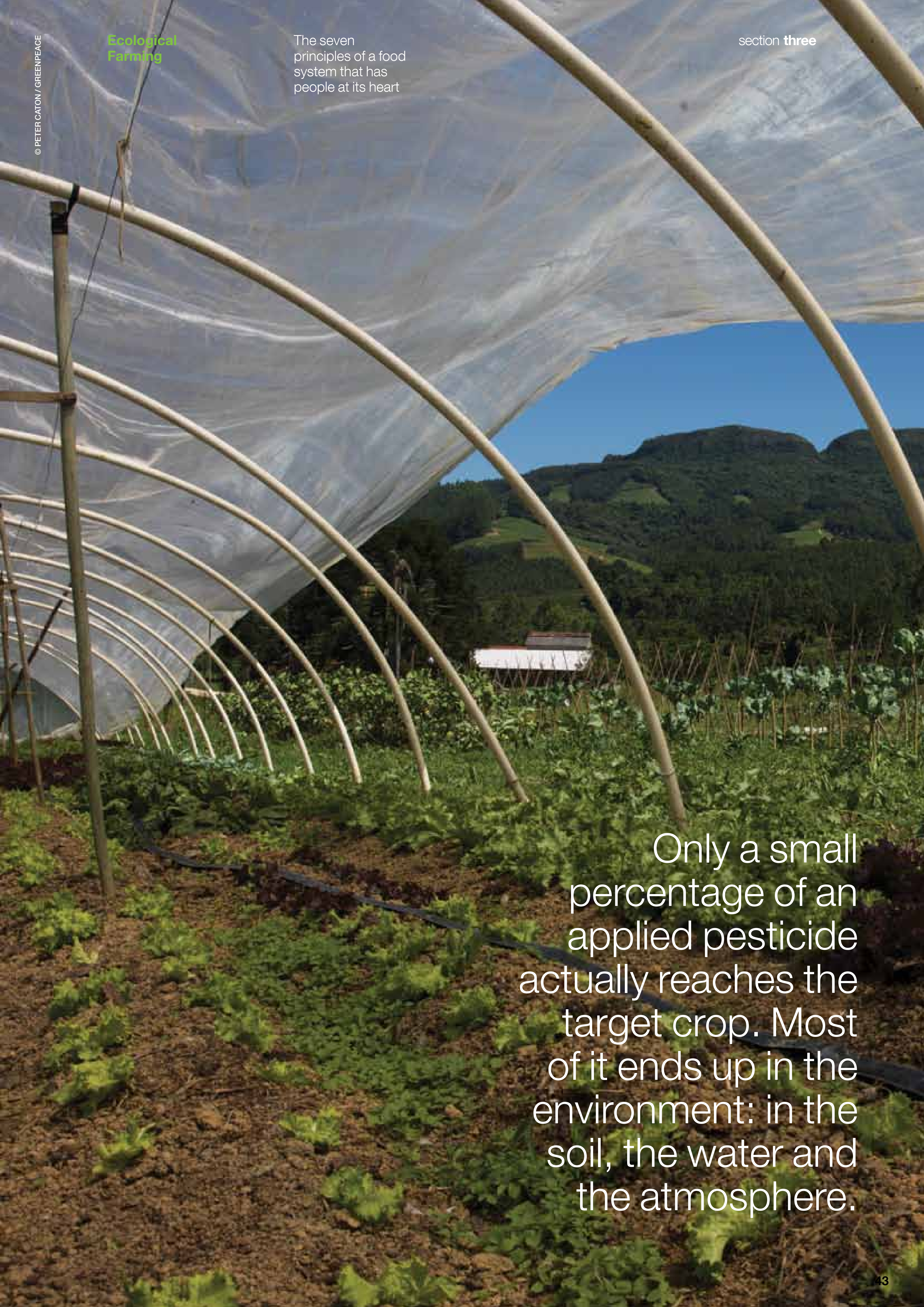
Worldwide, large amounts of chemical pesticides are used every year. This is evident from a global trade[28] that has grown enormously in the last decade. It now totals almost US$30 billion per year (Figure 6).

Figure 6: **Global pesticide trade**

Exports of pesticides, a proxy for global pesticide use, has tripled in the last decade



Global trade of pesticides in export value (billion US$) from 1990 to 2012. Global trade serves as a proxy for global pesticide consumption (see endnote 28). Data source: FAO Stats, 2015. European farms are not the largest consumer of pesticides worldwide, but Europe leads in pesticide export globally. (Regional aggregation as in FAO Stats).



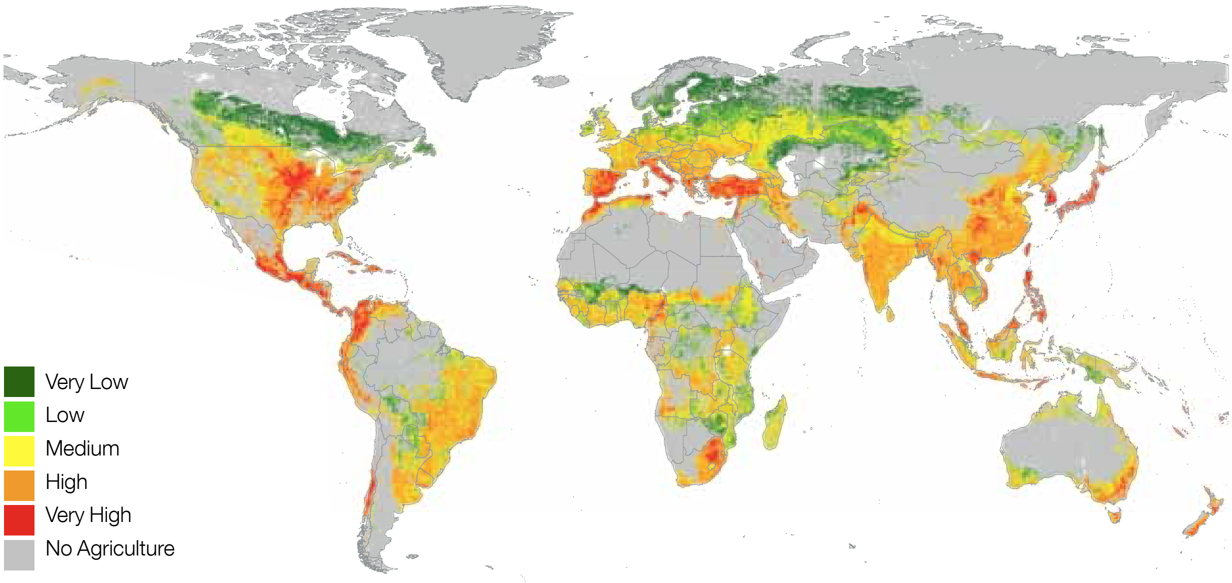
Only a small percentage of an applied pesticide actually reaches the target crop. Most of it ends up in the environment: in the soil, the water and the atmosphere.

Ecological Farming protects crops without chemical pesticides: a variety of different methods enable farmers to control pests without the need to use toxic chemicals.

Only a small percentage of an applied pesticide actually reaches the target crop. Most of it ends up in the environment: in the soil, the water and the atmosphere. Pesticides have a negative impact on non-target organisms, and they destroy the ecological balance of the surrounding environment (Relyea, 2009, Relyea, 2005, Ippolito et al., 2015). The impact is significant. It has been estimated, for example, that the surface waters in 43% of the entire global land area are potentially subject to insecticide load – as a consequence of current agricultural practices (Fig 6, Ippolito et al., 2015).

Figure 7: **The risk of contamination of our water systems with insecticides is widespread, and highest where agriculture is more intense**

43% of the global streams are at risk from the application of insecticides



Global Insecticide Risk Potential map. The map shows the spatial distribution of potential insecticide runoff to stream ecosystems. According to this estimation, the surface waters in 43% of the total global land area are potentially subject to insecticide load as a consequence of current agricultural practices. The class boundaries (-3; -2; -1; 0) are the same as those used to previous studies (kattwinkel et al, 2011). Grey areas indicate the absence of any relevant agricultural activity. Reprinted from Environmental Pollution, 198, Ippolito, A., Kattwinkel, M., Rasmussen, J. J., Schäfer, R. B., Fornaroli, R. & Liess, M., Modeling global distribution of agricultural insecticides in surface waters, pages 54-60, Copyright (2015), with permission from Elsevier.

Recent scientific analyses have been adding weight to the notion that certain chemical pesticides are one of the factors responsible for pollinators decline globally (EASAC 2015, see other references in Tirado et al., 2013). The ecological and economic importance of healthy pollinator populations underlies the urgent need to eliminate the use of bee harming pesticides. A separate study has recently estimated that 23 species of bees and flower-visiting wasps have become extinct in Britain, and the disappearance of these species was closely linked to agriculture intensification (Ollerton et al., 2014).

Chemical pesticides also kill many insects that can be beneficial for natural pest control in the farm. This is one reason why chemical pesticides make it harder to avoid pest damage in the crop. The result: an increase in incidence of damage by pests and disease. Thus, in the long term, chemical-intensive agriculture becomes more vulnerable to pest damage, and ever-higher levels of pesticide use are necessary. This is called the “pesticide treadmill”.

The “pesticide treadmill” places an enormous financial burden on farmers, especially if they exist on a low income. It is easy to become “trapped” in a cycle, which once entered, leaves little room for a departure. The “treadmill” also means there is a higher risk for all of us – due to the increasing presence of toxic chemicals throughout the agriculture system.

Ecological Farming protects crops without chemical pesticides: a variety of different methods enable farmers to control pests without the need to use toxic chemicals.

Farmers can find long-term solutions to pest problems by designing diverse crop fields, and by using low-input technologies that are locally available. Ecological pest protection is based on enhancing the “immunity” of the agroecosystem and promoting healthy soils and healthy plants (Altieri and Nicholls, 2005). By designing agroecosystems that on the one hand reduce the damage caused by pests (e.g. planting pest-resistant varieties) and on the other are less vulnerable to pest invasion (e.g. with biodiversity that enhances presence of natural enemies), farmers can substantially reduce pest numbers (Gardiner et al., 2009, Crowder et al., 2010, Turnbull and Hector, 2010).

At the core of ecological pest protection, is farming with biodiversity. Biodiversity-rich systems typical of ecological farms – both in species richness and evenness – enhance natural pest control by natural enemies. The result can be much stronger pest control than exists on farms that use chemical pesticides (Turnbull and Hector, 2010, Crowder et al., 2010, Krauss et al., 2011). In addition, diversified farming systems help to increase pollination services (Kremen and Miles, 2012).

In cereal fields in Germany, organic fields were found to have a richness in pollinator species that was 20 times higher compared to conventional fields, and a pollinator abundance that was more than 100 times higher. “In contrast, the abundance of cereal aphids (a pest) was five times lower in organic fields, while aphid predator abundances (natural enemies) were 3 times higher in organic fields, indicating a significantly higher potential for biological pest control in organic fields” (Krauss et al., 2011).

The mainstream research agenda has been focussed on chemical pest control for several decades. Yet, many studies have found successful agroecological ways to manage specific pest problems.

Ecological Farming is context specific, and there are many different approaches to ecological pest control. The guiding principle is to increase and maintain biodiversity as an insurance against pest damage through natural pest protection. This will need certain re-configuration of the farming system as a whole (Tittonell, 2013). Genetically uniform planting – the usual practice in industrial monocultures – is a shortsighted strategy to combat pests. Pest evolution is usually quicker than human interventions, and thus cultivating pest-resistant cultivars (i.e. plant varieties) is not a durable strategy in itself. A growing body of research confirms that incorporating biodiversity at different scales – from cultivars to landscape – is the most promising strategy for effective and sustainable pest control.

A 5-step multilevel approach (see figure 8) has been suggested to direct the process of ecological pest protection at the farm level (Forster et al., 2013). Under this model, most effort is put into the first 3 steps: incorporating biodiversity into the farming systems to indirectly, but efficiently, protect crops from pests.

Figure 8: **A 5-step approach for pest protection at the farm level**

In Ecological Farming, pest protection is based on a multi-level approach summarised in the 5 steps below. There is a strong focus on preventive measures (steps 1 to 3: based on biodiversity at various levels), with more direct curative measures applied only at later stages and only when needed. (steps 4 and 5: biocontrol and other biopesticides)

Preventative, indirect pest management

1

Environmental protection

Enriching biodiversity of non-crop habitats, interlinking of crop and non-crop habitats on farm and landscape level.

2

Cultural practice

Crop rotation, enhancement of soil fertility, choice of resistant cultivars, choice of site on field.

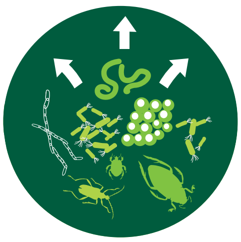
3

Functional biodiversity

Enhancing beneficial antagonists by vegetational management on field level.

Curative, direct pest management

4



Biocontrol agents

Inundate or inoculative release of beneficial bacteria, viruses, insects, nematodes.

5

Others

Approved insecticides of biological or mineral origin, mating disruption, physical measures.

Source: Based on Forster et al. 2013: "A five-step approach of arthropod pest management in organic agriculture based on the concept of Wyss et al. (2005) and Zehnder et al. (2007) modified by Hernyk Luka, FiBL 2012."

These are the most essential steps needed to eliminate chemical pesticides from agriculture. As a last resort, and of secondary importance to the core biodiversity practices, are the use of biocontrol agents and biopesticides and other compounds that contribute to a farmer's ability to cope with pests when the pressure is high.

Here are some cases of successful ecological pest protection based on biodiversity:

- In a unique cooperation project between Chinese scientists and farmers in **Yunnan Province** during 1998 and 1999, researchers demonstrated the benefits of biodiversity in fighting rice blast, the major disease of rice, caused by a fungus (Zhu et al., 2000). By growing a simple mixture of rice varieties across thousands of farms in China, they showed that disease-susceptible rice varieties inter-planted with resistant varieties had an 89% greater yield and a 94% lower disease incidence – compared to when they were grown in a monoculture. By the end of the two-year programme fungicidal sprays were no longer being applied. This approach is a calculated reversal of the extreme monoculture that is spreading throughout agriculture, pushed by agribusiness focussed solely on plant genetics (Zhu et al., 2000, Zhu et al., 2003, Wolfe, 2000).

- Rice-duck-fish and rice-fish systems, sometimes also with N-fixing bacteria (*Anabaena azollae*) associated with ferns of the genus *Azolla*, create an ecologically intensive production landscape, and have proven sustainable in many parts of **South East Asia**. Moving from rice monoculture to polycultures with rice + ducks + fish + *Azolla* resulted in more than a doubling of rice yields, while providing substantial amounts of animal protein at the same time (Khumairoh et al., 2012). Other benefits of this complex system include efficient pesticide-free weed and pest control, as well as reduced methane emissions (a highly potent greenhouse gas) as the trophic web is diversified.

- In **Africa**, scientists at the International Centre of Insect Physiology and Ecology (ICIPE) developed a cost-effective push-pull system to fight maize (stemborer) pests without the use of chemicals. Grasses planted on the borders of maize fields (Napier grass and Sudan grass) attracted insect pests away from maize – the pull – and two plants intercropped with maize (molasses grass and two *Desmodium spp.* legumes) repelled the insect pests from the crop – the push (Hassanali et al., 2008, Khan et al., 1997, Khan et al., 2011). Farms using push-pull systems showed between 40-90% less attack of stemborers and, on average, 50% higher yields of maize than monocrop farms. In addition, in the semi-arid Suba district, for example, plagued by both stemborers and Striga (witchweed, a parasitic weed), milk production is also going up, with farmers now being able to support increased numbers of dairy cows on the fodder produced from the Napier and Sudan grass. Economically, across 4 districts in **Kenya** over 7 years, the average economic return per hectare was 74% higher for push-pull farmers than for monocrop farmers (Hassanali et al., 2008).[29]

- Recent Greenpeace research in **Western Kenya** has shown that the push-pull system of pest protection without pesticides increased net income of smallholder maize farmers by almost 3 times, due to a combination of better yields and lower costs of cultivation (no chemical fertilisers or pesticides). Average yields for maize grown using push-pull were roughly double those of farmers not practising push-pull (Greenpeace Africa 2015).

- In the state of **Andhra Pradesh, India**, a pesticide-free farming revolution has taken place in the last few years. A non-pesticide approach to farming, based on locally available resources and local practices supplemented with modern science, has brought ecological and economic benefits to the farmers. Damages to a crop can be reduced by 10-15% without using chemical pesticides: the cost of plant protection is low. The small success of a few villages has been scaled up to more than 1.5 million hectares, benefitting more than 350,000 farmers from 1,800 villages in 18 districts of the state; 50 villages have become pesticide-free and 7 villages have gone completely organic (Ramanjaneyulu et al., 2008). Another example of this success in India is the performance of non-pesticide management in genetically engineered Bt cotton[30] and non-Bt cotton, studied by the Central Research Institute of Dryland Agriculture (CRIDA). This study showed that non-pesticide management in non-Bt cotton is more economical compared to Bt cotton with or without pesticide use (Prasad and Rao, 2006).

- A recent experiment in **France** demonstrated how weed control with 70% reduced or 100% herbicide-free farming is effective in keeping weeds low and maintaining high yields. Techniques such as mechanical weeding or weed seed bank preparation were proven to be effective. However, farmers often find this time-consuming, and would possibly need support in facilitating initial adoption. Benefits on environmental performance and profitability would justify this support (Chikowo et al., 2009).

Complex landscapes (with a mosaic of semi-natural habitats together with croplands) were 74% more favourable to natural enemy insects than simplified landscapes (with little semi-natural habitat) (Bianchi et al., 2006). Grasslands, herbaceous and wooded habitats were all associated with enhanced natural enemy populations. Although this review focussed on the temperate zones (North America and Europe), the authors acknowledge that “the mechanisms underlying biodiversity–pest control relationships are general and are also relevant for other regions” (Bianchi et al., 2006).

In addition to more research and development on pesticide-free techniques, experts agree that there is **an urgent need for effective science outreach to farmers and the communication of technical information in appropriate ways, led by public institutions** (Van den Berg and Jiggins, 2007). In a recent analysis in **East Africa**, participation in a Farmers Field School designed for sustainable farming practices, increased income by 61%, particularly among women, farmers with low-literacy, and medium land size farmers (Davis et al., 2012b).

Farmers Field Schools in Asia highlight the potential and urgent need for strengthening the link between technical knowledge and farmers’ knowledge. The positive effects of these initiatives, when specifically targeted towards Ecological Farming practices, are impressive. For example, among onion growers in **the Philippines**, those involved in Farmers Field Schools to learn about non-chemical pest control, spent significantly less on pesticides (around Ph 5,000 less, about 100 Euros) than conventional farmers not involved in these participatory programmes for knowledge-intensive techniques to reduce the use of chemical pesticides (Yorobe Jr et al., 2011).

In a creative initiative in **Vietnam**, a radio soap opera (drama series) was designed to simultaneously entertain and educate paddy rice farmers on techniques to reduce pesticide use. Farmers reduced their insecticide sprays by 31% after the soap opera experience. Rice yields increased and the percentage of farmers who did not apply any insecticide almost doubled. This effect was also evident in comparing farmers who listened to the soap opera – they showed reduced pesticide use and better yields – compared to those who did not listen to it. In this case, the soap opera was designed by a participatory process involving farmers, and was supported by a number of activities on the ground. This initiative has continued to change practices and beliefs about pesticides and received a number of awards (Heong et al., 2008).

7 Climate resilient food production

"A resilient agroecosystem will continue to provide a vital service such as food production if challenged by severe drought or by a large reduction in rainfal" (Holling 1973)

Farming is under stress: the climate crisis is worsening conditions in many parts of the planet, already. Over the coming decades, erratic weather events and unfamiliar climatic conditions are likely to become even more common. Uncertainties within the energy system and the commodity market contribute to the picture. It is against this backdrop that we must build a more resilient agricultural system. There is now a growing consensus for this need. Ecological Farming provides a large part of the answer.

Resilience is the ability to withstand a drastic change in external conditions (for example the weather, pests, or market prices) – and recover from it quickly. It is the opposite of vulnerability.

Resilience thinking focusses on reducing risks by increasing the adaptive capacity of people and the agriculture ecosystems on which they depend, enabling farmers to meet current and future food needs while coping with uncertainty and change (Adger, 2003). This is very different from our high-risk current system, which focusses solely on increasing productive capacity.

UN institutions and processes have long been highlighting the importance of strengthening resilience in order to support smallholder livelihoods and long-term food security under a changing climate and faced with volatile markets (FAO, UN High Level Task Force on the Global Food Crisis, UN Commission on Sustainable Development, UN Special Rapporteur on the Right to Food (United Nations, 2008, Commission on Sustainable Development, 2008, De Schutter, 2008, FAO, 2008)).

Ecological Farming can enable a more resilient farming system. In practice, resilience can be achieved by:

1. Ensuring biological diversity at the genetic and species level within the agricultural ecosystem. This includes soil biodiversity; diversity of the insect population (which can act as a natural control system and includes pollinators such as bees); diversity of crops; and diversity of varieties for food and nutrition. This also means curbing practices, such as use of toxic pesticides and chemical fertilisers, which reduce diversity (e.g. of plants, insects, soil biota). Biological diversity allows for local ecosystems to absorb shocks and adapt to change.
2. Ensuring diversity of food sources to ensure a diverse diet that promotes nutrition security. This includes urban planning systems that encourage urban farming for greater household food self-sufficiency and better nutrition. In rural settings, a diverse agriculture landscape, with multiple sources of food crops and animal protein, enhances regional food security.
3. Building social and economic systems that support rural livelihoods. Examples that could be scaled up include the promotion of local farmers' markets; Community Supported Agriculture programmes, reconnecting consumers and farmers; public procurement from local and ecological farms, such as the 'Sustain' initiative in the UK; linking hospitals with local farmers; farm-to-school programmes, and many others.
4. Linking farming to the disaster preparedness of farming communities. For example, by having secure seed systems (possibly through community seed banks or a network of household seed "banks") or seed stocks for distribution during rehabilitation after a disaster.
5. Building on local/farmer place-specific knowledge systems (indigenous knowledge) to reduce risks and uncertainty.

Central to adaptation strategies for agriculture is maintaining genetic diversity and promoting community-based natural resource management (Jarvis et al., 2011).

Our current food and agriculture systems are badly prepared to adopt the required mitigation and adaptation strategies recommended by experts (Smith et al., 2013). Current cropping systems in conventional agriculture require stable climates and ideal conditions to suit the highly specialised crop cultivars that thrive in narrowly defined geographic and climatic ranges. They also depend on expensive chemical inputs that farmers often buy with credits, expecting to get a return high enough to pay it back with interest. Industrial farming systems often work with monocultures lacking seed genetic diversity, embedded in large expanses of land with little refuge for any kind of biodiversity. Biodiversity is key to multiple ecosystem services, including pest protection, pollination, nutrient cycling, water filtration, and climatic adaptation (Cardinale et al., 2012).

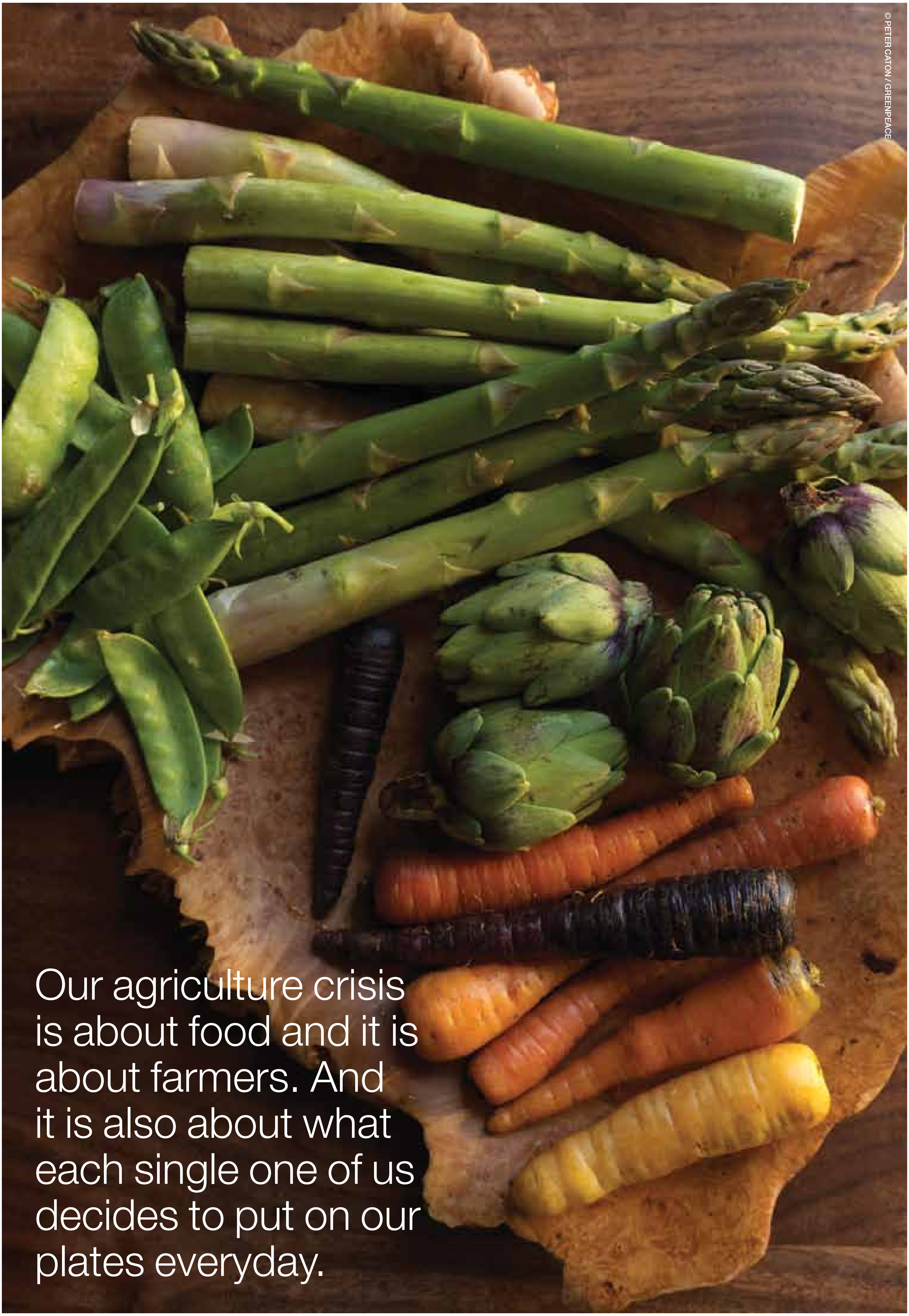
Ecological Farming can contribute to building food and agriculture systems with the inherent ability to cope with water limitations. To secure global resilience, agriculture systems (in the words of one research group) need to "invest in the untapped opportunities to use green water[31] in rainfed agriculture as a key source of future productivity enhancement. There is a need for more innovative options for water interventions at the landscape scale, accounting for both green and blue water" (Rockström and Karlberg, 2010). One of these innovations might be the case of distributed irrigation, with decentralised systems using low-cost solar irrigation pumps, as a development priority in Sub-Saharan Africa (Burney et al., 2010).

The CGIAR (Consultative Group on International Agricultural Research) Program on Climate Change, Agriculture and Food Security (CCAFS), which has almost 10,000 scientists and staff around the world, acknowledges that very low-tech adaptation and mitigation strategies for farmers are essential in the face of changing weather patterns and climate.[32] Many, if not most, adaptation options can build on existing practices and sustainable agriculture rather than being entirely new technologies (Jarvis et al., 2011).

Practices such as incorporating trees in croplands (agroforestry), making farms more diverse and traditional plant breeding for drought tolerance are all well known holistic practices that show promising results in identifying effective protections against future climate shocks (Beebe et al., 2008, Jarvis et al., 2011, Akinnifesi et al., 2010).

Building a healthy soil is a crucial element in helping farms cope with drought (Pan et al., 2009, Sharma et al., 2010, Mulitza et al., 2010). There are many proven practices available to farmers right now to do this. Cover crops and crop residues that protect soils from wind and water erosion, and legume intercrops, manure and composts that build soil rich in organic matter, enhancing soil structure, are all ways to help increase water infiltration, hold water once it gets there, and make nutrients more accessible to the plant (Fließbach et al., 2007, Mäder et al., 2002). In order to feed humanity and secure ecological resilience it is essential to increase productivity in rainfed areas where poor farmers implement current know-how on water and soil conservation.

Ecological farms that work with biodiversity and are knowledge-intensive rather than chemical input-intensive are the most resilient options under a drier and more erratic climate.



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Our agriculture crisis is about food and it is about farmers. And it is also about what each single one of us decides to put on our plates everyday.

04

Conclusion: Reclaiming our Food through Ecological Farming

How can we all contribute to changing the broken system into an ecological food system with people at its heart?

Everyday, at least three times a day, we are faced with the question: what to eat?

For almost 1 billion people, this is a painful question, with an uncertain answer.

But, for most of us - those fortunate enough to have a choice about what we eat - this is also our opportunity to act, to start the change we feel needs to happen.

Unlike many unfair situations in the world, our broken food system is very close to us, everyday: we feel it, touch it, smell it and eat it a few times a day. It is about the food we eat, about the people who are growing it and how they are growing it. Our agriculture crisis is about food and it is about farmers. And it is also about what each single one of us decides to put on our plates everyday. After all, as Michael Pollan nicely put it, "eating is a political act."[33]

The list of things we can do, as citizens, consumers or simply eaters, is long and exciting.

We can start by **deciding what food to buy and where**, wasting less and reducing our meat consumption. A simple thing we can do is to get to know the farmers that produce our food, listen to their stories and be inspired by their passion for cultivating the food that we eat. Visiting farmers markets or buying fresh produce directly from the farm are simple ways to 'give a face' to our food through knowing who grew it and where it came from. We can also be inspired to make more changes in our diet by chefs like Jamie Oliver,[34] Myke "Tatung" Sartou,[35] and Aquilles Chavez,[36] who give us plenty of tips and recipes for making our food choices more sustainable.

We can continue by **composting at home or asking that our schools, our cities and our villages do more composting with our (reduced) food waste**. Composting is an act of transformation, from waste into a precious resource that enriches our soils and gives it more life. It is also an act of transformation with the potential to transform our food system and our soils for a better future.

And finally, we can try **growing food ourselves by** planting herbs on our balconies and terraces, joining urban farms and neighbourhood gardens, or by creating a food garden in our children's school. There are many ways to start, from the easy to the more ambitious.[37] All small acts of growing our food are rewarding and inspiring. Growing food ourselves brings us closer to the miracle of how water, sun and soil combine to provide us with the food that gives us life. This alone can be a revolutionary start for the change that our food system needs.

You can find more examples of simple things that you can actively do to change the food system and be part of the food movement on www.iknowhogrewit.org.

However, a lot more needs to happen at the policy and private sector level, of course.

Greenpeace is demanding that private companies, governments, donors and philanthropies shift their investments in agriculture and their policy support away from industrial agriculture and towards ecological farming.

This means, for example, that governments stop allowing and subsidising the widespread use of potentially harmful chemicals on our farms. Thanks to the mobilisation of people in Europe to save bees and other pollinators from exposure to harmful pesticides, in addition to scientists showing their impacts, the EU is moving to restrict the use of some bee-harming pesticides.[38]

Funding coming from donors and philanthropies to support industrial agriculture feeds the broken food system. This needs to change. Vibrant ecological farming examples from around the world, some summarised in this report, show that real and very feasible alternative options are already in place. But, Ecological Farming and Agroecology need support to be scaled up. Right now, agroecology only receives about 5% of the global funding in agriculture research and development, while 95% of this funding is being spent on perpetuating and protecting the current broken, unjust and damaging food system and those who control it.[39] Ecological farming offers a better, more modern alternative that protects the planet and at the same time produces healthy and delicious food for all.

Over recent years, Africa has emerged as a new frontier for the expansion of industrial agriculture. Initiatives like the G7's New Alliance for Food Security & Nutrition and philanthropies like the Bill & Melinda Gates Foundation seem to be promoting a model of industrial agriculture that benefits big corporate agribusiness, over the needs of smallholder producers and rural communities. Greenpeace Africa is making the economic case for ecological farming[40] to donors and other funders of Agricultural Development to invest in ecological farming. Investing in farmers' knowledge and skills instead of chemical inputs, will improve their economic well-being and food security; governments will get better value for their money and make progress towards their poverty alleviation targets.[41]

To change our broken global food system, all of us - consumers, food lovers, farmers - need to get behind Ecological Farming by supporting the farmers already practising it and, by demanding that funding is urgently switched, and government policies aligned, to promote the urgent uptake of Ecological Farming all around the world.

Greenpeace is currently campaigning for better agriculture policies and funding in support of a better food system in Europe, Mexico, Argentina, East Africa, India, China, Japan, Brazil, and the Philippines. Wherever you are there are things you can do to support this call for bigger support of Ecological Farming.

Rural, social, and consumer movements, environmentalists and academics are increasingly united behind a shared vision: a food system that protects, sustains and restores the diversity of life on Earth. It is a system where safe and healthy food is grown to meet fundamental human needs, and where control over food and farming rests with local communities, not transnational corporations. It is a system that puts people and farmers at its heart, a system that we can all be a part of. **Join the movement!**

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Glossary of Terms, Definitions and Acronyms

Agrodiversity The variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems.[42]

Agroecology Agroecology refers to the scientific discipline of studying agriculture as ecosystems, looking at all interactions and functions (i.e. producing food but also cycling nutrients, building resilience, etc.).

Agroforestry Greenpeace follows the definition of Agroforestry included in the IAASTD reports: "A dynamic, ecologically based, natural resources management system that through the integration of trees in farms and in the landscape diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. Agroforestry focusses on the wide range of work with trees grown on farms and in rural landscapes. Among these are fertiliser trees for land regeneration, soil health and food security; fruit trees for nutrition; fodder trees that improve smallholder livestock production; timber and fuelwood trees for shelter and energy; medicinal trees to combat disease; and trees that produce gums, resins or latex products. Many of these trees are multipurpose, providing a range of social, economic and environmental benefits."

CGIAR A global partnership that unites organisations engaged in research for a food secure future.[43]

Chemical-Intensive This agricultural model is characterised by the extensive use of chemical fertilisers and/or pesticides. Chemical-intensive agriculture is widely associated with the so-called green revolution and the many negative effects on humans and the environment, from algae blooms (dead zones) to poisoning of farmers and farm workers.

Donors We define donors broadly to include: governments providing bilateral overseas development assistance, multilateral financial institutions, philanthropies, and international (UN) development organisations.

Ecological Farming	Ecological farming ensures healthy farming and healthy food for today and tomorrow, by protecting soil, water and climate. It promotes biodiversity, and does not contaminate the environment with chemical inputs or genetically engineered plant varieties. Ecological farming encompasses a wide range of crop and livestock management systems that seek to increase yields and incomes and maximise the sustainable use of local natural resources whilst minimising the need for external inputs.
FAO	UN Food and Agriculture Organization
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development. The IAASTD was launched as an intergovernmental process, with a multi-stakeholder Bureau, under the co-sponsorship of the FAO, GEF, UNDP, UNEP, UNESCO, the World Bank and WHO.
Organic Farming	Organic farming is a system of crop production that avoids the use of chemical fertilisers or chemical pest and disease control measures. The International Federation of Organic Agricultural Producers (IFOAM) defines organic agriculture as: "...a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved."
Push-Pull Technology	Push-Pull Technology is a form of ecological farming used to control parasitic weeds and pest insects that damage crops. It involves no use of chemical pesticides. Volatile chemicals from Desmodium, a leguminous herb, intercropped with the food crop (maize, sorghum or rice) repel corn borer moths (push), while volatile chemicals from a border of Napier Grass attract the moths, which lay eggs in the grass instead of the crop (pull). Desmodium also improves soil fertility, thereby combating the parasitic Striga weed. Push-pull is an affordable farming technique for small-scale farmers, which not only increases yield but also provides a source of fodder for animals (Napier Grass), which increases milk yields.

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Endnotes

1. FAO Director-General José Graziano da Silva said at the first ever FAO International Symposium on Agroecology for Food Security and Nutrition in 2014 "Agroecology continues to grow, both in science and in policies. It is an approach that will help to address the challenge of ending hunger and malnutrition in all its forms, in the context of the climate change adaptation needed".
2. http://www.fao.org/nr/water/aquastat/water_use/index.stm
3. Securing land tenure, stopping land grabs and other urgent issues around access to natural resources are intentionally left out of the scope of this paper. They are crucial issues addressed by a large number of civil society organisations worldwide.
4. http://www.foodsovereignty.org/forum-agroecology-nyeleni-2015/
5. La Via Campesina (global peasant network) on food sovereignty: http://viacampesina.org/en/index.php/main-issues-mainmenu-27/food-sovereignty-and-trade-mainmenu-38
6. http://viacampesina.org/en/index.php/main-issues-mainmenu-27/food-sovereignty-and-trade-mainmenu-38/1671-international-symposium-on-agroecology-at-the-fao-in-rome
7. SOCLA: Sociedad Científica Latinoamericana de Agroecología (Latin-American Scientific Association of Agroecology) http://agroeco.org
8. http://rajpatel.org/wp-content/uploads/2014/09/SOCLA-reflections-Agroecology-Conference-in-ROME-in-english.pdf
9. CGIAR: a global partnership that unites organisations engaged in research for a food secure future, formerly known as 'Consultative Group on International Agricultural Research'. Within CGIAR centres, some scientists continue to follow the paradigm of industrial agriculture systems, while others are increasingly focusing on issues relevant to smallholders and agroecology. http://www.cgiar.org/who-we-are/e
10. Nyeleni, 2007: Forum for Food Sovereignty Synthesis report. Feb 23-27, 2007. Accessed by http://nyeleni.org/spip.php?article334
11. IAASTD, 2009. Agriculture at a Crossroads. International Assessment of Agricultural Knowledge, Science and Technology for Development. Global Report. Accessed by http://www.unep.org/dewa/agassessment/reports/IAASTD/EN/Agriculture at Crossroads_Global Report (English).pdf
12. Food sovereignty: a critical dialogue 2013/14 conference paper series: http://www.iss.nl/research/research_programmes/political_economy_of_resources_environment_and_population_per/networks/critical_agrarian_studies_icas/food_sovereignty_a_critical_dialogue/ Additional papers from the 2013 conference can be found here: http://www.yale.edu/agrarianstudies/foodsovereignty/papers.html
13. http://www.foodsovereignty.org/forum-agroecology-nyeleni-2015/
14. Of these, half a billion are obese (Finucane et al., 2011).
15. Organic farming can be equated with ecological farming when they share the fundamental principles of being based on biodiversity and people, irrespective of standards certification. In occasions, like with 'industrial' organic agriculture where just chemical inputs are substituted to organic ones, these principles differ. In the study above, the fundamentals of agroecology where used to select organic farms, not necessarily meaning 'certified' organic farms.
16. http://opinionator.blogs.nytimes.com/2012/10/19/a-simple-fix-for-food/
17. Organic farming can be equated with ecological farming when it goes beyond chemical inputs substitution and is based on biodiversity-rich and people-centric farming systems.
18. Anna Lartey, Director Nutrition, FAO: http://www.bioversityinternational.org/news/detail/a-step-closer-to-mainstreaming-biodiversity-for-improved-nutrition-and-health/
19. http://www.bioversityinternational.org/research-portfolio/diet-diversity/biodiversity-for-food-and-nutrition/
20. Greenpeace 2014. Smart breeding: the next generation. http://www.greenpeace.org/eu-unit/en/Publications/2014/Smart-breeding-The-next-generation/
21. http://cehsciencenews.blogspot.co.uk/2013/02/nitrogen-narratives-in-nairobi.html
22. One recent example of these human costs can be seen from the impacts of Phosphate mining and processing operations in China. http://www.greenpeace.org/eastasia/news/stories/food-agriculture/2013/living-with-danger-sichuan/
23. Safety concerns related to pollutants in organic sources need to be eliminated prior to their use in soils, but this is a feasible approach already up-scaled in many regions of the world.
24. http://www.unicef.org/wash/
25. Precautionary measures are necessary to avert health risks associated with fertilising soils with urine and composted faeces. In 2006, the World Health Organization published comprehensive guidelines on the safe reuse of wastewater in agriculture. Use of human excreta is safer where waste streams are not mixed with other waste streams such as industrial or domestic wastewater because of pollutants such as heavy metals or organic contaminants (Cordell et al., 2009). Human excreta itself may contain pollutants, primarily steroidal hormones and pharmaceuticals which can be removed to different degrees thought natural attenuation or with existing engineering treatment technologies (Mihelcic et al., 2011). More research is needed on how to treat hormone, pharmaceutical residues and microbes in human excreta. However, this is also true for any other type of wastewater treatment, including the "flush and forget" system.
26. Crop residues form an important ingredient for improving soil nutrients and soil organic matter. Crop residues (used as feed, fuel or for soil improvement) can also be used in sequence (cascading), thus minimising competition between the various potential functions. For example, in India crop residues in the form of rice straw after harvest are used to feed cows in a mixed farming system. The manure produced by cows is then used in small-scale biogas plants to supply energy to the farm household.

The nutrient-rich residue from the biogas plant is later put back to the soil to enhance soil fertility (given that the residue is not polluted, which depends in turn on un-contaminated cow's feed). Some crop residues should also be returned to the soil to enhance soil organic matter. This type of cascading of nutrients and energy can build efficient and resilient food systems.

27. http://www.greenpeace.org/india/Global/india/report/Living soils report.pdf
28. Trade in pesticides is the best proxy available to the trend on global use of pesticides, as data on pesticide volumes use is more uncertain and unavailable, and pesticide volumes change with the nature of active ingredients composition (e.g. less volume but more potent), so volume does not necessarily reflect usage.
29. http://www.push-pull.net/adoption.shtml
30. Cotton genetically modified (GM) to produce the Bt toxin -Bacillus thuringiensis proteins- insecticide toxins produced by the GM plants themselves.
31. Green water is the water stored in the soil, while blue water is the water in rivers, lakes, dams and groundwater wells. See more: http://www.stockholmresilience.org/21/research/research-news/4-26-2010-a-paler-shade-of-blue.html
32. http://ccafs.cgiar.org/bigfacts2014
33. http://michaelpollan.com/resources/cooking/
34. http://www.foodrevolutionday.com
35. https://www.tumblr.com/search/chef%20tatung
36. http://www.aquileschavez.com.mx/
37. http://www.growtheplanet.com/en/
38. http://sos-bees.org/
39. https://www.wageningenur.nl/en/show/Towards-ecological-intensification-of-world-agriculture.htm
40. http://www.greenpeace.org/africa/financialbenefits/
41. http://www.greenpeace.org/africa/en/campaigns/Ecological-Farming-in-Africa/
42. http://www.fao.org/docrep/007/y5609e/y5609e01.htm
43. http://www.cgiar.org/who-we-are/

Greenpeace is an independent campaigning organisation that acts to change attitudes and behaviour, to protect and conserve the environment, and to promote peace.

Greenpeace International
Ottho Heldringstraat 5
1066 AZ Amsterdam
The Netherlands

greenpeace.org