Defining Ecological Farming

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Dedicated to Mark Strutt (1957-2007), who worked tirelessly for a more sustainable world and who inspired and initiated the writing of this paper.

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One sentence definition

Ecological Farming ensures healthy farming and healthy food for today and tomorrow, by protecting soil, water and climate, promotes biodiversity, and does not contaminate the environment with chemical inputs or genetic engineering.

A. The benefits of ecological farming

1. Ecological farming provides the ability of communities to feed themselves and ensures a future of healthy farming and healthy food to all people.
2. Ecological farming protects soils from erosion and degradation, increases soil fertility, conserves water and natural habitats and reduces emission of greenhouse gases.
3. Ecological farming is both a climate change mitigation and adaptation strategy. Ecological farming can provide large-scale carbon sinks and offer many other options for mitigation of climate change. In addition, farming with biodiversity is the most effective strategy to adapt agriculture to future climatic conditions. A mix of different crops and varieties in one field is a proven and highly reliable farming method to increase resilience to erratic weather changes.
4. Ecological farming both relies on and protects nature by taking advantage of natural goods and services, such as biodiversity, nutrient cycling, soil regeneration and natural enemies of pests, and integrating these natural goods into agroecological systems that ensure food for all today and tomorrow.

B. The current model of destructive, polluting agriculture

1. Destructive agriculture relies on expensive non-renewable and artificial resources (fossil fuels, agrochemicals and genetically engineered crops) that damage the basic natural resources needed for food production.
2. Destructive agriculture pollutes nature with synthetic fertilisers and toxic chemicals that strip the soil of its fertility, harm biodiversity and destroy nature’s capacity to keep pests and disease under control.
3. Destructive agriculture spreads genetically engineered varieties that threaten the biodiversity of our crop plants which have withstood local conditions for thousands of years and thus risk our ability to produce food under changing conditions. It threatens food security, giving a handful of chemical companies global control over food produced worldwide.

4. Destructive agriculture endangers the future of our soils, our water, our climate and our forests, and it is based on the indiscriminate exploitation of natural resources and often on artificial monocultures.
5. Destructive agriculture is a major source of global human-induced climate change gas emissions. Direct emissions from agriculture come mainly as methane from livestock and nitrous oxide from fertilized soils. Climate change will profoundly affect food production worldwide.
6. Destructive agriculture is a model of agriculture pushed by agrochemical corporations whose main aim is to profit from sales of pesticides, synthetic fertilisers and genetically engineered seeds – not to feed the world. They are, in turn, supported, promoted and subsidised by governments.

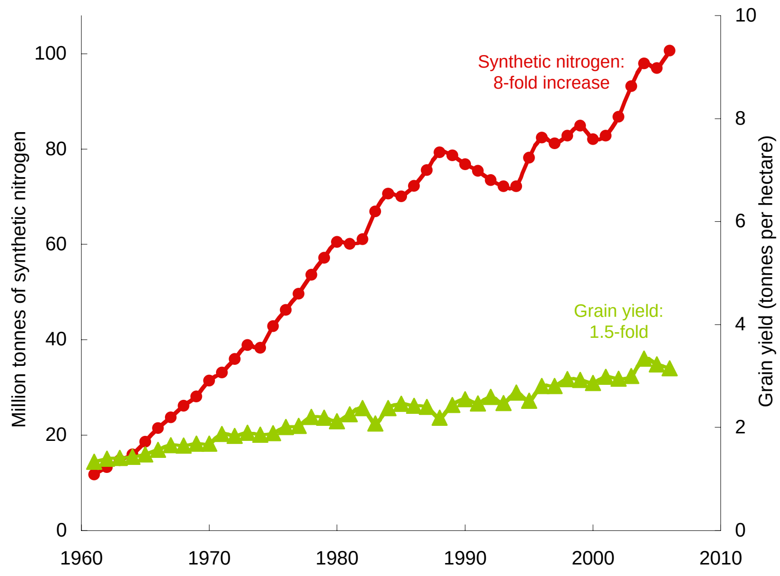
C. Facts and figures (backed by recent scientific studies)

The problem

Destructive agriculture relies on non-renewable and artificial resources (fossil fuels, agrochemicals and genetically engineered seeds) that damage the natural resources needed for food production.

Fossil fuels: In the most industrialised countries, agriculture requires up to 20 percent of the total fossil fuel used in each nation (Pimentel et al., 2008). Chemical fertilisers, mostly made of natural gas but also of coal and heavy fuels in some countries, require the highest share of this oil energy (about 1.5 percent, but more than 3 percent in countries like India). Diesel needed for irrigation and to power machines and the petroleum needed for pesticide production, combined represent about 1 percent of the total fuel used (Bellarby et al., 2008). As a consequence of this fossil fuel dependence, current grain price movements reflect almost exactly the roller-coaster fluctuations of the oil market.

Agrochemicals: Use of synthetic nitrogen fertilisers has increased globally by more than 8-fold from 1961 to 2006, while grain yields increased globally by 1.5-fold in the same period (FAO stats, 2009).



Use of chemical insecticide increased in the United States by 10-fold between 1945 and 2000, while there was a doubling of crop losses from insect damage (Pimentel 2005). The cost of this chemical intensity is an estimated 1 million to 5 million cases of pesticide poisonings per year (UNEP 2004). The worsening of most insect pest problems, and thus dependence on chemical inputs, is increasingly linked to the expansion of crop monocultures and losses in crop diversity (Letourneau and Bothwell, 2008).

Groundwater contamination, fishery losses, loss of natural enemies and increases in pesticide resistance are only a few of the problems arising from agriculture's addiction to pesticides. Pesticides have also been linked to global biodiversity loss and amphibian decline (Rohr et al., 2008).

A recent study has shown that pesticides represent a further threat to farming. Some pesticides are found to disrupt the natural mechanism of nitrogen fixation in legumes, which translates into an estimated loss by one-third of plant yields per growing season and rendering legume crop rotations less effective for maintaining soil fertility (Fox et al., 2007).

Chemical fertilisers cause soil degradation and loss of soil fertility in farmlands, plus pollution and dead zones in lakes, rivers and oceans (Carpenter, 2008, Galloway et al., 2008). Nitrogen fertilisers are also responsible for emissions of the potent greenhouse gas, nitrous oxide (N_2O) (Bellarby et al., 2008). Phosphorus fertiliser is a non-renewable resource and approximately 50-100 years remain of current known reserves (Cordell et al., 2009).

Genetically engineered (GE) seeds: GE is an unnecessary outdated technology that threatens crop biodiversity and poses potential risks to human health and the environment. The UN Agriculture Assessment (International Assessment of Agriculture Science and Technology for Development) found that GE was not a relevant technology to solving the world's food crisis (IAASTD, 2009). While agroecological systems have a proven track record of being able to ensure food security and high yields under multiple and diverse stresses (like diseases, pests and droughts), GE crops have failed. There is not a single commercial GE crop with increased yield, drought tolerance, salt tolerance, enhanced nutrition or other attractive-sounding traits touted by the industry. GE is developed and controlled through patent rights by big agrochemical companies to further their profits from seeds. Patent control on seeds have already led to drastic increased seed price, restricted availability and access to non-GE seeds in many countries, and resulted in legal actions by patent holders against farmers and other stakeholders.

Agrochemical corporations push destructive agriculture with their goal of profiting from sales of pesticides, synthetic fertilisers and genetically engineered seeds – not of feeding the world. Amidst the global food price crisis, profits for agrochemical corporations continue to grow due largely to boosting input prices. For example, the US Department of Agriculture informed that “prices paid for seeds increased an estimated 27 percent in 2008, and are expected to rise another 7 percent in 2009” and “in 2008 prices paid for fertilizers rose 68 percent” (USDA, 2009). The world’s commercial seed supply is increasingly in the hands of a few corporations that have taken control over farmers and public-sector plant breeders. Currently, the top 10 seed companies together account for 67 percent of the worldwide proprietary seed market, and the top 3 (Monsanto, DuPont, Syngenta) account for close to 50 percent of the total (ETC, 2008).

The solution

Ecological farming both relies on and protects nature by taking advantage of nature’s goods and services, such as biodiversity, nutrient cycling, soil regeneration and natural enemies of pests, and integrating these natural goods into agroecological systems that ensure food for all today and tomorrow.

The ecological farming model is backed up by scientific evidence:

Biodiversity

Diversity farming is the single most important modern technology to achieve food security in a changing climate. Scientists have shown that diversity provides a natural insurance policy against major ecosystem changes, be it in the wild or in agriculture (Chapin et al., 2000, Diaz et al., 2006, McNaughton, 1977). A mix of different crops and varieties in one field is a proven and highly reliable farming method to increase resilience to erratic weather changes. And, the best ways to increase stress tolerance in single varieties are modern breeding technologies that do not entail genetic engineering, such as Marker Assisted Selection (MAS). In contrast, there is no evidence that genetically engineered (GE) plants can ever play any role to increase food security in a changing climate.

This diversification strategy is backed by a wealth of recent scientific data, for example:

- In the United States, agronomists compared corn yields over three years between fields planted as monocultures and those with various levels of intercropping in Michigan. They found the yields in fields with the highest diversity (three crops, plus three cover crops) were over 100 percent 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).

- In rainfed wheat fields in Italy, high genetic diversity within fields reduces risk of crop failure during dry conditions. In a model scenario where rainfall declines by 20 percent, the wheat yield would fall sharply. But when diversity is increased, this decline is reversed and yields are larger than average (Di Falco and Chavas, 2006, 2008).

Agroecological soil fertility

Growing legumes and/or adding compost, animal dung or green manures are some smart ways to increase organic matter and fertility of the soil. Natural nutrient cycling and nitrogen fixation can provide fertility without synthetic fertilisers, and at the same time cut farmers' expenses on artificial inputs and provide a healthier soil, rich in organic matter, better able to hold water and less prone to erosion.

The use of organic fertilisers, generally cheap and locally available, makes ecological farming more secure and less vulnerable to external inputs' accessibility and price fluctuation. Sequestration of carbon in farming soils can also significantly contribute to climate change mitigation.

Ecological farming makes the best possible use of inputs, aiming to build up natural soil fertility and improve efficiency. Organic fertilisers, as well as bio-pesticides, can be overused; ecological farming aims at the best efficient use of any type of input.

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

- 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 apple orchards in the US, fertilisation with manure (compared to fertilization with chemical fertilisers) increases the amount of carbon stored in the soil, increases the diversity and activity of soil microbes, and decreases the losses of nitrates to water bodies while keeping nitrous oxide losses to atmosphere similar (Kramer et al., 2006).

- Organic farming methods can help reverse the trend of declining soil fertility that many farmers in developing countries are facing. Problems like soil erosion, acidification and organic matter depletion can benefit from agroecological practices that nurture soil fertility and biodiversity (Eyhorn, 2007).

Pest protection without chemical pesticides

Ecological farming can achieve pest protection in crop fields without relying on pesticides, by making croplands more resilient to pests.

Farmers can find long-term solutions to pest problems by designing diverse crop fields and using low-input technologies 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 side work against the pests’ performance and on the other are less vulnerable to pest invasion, farmers can substantially reduce pest numbers (Gardiner et al., 2009).

Despite the mainstream research agenda being focused on chemical pest control for the last decades, many studies have found successful agroecological ways to regulate specific pest problems. Some examples are:

- In a unique cooperation project among Chinese scientists and farmers in Yunnan 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 percent greater yield and 94 percent less disease incidence than when they were grown in a monoculture. Fungicidal sprays were no longer applied by the end of the two-year programme. This approach is a calculated reversal of the extreme monoculture that is spreading throughout agriculture, pushed by agribusiness in plant genetics (Wolfe, 2000, Zhu et al., 2000, Zhu et al., 2003).

- In Africa, scientists at the International Centre of Insect Physiology and Ecology (ICIPE) developed the push-pull system to fight maize stemborers without use of chemicals. Grasses planted on the borders of maize fields (Napier grass and Sudan grass) attract insect pests away from maize – the pull, and two plants intercropped with maize (molasses grass and the legume silverleaf) repel the insect pests from the crop – the push (Hassanali et al., 2008, Khan et al., 1997). The push-pull system has been tested by over 4000 farmers in Kenya and about 500 farmers in Uganda and Tanzania, with impressive positive outcomes. Farms using push-pull systems showed between 40 and 90 percent less attack of stemborers and, on average, 50 percent higher yields of maize than monocrop farms. In addition, in the semi-arid Suba district, for example, plagued by both stemborers and Striga, milk production is also going up, with farmers now being able to support increased numbers of dairy cows on the fodder produced. Economically, across 4 districts in Kenya over 7 years, the average economic return per hectare was 74 percent higher for push-pull farmers than for monocrop farmers (Hassanali et al., 2008).

- In the state of Andhra Pradesh in 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 traditional practices supplemented with modern science, has brought ecological and economic benefits to the farmers. Under such practices, damages to a crop can be reduced by 10-15 per cent without using chemical pesticides so that the cost of plant protection is low. The small success from a few villages has been scaled up into more than 1.5 million hectares, benefiting more than 350 thousand farmers from 1800 villages in eighteen 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 is the performance of non-pesticide management in genetically engineered Bt cotton[2] and non-Bt cotton, studied by the Central Research Institute of Dryland Agricuture (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).

Ecological farming ensures food for all today and tomorrow: economic success of ecological farming

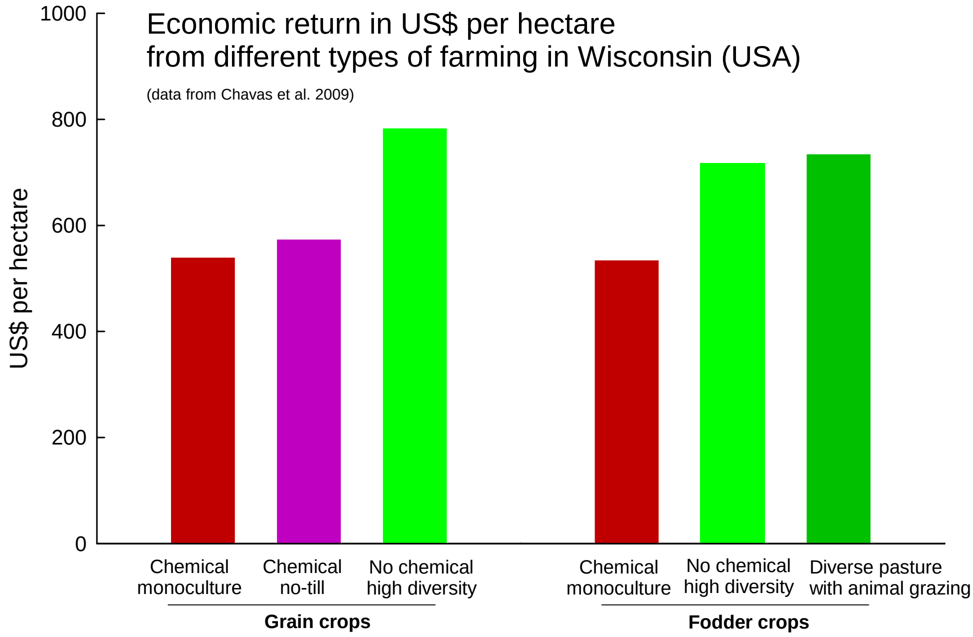
Ecological farming with practices based on biodiversity and without use of synthetic fertilisers or pesticides, can produce as much food per hectare as the conventional agriculture systems, and even increase yields, especially in developing countries. A recent meta-analysis showed that globally, ecological farming can produce, on average, about 30 percent more food per hectare than conventional agriculture, and in developing countries organic farming can produce about 80 percent more food per hectare (Badgley et al 2007).

Ecological farming is the most promising, realistic and economically feasible solution to the current destructive agriculture model. In a recent UN study, in-depth analysis of 15 organic farming examples in Africa have shown increases in per-hectare productivity for food crops, increased farmer incomes, environmental benefits, strengthened communities and enhanced human capital. Organic 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).

Ecological farming is a profitable farming system. Across Europe, for example, a region-wide analysis indicates that profits on organic farms are on average comparable to those on conventional farms (Offermann and Nieberg, 2000). In apple orchards in the west of the US, when compared with the conventional and integrated farms, the organic farms produced sweeter and less tart apples, higher profitability and greater energy efficiency (Reganold et al., 2001).

In a decade long study in Wisconsin (USA), 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).

[2] Cotton genetically modified (GM) to produce the Bt toxin -*Bacillus thuringiensis* proteins- insecticide toxins produced by the GM plants themselves.



An example of economic benefits of ecological farming is the success of the Non-Pesticide Management program in Andhra Pradesh (India) in reducing the costs of cultivation and increasing the net incomes of the farmers. The cost of cultivation was brought down significantly, with savings on chemical pesticides ranging between 600 and 6000 Indian Rupees (US$ 15 - 150) per hectare without affecting the yields (Ramanjaneyulu et al., 2008). This success has received the Indian Prime Minister's attention and was selected under a National Agriculture Development Project to scale up non-pesticide into organic farming in 5000 villages over the next five years covering 10 million hectares.

Ecological farming represents a significant net saving for citizens. For example in the UK, if the whole farming system shifted to organic farming, environmental costs savings would be of about 1 billion £ per year (1.5 billion US$) (Pretty et al., 2005).

Ecological farming practices are ideally suited for poor and smallholder 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 resistant to stress (UNEP and UNCTAD, 2008).

As the UN Agriculture Assessment (International Assessment of Agriculture Science and Technology for Development) states about food security: "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).

D. Questions and answers

1. Genetically modified crops are the recipe to halve hunger. With the new food crisis we are having, why are you opposed to this reasonable solution?

There is no evidence that genetically modified (GM) plants can ever play any role to increase food security in a changing climate. Food insecurity is related to a number of factors: industrial farming, bad harvests related to climate change, unjust distribution of food, changes in consumption patterns, financial speculation on agricultural commodities and the rush for agrofuels.

Genetic engineering does not increase yields and GM crops have failed under extreme fluctuations in temperature. Rather than increasing critical biodiversity, genetic engineering puts the world's natural biodiversity at risk of contamination in an unforeseeable and uncontrolled way. Since 1996, there have been 216 cases of crops being contaminated by GMOs in 57 countries (www.gmcontaminationregister.org).

Genetic engineering is also expensive and risky for farmers. GM seeds are subject to patent claims which will indirectly increase the price of food and, as a result, will not alleviate poverty or hunger and pose a threat to food sovereignty. This analysis is shared by the 2008 International Assessment of Agricultural Science and Technology for Development (IAASTD) report. Compiled by over 400 scientists from around the world, the assessment sees no role for GM crops in achieving the Millennium Development Goals or in eradicating hunger.

2. Can ecological farming feed the world?

Yes, it can. Ecological farming can ensure enough food for all the people, while reducing the detrimental environmental impacts of destructive agriculture.

Different recent reports from scientists at universities and international institutions like the Food and Agriculture Organization (FAO) and the United Nations Environment Programme (UNEP) confirm that ecological systems increase food security exactly in those locations where poverty and hunger are most severe (IAASTD, 2009).

Genetically modified seeds and patent rights may represent a threat to food security. As the UN Agriculture Assessment states: "In developing countries especially, instruments such as patents may drive up costs, restrict experimentation by the individual farmer or public researcher while also potentially undermining local practices that enhance food security and economic sustainability." (IAASTD, 2009).

Supporting farmers and farm workers in eco-agriculture systems that minimize dependency on external inputs like artificial fertilizers and pesticides is one of the three mid-term options presented by UNEP to fight hunger and improve food security worldwide (Nellemann et al., 2009).

3. Can ecological farming help fight climate change?

Yes, very much so. Our current destructive agriculture model is one of the largest sources of global greenhouse gas emissions. Ecological farming is both a climate change mitigation and adaptation strategy:

- Efficient ecological farming practices that reduce synthetic fertiliser use and promote fertile soils rich in carbon could mitigate up to 70 percent of global agriculture emissions.
- Key to ecological farming for climate change mitigation is to build up a healthy, carbon-rich soil. This will provide a major carbon sink and at the same time will be the basis for a non-chemical, biodiverse and healthy agriculture.
- Significant emission reductions can be achieved by eliminating fertilizer overuse, which is a triple win: farmers save money by using only the amount of fertilizer used by the plant, emissions are significantly reduced, and nitrate contamination of lakes, rivers, oceans and groundwater is reduced. Growing legumes and/or adding compost, animal dung or green manures, natural nutrient cycling and nitrogen fixation can provide fertility without synthetic fertilisers, and at the same time cut farmers' expenses on artificial inputs and provide a healthier soil, rich in organic matter, better able to hold water and less prone to erosion.
- Reduced consumption of meat in developed countries would contribute to lowering greenhouse gas emissions from livestock.

4. Is ecological farming more costly in terms of labour requirements?

Yes, and because of this ecological farming provides employment in poor rural areas without increasing farmer's costs: what she saves on chemicals, she can spend on labour, and the benefits go not to an American or German chemical giant, but to rural workforce.

Ecological farms generally substitute external inputs with the farmer's own labour, as synthetic fertilizers and pesticides are replaced by management practices and inputs produced on the farm itself (manure, compost, etc.). Hence, there is a trade-off between savings on expensive agrochemicals and higher investments in labour, but studies have shown that ecological farming generally increases farmer's revenues by savings in off-farm inputs and it contributes to higher local employment (Scialabba and Hattam, 2002).

5. Are other commercial, less-toxic methods of pest control (e.g., biological control insects, integrated pest management, less-toxic pesticides) considered ecological?

It depends, but mostly not. Substituting chemical inputs with biological or organic inputs as a step towards converting the farming system to ecological is fine. However, just replacing one input with another will not move farmers towards an alternative ecological farming system. Ecological farms are based on a redesign of farms from the current destructive agriculture system based on fossil fuel, agrochemicals and genetic engineering to one based on biodiversity and nature's good and services.

6. Why do organically fertilised soils improve crop protection against pests?

A healthy soil grows a healthy plant. Research shows that the ability of a crop plant to resist or tolerate insect pests and diseases is tied to optimal properties of soils. Crops grown in organically fertilised soils generally exhibit lower abundance of insect herbivores, reductions that may be attributed to lower nitrogen content in these crops. In contrast, the excessive use of inorganic fertilizers can cause nutrient imbalances and lower pest resistance (Altieri and Nicholls, 2003).

7. Can large-scale farms be ecological?

Yes. Agroecological principles can be applied to all farm sizes and thus, through the use of the right on-farm resources and nature's goods and services, where large-scale farms make sense geographically and socially, they can also be ecological.

There are many examples of large farms that use innovative approaches of increasing biodiversity and working with nature, like planting a diversity of crops, maintaining wild diversity within fields (e.g., scattered tress) or along margins (e.g., hedgerows).

- In Montana (USA), Bob Quinn overhauled his over 1,500 hectare family ranch to organically grow different varieties of wheat (including khorasan, durum, hard red winter and soft white), buckwheat, plus barley, flax, lentils, alfalfa (for hay and green manure) and peas (for green manure). His five-year rotation disrupts insect, disease and weed cycles and builds soil quality, while producing a high-quality crop.

He actually bases his cash crop choice on the level of nitrogen in that season's soil test: "Here on the northern Great Plains, the fields are so big that it is impossible to spread compost or manures," he says. Instead, Quinn uses green manure.

"Organic farming has certainly been more fun and more profitable than conventional farming," says Quinn. "It's made me a better farmer because I'm forced to really study and learn what's going on with my fields, my crops, and weeds and diseases." (Rodale Institute, 2003).

8. What can consumers do to support ecological farming?

Eat food. Not too much. Mostly plants.

We like these seven words by Michael Pollan because they summarise what we well-off consumers can do with our fork to support ecological farming:

Eat food. Think about what you eat: is it real food or some genetically modified product wrapped in plastics and chemicals that is more the result of biotech and fossil fuel than of soil and sun in a farm? Try cooking and eating food, products that resemble as much as possible the crop when it leaves the farm. You will support the farmer and farm workers, and you will win in health, in pleasure and also in your wallet. When possible, eat seasonal products, you will support your local community and enjoy the food when tastiest.

Not too much. Avoid over-consumption and waste. According to the February 2009 UNEP report on food security, over half of the food produced today is either lost, wasted or discarded as a result of over-consumption and inefficiency in our food chain. Almost one-third of all food purchased in the United Kingdom each year is not eaten (Nellemann et al., 2009). You could try buying less, but higher quality food grown on ecological farms.

Mostly plants. Eat low in the food chain; centre your diet around plants as much as you can. If you like meat and dairy, look at them more as condiments and as special occasions treats; enjoy higher quality, smaller amounts and less often. Growing calories in plants is much more efficient in terms of energy, land, water, labour, nutrients and climate-change gases, than growing calories in meat or animal products (Galloway et al., 2007, McAlpine et al., 2009). The average fossil fuel energy needed to produce calories in meat is about 10 times higher than the energy needed to produce calories in plants (Bellarby et al., 2008, Pimentel and Pimentel, 2003). A plant-based diet is better for our health, for our climate, for our forests, for our rivers and oceans, and for global food security, and it also helps keep food prices low (Nellemann et al., 2009).

Some more facts about what we eat:

- According to UNEP, if we could use the cereals allocated to animal feed as human food, we could feed more than 3.5 billion people a year. Reducing use of cereals and food fish in animal feed and raising awareness about consumption patterns are two of the seven options highlighted by UNEP for improving food security (Nellemann et al., 2009).
- Currently, about 72% of poultry and 55% of pigs are raised in global industrialized animal-production systems sustained by feed from other regions and often consumed far from the point of production (Galloway et al., 2007). This creates in huge pollution problem from manure, generally far away from where this manure could be used to fertilise soils (Naylor et al., 2005).
- Most of Brazil’s land used to grow soy exports is associated with pig and chicken production in Europe and China. Europe is responsible for about 40%, and China for about 20%, of the roughly 4 million hectares of soy exported from Brazil as pig and chicken feed (Galloway et al., 2007).
- Beef cattle are the least efficient converters of feed to meat of domestic livestock, using 9–13 kg of feed per kg of live weight, while it takes 13,500 litres of water to produce 1 kg of beef. Increased demand for beef, and higher beef and soy prices, have been recently linked to deforestation and other environmental impacts in Latin America and Australia (McAlpine et al., 2009).
- Because meat and dairy products require more phosphorus input that other foods, a change from the average western diet to a vegetarian diet could decrease phosphorus demand of fertilizers by at least 20-45% (Cordell et al., 2009).

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