How to feed nine billion within the planet's boundaries

The need for an agroecological approach

Policy Brief

March 2015

New challenges require new solutions

Global agriculture is challenged by a combination of climate change, biodiversity loss, and the growing demand for food, feed, fiber and energy. A series of recent international expert studies have identified a need for a new, truly green, revolution in agriculture based on local conditions and sustainable agricultural practices (e.g. IAASTD, 2009; UNCTAD, 2013). This implies a greater degree of so-called agroecological production systems (see box below) based on diversity, local inputs and ecosystem services instead of monocultures and non-renewable resources. Such resources include fossil fuels (e.g. for ploughing, irrigation, and production of fertilizers and pesticides) and phosphate ore (for fertilizers); non-renewables that form the basis for today's industrial food production. For resource poor small-holders managing land under marginal conditions, agroecological production systems have often been found to perform better than high input industrial ones, especially when looking at the farm as a whole and not just a single crop (de Schutter, 2010). Under such circumstances, the greatest challenges are to reduce reliance on expensive inputs, build soil fertility and to develop breeds that provide stable and high yields under varying and rapidly changing conditions.

Farming within the planet's boundaries

In the near future, agricultural production needs to be transformed to meet the demands from population growth, dietary changes, and bioenergy use. At the same time, agriculture must also tackle the fact that it is now a dominant force underlying many environmental threats, and a major force driving the environment beyond the "planetary boundaries" (Rockström and others, 2009; Steffen and others, 2015) (see box below). An agroecological approach holds many of the keys to test and implement practical, local and appropriate solutions to this dilemma. Many practical solutions emanating from such agroecological knowledge have also proven to be cost-effective since farmers spend less on inputs such as fertilizers and pesticides.

A study of 33 case studies from Asia, Africa, South and North America and Europe showed that agroecologically inspired practices had positive economic benefits in more than 80 % of the cases, while the rest had a neutral impact on incomes (Scherr and others, 2008). Agroecology is not a one-size-fits-all solution, it is all about taking into consideration the local socio-economic and ecological conditions. Today's agriculture may have allowed us to grow enough food, but it has not given everyone access to sufficient, safe and nutritious food. Moreover, global agriculture has contributed to the crossing of crucial planetary boundaries and misuse of natural resources. It is time to devote more attention, public funds and policy measures to the agroecological approach and to support more resilient production systems.

Agroecology is a scientific approach to sustainable agriculture. It includes the study of ecological processes in farming systems as well as the practice of applying ecological concepts and principles to the design and management of sustainable agro-ecosystems. As such, it minimises or precludes the use of fossil fuels and chemical inputs, and large-scale monocropping. Agroecology supports diversified and regenerative agricultural systems. As a systemic approach, agroecology also deals with the multifunctional dimensions of agriculture: food and fiber production, food security, health benefits, job security, social and economic justice, culture, and community resilience. And it includes important ecosystem services such as erosion control, carbon sequestration, pollinator protection, biodiversity conservation, water and nutrient cycling (nothing wasted, everything transformed), air and water quality. (IAASTD, 2009; de Schutter, 2010).

POLICY RECOMMENDATIONS

Seven steps for an agroecological transformation of farming to feed the world within the planet's limits:

1. **Raise awareness among policy-makers and extension agents of the benefits of agroecological farming**, focusing on its contributions to rural livelihoods, ecological sustainability, climate change adaptation and the resilience of food systems.
2. **Provide a new perspective on agriculture – particularly what is a 'productive' and 'efficient' system – among financial partners, governments and farmers**. Instead of a short-term focus on maximising production (and profits), they should consider the benefits of farming practices that support ecosystem services and resilience and use fewer resources.
3. **Provide economic incentives to adopt agroecological practices on a landscape level,** e.g. subsidies for actions that support ecosystem services, and taxation of actions that reduce them. Other helpful measures include integrating agroecological farming in public food procurement schemes (e.g. for schools, hospitals or public catering); supporting agroecological extension services; and supporting local business development and markets for agroecological products.
4. **Sharpen environmental laws and regulations (and their enforcement on a landscape level)** to better protect ecosystem services. Revise trade regulations and agreements so that they support markets for environmentally friendly agricultural products. Amend regulations that distort local markets for agricultural products.
5. **Build strong farmer-led, bottom-up knowledge and research systems.** Farmers should be at the centre of the agricultural innovation system, setting the agenda for research and extension services and shaping policies and investments.
6. **Mainstream agroecology in agricultural education at all levels** (from pre-schools to universities) and encourage interdisciplinary research on the social, environmental and economic aspects of food production.
7. **Provide incentives for more sustainable diets and consumption patterns.** Rising meat and dairy products consumption, as well as food waste, are increasing pressures on the land; these trends need to be reversed as part of an agroecological transformation of our food systems.

Agroecology

Applying ecological principles to agriculture

> "Today's scientific evidence demonstrates that agroecological methods outperform the use of chemical fertilizers in boosting food production where the hungry live – especially in unfavorable environments."
>
> ***Olivier De Schutter***
> *Former U.N. Special Rapporteur on the right to food.*

Cases

Top soil retention

20-40%

After a hurricane hit Nicaragua, Honduras, and Guatemala in 1998, farmers using agroecological practices retained 20-40 percent more top soil and experienced less erosion than conventionally managed, monoculture farms in the same region (Holt-Gimenez, 2001).

Crop yield increase

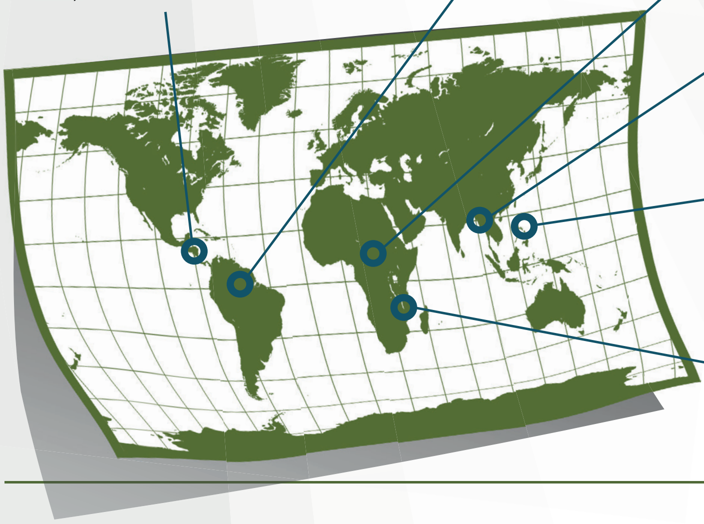
100-300%

Brazil: some 100,000 family farms have experienced increases in yields of 300 % for black beans and 100 % for corn (while increasing resilience to irregular weather patterns) (McKay, 2012).

Crop yield increase

x2

Projects conducted in 20 African countries demonstrated an average doubling of crop yields over a period of 3-10 years (Pretty *et al.*, 2011).



Reduction in insecticides

up to 90%

In Indonesia, Vietnam and Bangladesh AE-projects lead to up to 90 % reduction in insecticide use for rice, leading to important savings for poor farmers (Van den Berg and Jiggins, 2007).

Increase in incomes

x1.5

Philippines: group of full organic farmers benefited from net incomes one and a half times higher than those of conventional farmers (Altieri *et al.*, 2012).

Benefited by agroecology

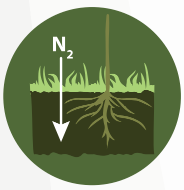
1.3 million

Malawi: agroecology benefits more than 1.3 million of the poorest people, with maize yields increasing from 1 ton/ha to 2-3 tons/ha (Ajayi *et al.*, 2009).

Methods

Conservation tillage

Minimum tillage improves soil structure, aeration and water infiltration/retention, and increases organic matter (maintains soil carbon).



Natural nitrogen fixation

Use of legumes like beans, peas, clover, lucern, acacia are used to fix nitrogen. These plants contain symbiotic bacteria in their roots that sequester nitrogen from the air.

Natural pest control

Increasing resilience to pests, e.g. by favouring pests' natural enemies, use crop rotations and a diversity of crop varieties.

Agroforestry

Integrating trees in farming systems can provide fodder, fuel and shade, erosion control and natural nitrogen fertilization.

Cover crop & mulching

Cover crops and mulching: provide soil nutrients, reduce erosion, and enhance biological pest control.

Rainwater harvesting

Small-scale collection and storing of rainwater combined with innovative watering techniques for better water resource management.

Empowerment and stakeholder engagement

Taking advantage of local stakeholder's knowledge, initiatives and creativity, e.g. through participatory research projects and establishment of value change groups.

Recycling of nutrients

Local recycling of plant nutrients and improved fertility by composting, which build humus that increases water retention and soil permeability.

Biodiversity & ecosystem services

Diversity on different scales; varieties, crops, animals, crop rotations, farming systems and use of ecosystems services for more resilient production and food security.

Socio-economic regulations

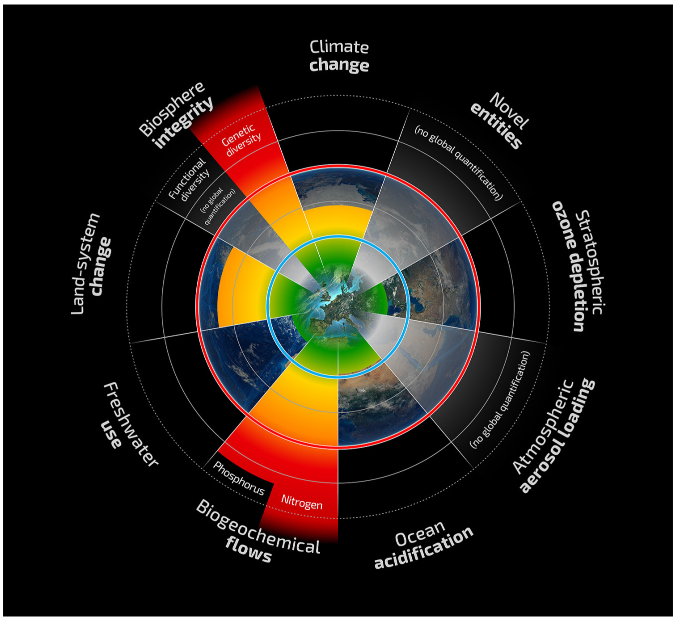
If agriculture is to deliver both livelihoods and collective benefits, there is a need for economic instruments (e.g. subsidies, certification) and law based regulations (e.g. environmental legislation, procurement schemes).

Today's agriculture and its effect on planetary boundaries

Globally, agriculture displaces natural ecosystems, uses too much fresh water, pollutes rivers and coastal seas, and releases greenhouse gases. Altogether, today's agriculture impacts all the nine planetary boundaries (updated by Steffen and others, 2015) that we should stay within to avoid large-scale and abrupt environmental change. In this context an agroecological approach holds much promise.

Global process (defined by Steffen and others, 2015)	Proposed boundary and current status (orange = high risk; yellow = increasing risk; green = safe)	Agriculture's impact	Benefits of an Agroecological approach
Climate change Global temperature has risen by nearly 0.7°C since 1950 , mostly due to CO_2 emissions from fossil fuel use.	**Boundary:** atmospheric concentration no higher than 350 ppm CO_2 **Current:** 400 ppm CO_2 ***and rising.***	Agriculture is responsible for 30 % of greenhouses gases (through crop cultivation, fertilizer manufacture, livestock, and land use change), making it the single largest contributor to climate change – more than transportation or industry manufacturing (Vermeulen and others, 2012).	Fossil energy inputs can be up to 30% lower than for conventionally produced crops. Agroecological systems are built on systems with high organic matter (carbon) in the soils. Also use of perennial crops, intercropping and agroforestry systems can contribute to decreased emissions of carbon.
Loss of biosphere integrity Wild animal populations have roughly halved since 1970, and ecosystems worldwide have been impacted by human activities.	**Boundary:** no more than 10 extinctions per million species per year. **Current:** ~1000 E/MSY ***and rising*** (plus regionally determined boundaries for ecosystem function).	Globally agriculture remains the largest driver of genetic erosion, species loss and conversion of natural habitats. According to one estimate, over 4000 species of plants and animals are threatened by agricultural intensification. Since the 1900s, some 75 percent of plant genetic diversity has been lost as many farmers have switched to genetically uniform, high-yielding varieties (FAO, 1999).	Agroecology as an approach builds on diversity of crops, varieties, farming methods and ecosystem services. Many studies have shown that different applied agroecological production systems facilitate for higher biodiversity in and around fields.
Changes to biogeochemical flows – **Nitrogen**. An essential nutrient for all life. Exponential rises in N emissions from industry and intensive agriculture damage marine life, cause severe air pollution and affect climate through release of nitrous gas.	**Boundary:** no more than 62 million tons N applied to land per year. **Current:** ~150 Mt per year ***and rising***.	The use of synthetic nitrogen fertilizers has helped to increase yields, but excessive use and/or inappropriate application has also caused significant eutrophication.	Intercropping of companion tree and groundcover species including nitrogen-fixing legumes, together with composting and recycling of manure minimises the need for synthetic nitrogen fertilizers
Changes to biogeochemical flows – **Phosphorus**. An essential nutrient for all life. Exponential rises in P emissions from industry and intensive agriculture cause nutrient pollution in lakes and the sea.	**Boundary:** no more than 6.2 million tons P applied to land per year **Current:** ~14 Mt per year ***and rising***	The application of industrially processed mineral phosphorus fertilizers entails eutrophication problems in both marine and freshwater systems. In addition, the natural resources used to make synthetic fertilizers (e.g. phosphate rock) are finite.	Composting and recycling of manure minimises the need for phosphorus fertilizers. Recirculation of urban waste can also add benefits by returning phosphate to the soil.
Loss of stratospheric ozone, allows more harmful UV light to reach Earth's surface. The minimum concentration has now been steady for ~15 years after phasing out of ozone depleting substances.	**Boundary:** no lower than 276 Dobson Units (DU) ozone (latitude-dependent) **Current:** 283 DU ***and improving***	Agriculture is the largest manmade source of nitrous oxide (laughing gas), producing two-thirds of total emissions. It is emitted when people add nitrogen to the soil, e.g. through the use of synthetic fertilizers. This makes nitrous oxide the single biggest threat to the ozone layer since other damaging gases were restricted by the Montreal Protocol in 1987 (UNEP, 2013).	Release of nitrous oxide from agroecological farming systems can be reduced through greater nitrogen circulation within the system and less total input of "new" nitrogen into the system. (3-5% of all newly added (both through chemical fertilizers and biologically fixed nitrogen), that is built into farming systems are turned into nitrous oxide).
Ocean acidification due to fossil fuel CO_2. Today's rate of ocean acidification is unprecedented in over 65 million years. Effects on marine life are already evident	**Boundary:** ≥80% of pre-industrial ocean aragonite saturation state **Current:** ~84% of pre-industrial ocean aragonite saturation state	Agricultural production gives rise to massive emissions of carbon dioxide which dissolve in sea water and produce carbonic acid, which then lowers the pH and causes severe impacts on life in the oceans.	See above for climate change (carbon dioxide is both a major greenhouse gas and the underlying cause of ocean acidification). Also nitrogen contributes to ocean acidification. Less N input to the system results in less acidification.
Freshwater water use (irrigation) impairs or even dries up rivers and aquifers, harming the environment and altering the hydrological cycle and climate.	**Boundary:** 4000 km^3 water use per year **Current:** 2600 km^3 per year River-basin boundaries also defined.	Agriculture uses most of the planet's available freshwater; it accounts for 70 % of the freshwater taken out of rivers, lakes and aquifers (Postel and others, 1996).	Waterharvesting techniques and drip irrigation combined with higher levels of soil organic matter help to conserve water resources during drought years.

Global process (defined by Steffen and others, 2015)	Proposed boundary and current status (orange = high risk; yellow = increasing risk; green = safe)	Agriculture's impact	Benefits of an Agroecological approach
Land use change (forest conversion to croplands, roads and cities)	**Boundary:** no less than 75% of original natural forest cover **Current:** 62% and shrinking	Agriculture has degraded 70% of grasslands, 50% of savannas, 45% of deciduous forests and more than a quarter of tropical forests. Land use change is driven by such things as population increase, dietary changes, changes in consumers habits, etc. (Foley and others, 2011).	Many fear that more land needs to be converted, but agroecologically managed crop yields on a per-hectare basis can equal or surpass those from conventional agriculture even doubling in many low yielding areas
Atmospheric aerosol loading, Microparticles emitted into the air cause severe local pollution problems and global impacts on nature and climate.	Regionally determined, e.g., **boundary for South Asia:** Aerosol Optical Depth 0.25 **Current:** AOD 0.30 ('brown cloud')	A range of different airborne particles are released from agricultural production around the world, these include dust and soot.	Agroecological systems are often of a more perennial nature and do not include slash and burn agriculture. Systems with a soil cover are less susceptible to soil erosion.
Release of **novel entities** Synthetic substances – and even novel life-forms.	Multiple boundaries, yet to be quantified	The use of synthetic pesticides, hormones and antibiotics as practised throughout the developing world, poses significant risks to human health and to biodiversity.	Biological control, combined with crop rotations and cover cropping, reduces pest problems, and as a consequence chemical pesticide use. No systematic use of hormones and antibiotics.



PLANETARY BOUNDARIES. The inner green shading represents the proposed safe boundaries for nine key planetary processes. The wedges represent an estimate of the current position for each process, indicating that the boundaries for climate change, loss of biosphere integrity, land-system change, altered biogeochemical cycles (phosphorus and nitrogen) have been crossed. Today's agriculture has impact on all the nine planetary boundaries. Image source: F. Pharand-Deschênes /Globaïa

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