Three activities – no-till agriculture, biochar and more intensified livestock farming with reduced methane emissions – are likely to benefit from increased funding because of their alleged role in combating global warming. What is the evidence that these activities can reduce greenhouse gas emissions? What will happen to the world's biodiversity and the global climate if these sectors are hugely expanded? And who is likely to benefit ?

* This is a version, shortened and edited by GRAIN, of part of "Agriculture and climate change: real problems, false solutions" – preliminary report by the Grupo de Reflexión Rural, Biofuelwatch, EcoNexus and NOAH–Friends of the Earth Denmark", http://www.econexus.info/pdf/agriculture-climate-change-june-2009.pdf

Real problems, false solutions

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No-till agriculture

Non-tillage agriculture (NT), also known as no-till and conservation tillage, is a cultivation method which avoids soil disturbance. Modern development of NT began in 1955, when the chemical company ICI discovered the herbicide paraquat, and it became possible to get rid of weeds without ploughing. Before then, it had been assumed that tillage was necessary both to control weeds and to improve water infiltration. NT is often recommended for eroded and depleted soils, with the argument that it prevents the soil from being exposed and thus being made vulnerable to further erosion. NT is also said to improve soil-aggregate formation and microbial activity, as well as water infiltration and storage. NT was not originally developed with genetically modified crops in mind, but it clearly lends itself to the farming of crops that are tolerant to a herbicide. NT requires little labour: herbicide, fertiliser and seed can all be applied by a large machine at a single pass. This favours large, wealthy farmers and monoculture farming on a huge scale. As a result, it is massively embraced by farmers of GM crops.

As yet, there is no certainty as to the impact of NT farming on the soil. The IPCC 2006 Greenhouse Gas Inventory Guidelines suggest that the conversion from conventional tillage (CT) to NT leads to a 10 per cent increase in the estimated sequestration of carbon in the soil.[1] The IPCC's more recent Assessment Report 4, however, is much more cautious:

> Since soil disturbance tends to stimulate soil carbon losses through enhanced decomposition and erosion, reduced- or no-till agriculture often results in soil carbon gain, but not always. Adopting reduced- or no-till agriculture may also affect nitrous oxide (N_2O) emissions but the net effects are inconsistent and not well-quantified globally.[2]

Indeed, recent studies make it clear that there is, as yet, little understanding of how tillage controls soil respiration in relation to N_2O emissions and denitrification.[3] Furthermore, new studies have cast doubt on the carbon sequestration claims. In a review of studies on carbon sequestration in NT systems, Baker *et al.* found that the sampling protocol produced biased results.[4] In the majority of the studies they reviewed, soils were sampled to a depth of only 30 cm or less. The few studies they examined that had sampled deeper soils found that NT showed no consistent build-up of soil organic carbon. Indeed, other studies involving deeper sampling generally show no carbon sequestration

1 With a 5 per cent uncertainty factor.

2 P. Smith *et al.*, "Agriculture", in IPCC (eds), *Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, chapter 8, http://tinyurl.com/2e9c9b

3 X.J. Liu *et al.*, "Dinitrogen and N_2O emission in arable soils: Effect of tillage, N source and soil moisture", *Soil Biology and Biochemistry*, Vol. 39, No. 9, September 2007, pp. 2362–70.

4 J.M. Baker *et al.*, "Tillage and soil carbon sequestration – what do we really know?", Agriculture, Ecosystems and Environment Vol. 118, Nos. 1–4, January 2007, pp. 1–5.

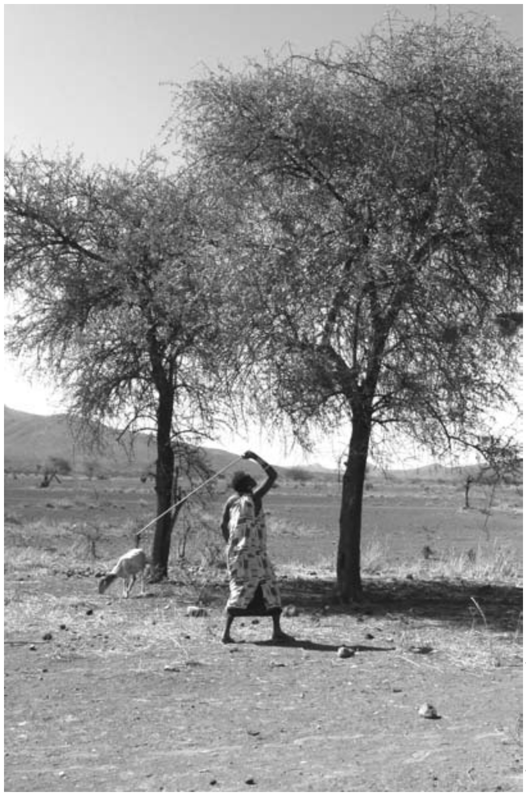


Photo: Practical Action

A woman collects leaves to feed her goat, Maasai Mara, Kenya.

advantage for conservation tillage and, in fact, often find conventionally tilled systems to contain more carbon.

Despite the current uncertainty, international bodies are calling for NT farming to be considered a carbon sink activity and for carbon offsets to be permitted for it. In August 2008 FAO included NT in a submission to the UNFCCC in which it proposed approval of a number of practices to reduce the rate of CO_2 released through soil respiration and to increase soil carbon sequestration.[5] This was followed in October 2008 by the publication of a briefing titled "Framework for Valuing Soil Carbon as a Critical Ecosystem Service" by FAO and the Conservation Technology Information Center (CTIC). As the biotech industry is well represented on the CTIC board of directors, with Monsanto, Syngenta America and Crop Life America all having seats, it is scarcely surprising that the briefing called for a wider use of conservation agricultural systems and recommended the inclusion of carbon offsets from conservation agriculture.[6]

Biochar

Biochar is a term coined by Peter Read, a lobbyist for this technique (who strongly supports industrial tree planations), to describe fine-ground charcoal when it is applied to soil. Charcoal generally is a by-product of pyrolysis, which is a type of bioenergy production in which biomass is exposed to high temperatures for short periods, with little or no oxygen. Fourteen governments, as well as the United Nations Convention to Combat Desertification (UNCCD), are formally calling for biochar to play a significant role in a post-2012 climate change agreement and in carbon trading. They are working with the International Biochar Initiative (IBI), a lobby largely made up of biochar entrepreneurs and scientists (many of them with close industry links), that is active at UNFCCC meetings.[7] The IBI argues that applying charcoal to soil creates a reliable and permanent "carbon sink", thus mitigating climate change. It also claims that biochar makes soils more fertile and permits more water to be retained in them, thus helping farmers to adapt to climate change.

However, scientific studies, including ones by leading IBI members themselves, point to high levels of uncertainty regarding all those claims. Indeed, it is interesting to examine in some detail the main claims made for biochar:

a) that its production is "carbon negative"

Biochar lobbyists say that the process of producing bioenergy from biochar absorbs more carbon than it produces. This is based on two arguments. The first is that biomass burning is carbon neutral or close to it; that is to say, it results in no significant greenhouse gas emissions since emissions during combustion are supposedly offset by new growth. Given that the advocates propose that biochar plantations should be created on a massive 500 million hectares, which is the amount of land needed if biochar is to have the "climate change mitigation" effect recommended by its proponents,[8] this argument is highly dubious. The impact on the climate of converting ecosystems into plantations for biochar production, with all the associated forest and soil degradation, would be colossal, making it impossible to consider the biomass burning carbon neutral, or even close to it.

The second assertion is that the carbon contained in biochar would remain permanently in the soil and that the technology can therefore be considered carbon negative because it would sink CO_2 from the atmosphere. This argument is to a large extent based on *terra preta*: highly fertile soils rich in black carbon – the type of carbon found in charcoal. These soils were created between 4,500 and 500 years ago by indigenous farmers in Central Amazonia, who applied a large variety of biomass residues, including compost, river sediments, manure, fish bones and

5 FAO, Submission by Food and Agriculture Organisation of the United Nations, 3rd Session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA3), Accra, 21–27 August 2008, accessed 26 May 2009, http://tinyurl.com/m9lh73

6 FAO, *Soil Carbon Sequestration in Conservation Agriculture: A Framework for Valuing Soil Carbon as a Critical Ecosystem Service*, 2008. Summary document derived from the Conservation Agriculture Carbon Offset Consultation, West Lafayette, USA, 28–30 October 2008, http://tinyurl.com/mjk648

7 For membership of the IBI Board and Science Advisory Committee, see http://tinyurl.com/ql94wj

8 A. Ernsting and D. Rughani, *Climate Geo-engineering with "Carbon Negative" Bioenergy*, Biofuelwatch, updated version, December 2008, http://tinyurl.com/ll3nhq

9 For more information, see FAO, Terra Preta – Amazonian Dark Earths (Brazil), http://tinyurl.com/nndnwt

10 J. Lehmann *et al.*, "Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: fertilizer, manure and charcoal amendments", *Plant and Soil*, Vol. 249, No. 2, February 2003, pp. 343–57; C. Steiner *et al.*, "Long term effects of manure, charcoal and mineral fertilization on crop production and fertility on a highly weathered Central Amazonian upland soil", *Plant and Soil*, Vol. 291, No. 1–2, February 2007, pp. 275–90. These two articles are based on the same field experiment near Manaus.

11 Chih-Hsin Cheng et al., "Oxidation of black carbon by biotic and abiotic processes", Organic Geochemistry, Vol. 37, No. 11, November 2006, pp. 1477–88.

12 J. Lehmann *et al.*, "Stability of black carbon/biochar", presentation at SSSA Conference, October 2008, http://tinyurl.com/o9nq4p

turtle shells, as well as charcoal, to their soils.[9] The charcoal in *terra preta* has been shown to interact with fungi, which help to maintain soil fertility over long periods. Charcoal residues from wildfire and other sources have been found in soils which date back thousands of years, for example in the North American prairies, Germany and Australia. It is therefore certain that some carbon in charcoal can – under certain circumstances – be retained in soils for thousands of years. Eventually, however, it will be released as CO_2 and warm the atmosphere. Moreover, the fact that some carbon from charcoal remains in the soil does not mean that all or even most of it will. Most of the studies on which claims about the properties of biochar are based have been done in laboratories or greenhouses, some of them with sterile soils. There are very few field studies, and only one peer-reviewed field experiment, which looks at (short-term) impacts on both soil fertility and soil carbon.[10] This still remains the case seven years after the first biochar company, Eprida, was founded. By analogy, this would be like releasing a new pharmaceutical product without clinical testing.

Carbon in charcoal is certainly more stable than soil organic carbon because it is mostly unavailable to soil organisms and thus does not nourish the soil. While carbon in charcoal can remain in soil for long periods, however, it can also be lost within decades, a few years, or even faster. Black carbon, the type of carbon contained in charcoal, can be degraded and turned into CO_2 either through chemical processes or by microbes, and some types of carbon within charcoal are degraded far more easily than others.[11] Johannes Lehmann, Chair of the IBI Board, claims that only between 1 per cent and 20 per cent of the carbon in charcoal will be lost this way in the short term and that the remainder will stay in the soil for thousands of years.[12] But another study, about the fate of black carbon from vegetation burning in Western Kenya, suggests that 72 per cent of the carbon was lost within 20–30 years.[13] One study about a global "black carbon budget" shows that the sums do not add up: a lot more black carbon is produced through wildfires every year than is found in soils or marine sediments, suggesting mechanisms for losses which are not fully understood.[14] Another open question is the possibility that biochar has different impacts on different soil types.

There is some evidence that the types of carbon in charcoal which degrade fastest might be those which can increase plant yields in the short term when used together with fertilisers.[15] In other words, there could be a trade-off between biochar that raises soil fertility and biochar that sequesters carbon, although the lack of field studies makes it impossible to be certain. Moreover, soil microbes have been found which can metabolise black carbon and thus turn it into CO_2.[16] Conceivably, if biochar was applied to large areas of land, these microbes might multiply and break down black carbon more easily than currently occurs.

Another question is whether adding biochar to soil can cause pre-existing soil organic carbon to be degraded and emitted as carbon dioxide. This possibility was suggested by a study in which charcoal in mesh bags was placed into boreal forest soils and significant amounts of carbon (apparently, soil organic carbon) was lost. The authors suggest that the biochar could have stimulated greater microbial activity, which degraded soil organic carbon and caused it to be emitted as carbon dioxide.[17] This is further supported by a laboratory study by Rogovska *et al.* (2008) which showed that adding charcoal to soil increased soil respiration and thus CO_2 emissions.[18]

b) that biochar improves soil fertility

Ash, which accounts for a proportion of fresh biochar, contains nutrients and minerals that can boost plant growth – the main reason for slash-and-burn farming. Soils treated in this manner, however, are depleted after one or two harvests. Biochar proponents recognise that nutrients and minerals are quickly depleted, but maintain that biochar can improve yields none the less, because it enhances the uptake of nutrients from other fertilisers, improves water retention and encourages beneficial fungi. This has proved to be the case for *terra preta*, but the evidence for modern biochar is, yet again, inconclusive. In some cases, biochar can inhibit rather than aid beneficial fungi.[19] Furthermore, the lack of long-term field studies


Biochar

13 Binh Thanh Nguyen *et al.*, "Long-term black carbon dynamics in cultivated soil", *Biogeochemistry*, Vol. 89, No. 3, July 2008, pp. 295–308.

14 C.A. Masiello, "New directions in black carbon organic chemistry", *Marine Chemistry*, Vol. 92, No. 1–4, December 2004, pp. 201–13.

15 J.M. Novak *et al.*, "Influence of pecan-derived biochar on chemical properties of a Norfolk loamy sand soil", presentation at SSSA Conference, October 2008, http://tinyurl.com/o4vvlw

16 U. Hamer *et al.*, "Interactive priming of black carbon and glucose mineralization", *Organic Geochemistry*, Vol. 35, No. 7, July 2004, pp. 823–30.

17 D.A. Wardle *et al.*, "Fire-Derived Charcoal Causes Loss of Forest Humus", *Science*, Vol. 320, No. 5876, 2 May 2008, p. 629; see also the comment by J. Lehmann & S. Sohi, and the authors' response, Science, Vol. 321, No. 5894, 5 September 2008, p. 1295 http://tinyurl.com/mjtaxv

18 N. Rogovska *et al.*, "Greenhouse gas emissions from soils as affected by addition of biochar", presentation at SSSA Conference, October 2008, http://tinyurl.com/pdycee

19 See, for example, D.D. Warnock *et al.*, "Non-herbaceous biochars (BC) exert neutral or negative influence on arbuscular mycorrhizal fungal (AMF) abundance", presentation at SSSA Conference, October 2008, http://tinyurl.com/pqs9e9

Photo: Practical Action

Constructing riverbank reinforcements to act as flood defences, Nepal

means that there is little information on what happens beyond the initial period when charcoal still retains nutrients and minerals. Moreover, it has been shown that, even during this initial period, charcoal can in some cases reduce plant growth, depending on the type of biochar and the crops on which it is used. Perhaps most worryingly of all, studies which result in (short-term) increases in soil fertility involve much larger quantities of biochar than can be obtained from charring residues from that same land, let alone from charring only some of the residues so that sufficient are left for the soil. It is evident that either large areas of land have to be stripped of all biomass to make another smaller piece of land more fertile, or industrial monocultures are required.

Where biochar does increase yields – at least in the short term – it appears to do so mainly by working in conjunction with other materials, such as chicken manure or nitrogen fertilisers.[20] Hence companies such as Eprida are seeking to produce not just charcoal but a combination of charcoal with nitrogen and other compounds scrubbed from flue gases of coal power plants. Such a technology bears little resemblance to *terra preta*, however; instead, it relies on burning fossil fuel and using fossil-fuel based fertilisers in industrial agriculture.

Black carbon, tilling and global warming

Although black carbon is being promoted as a carbon sink while it remains in the soil, airborne black carbon is a major cause of global warming. Although not a greenhouse gas, black carbon reduces albedo – that is, it makes the earth less reflective of solar energy. The small dark particles absorb heat, and contribute to ice melting in the Arctic and elsewhere. Over a century, black carbon has proportionally a global warming impact that is 500–800 times greater than that of CO_2.[21] There is a serious risk that, during biochar production, some of the more finely powdered charcoal will become airborne. It is difficult to see a way out: on the one hand, tilling biochar deep into soils would minimise biochar losses, but tilling can damage soil structures and cause breakdown of pre-existing soil carbon; on the other hand, laying biochar near the soil surface will result in more exposure to erosion and oxidation and could ultimately add significantly to airborne black carbon. This latter problem is well illustrated in pictures from a study commissioned by the biochar company Dynamotive,[22] which show large clouds of charcoal dust during transport and application. The researchers report that 30 per cent of the charcoal was lost in this manner. The significance of airborne particles is also indicated by the fact that dust carried from the Sahara is routinely deposited in the Amazon basin. Even if a small percentage of the biochar becomes airborne, it would mean that biochar would make global warming worse, irrespective of any carbon sequestration.

Large-scale biochar?

It is almost inevitable that a large new demand for biomass would compete with existing and already unsustainable demands on land and would further increase pressure on natural ecosystems, on community lands and on food production. Biochar advocates claim that they do not advocate deforestation for biochar plantations. However, the large quantities of biochar under discussion – with 1 billion tonnes of carbon sequestration per year quoted as a "lower range" – make further pressure on ecosystems inevitable. Johannes Lehmann (IBI), for example, states that dedicated crops and trees have the greatest biochar potential,[23] and a discussion at the 2008 IBI Conference suggested that plantations would be required for scaling up biochar.[24] This is the main concern expressed in a declaration titled "Biochar: A new big threat to people, land and ecosystems", signed by over 150 organisations in spring 2009.[25]

To sum up: there is no unequivocal evidence that biochar "works" at any level, including small-scale. Instead, there are some indications that biochar could accelerate global warming and soil depletion, even if we ignore the inevitable pressures on land and ecosystems that would be created if biochar were to be produced on a huge scale. As well as stripping soils and forests of vital organic residues, the resultant industrial tree plantations would lead to the widespread displacement of traditional

20 See, for example, K.Y. Chan *et al.*, "Agronomic values of greenwaste biochar as a soil amendment", *Australian Journal of Soil Research*, Vol. 45, No. 8, 2007, pp. 629–34.

21 See T.C. Bond and H. Sun, "Can Reducing Black Carbon Emissions Counteract Global Warming?", Environmental Science & Technology, Vol. 39, No. 16, 15 August 2005, pp. 5921–6; and J. Hansen et al., "Climate Change and Trace Gases", Philosophical Transactions of the Royal Society, Vol. 365, No. 1856, 15 July 2007, 1925–54.

22 B. Husk, *Preliminary evaluation of biochar in a commercial farming operation in Canada*, study by BlueLeaf Inc. http://tinyurl.com/kqaex9

23 J. Lehmann et al., "Biochar Sequestration in Terrestrial Ecosystems – a review", Mitigation and Adaptation Strategies for Global Change, Vol. 11, No. 2, March 2006, pp. 395–419.

24 IBI 2008 Conference, Session D, "Biochar and bioenergy from purpose-grown crops and waste feedstocks: Relevance for developed and developing countries?", http://tinyurl.com/7zsr2u

25 "Declaration: 'Biochar', a new big threat to people, land, and ecosystems", Rettet den Regenwald, 26 March 2009, http://tinyurl.com/cabtlu

communities and indigenous peoples, with the destruction of food production and livelihoods, as well as the depletion and pollution of freshwater.

Flood defences in place, Nepal

Photo: Practical Action

Livestock

Livestock farming is a huge producer of greenhouse gases: out of total human-related emissions, it is responsible for 9 per cent of the carbon dioxide, 65 per cent of the nitrous oxide (mainly from manure), 37 per cent of the methane and 64 per cent of the ammonia. It is responsible for nearly 80 per cent of all agriculture-related emissions and has a larger share (18 per cent) in total emissions than transport (14 per cent). These figures include the emissions caused by the production of animal feed, with a third of cultivated land being used to grow grain for livestock,[26] but they exclude the high carbon emissions that stem from clearing forests and other ecosystems to raise livestock. So livestock's real contribution to greenhouse gas emissions is even higher than official figures suggest.

As a result, it is scarcely surprising that considerable efforts are being made to reduce the greenhouse gas footprint of livestock farming. With CDM funding, biogas digesters are being built to reduce methane emissions from factory farms. Nitrification inhibitors[27] are being propagated that could inhibit nitrous oxide, although they are far from efficient, practical or affordable. Endeavours are being made to lower the feed conversion ratio – that is, the amount of feed required to produce meat, eggs and milk. Indeed, faster livestock growth and better use of feed have been achieved over recent decades. Proponents of industrial farming are now claiming that traditional, extensive livestock keeping is harming the climate and a further intensification of the industry inside industrial installations is the best – and perhaps the only – way of saving the planet. But is this credible?

Livestock production has been revolutionised over the last few decades.[28] Through massive subsidies and favourable regulations, the developing countries have followed the example of the developed world and created their own industrial livestock production. Asia has become a larger producer of milk than Europe. In 2004 Brazil overtook the USA to become the world's largest meat exporter. In factory farms compound food, manufactured in feed mills from resources that compete with food and transported over long distances, has

Box 1: Time for a sea change

Fishing was once the most efficient way of providing food without emitting greenhouse gases (GHGs). Industrial fishing has reversed the equation. According to Seas at Risk and the North Sea Foundation, not only does today's commercial overfishing make already depleted fish stocks less resilient to the impact of climate change, but large-scale commercial fisheries are a significant source of global GHG emissions. Consider the following:

- for each ton of live-weight landed fish product, 1.7 tons of CO_2 are emitted;
- global fisheries burned almost 50 billion litres of fuel in the year 2000, to land about 80 million tons of marine fish and invertebrates;
- global fisheries account for at least 1.2 per cent of the global oil consumption, an amount equal to that of the Netherlands, the world's 18th largest oil consuming country;
- the energy content of the fuel burned by global fisheries is 12.5 times as great as the edible protein energy content of the resulting catch.[1]

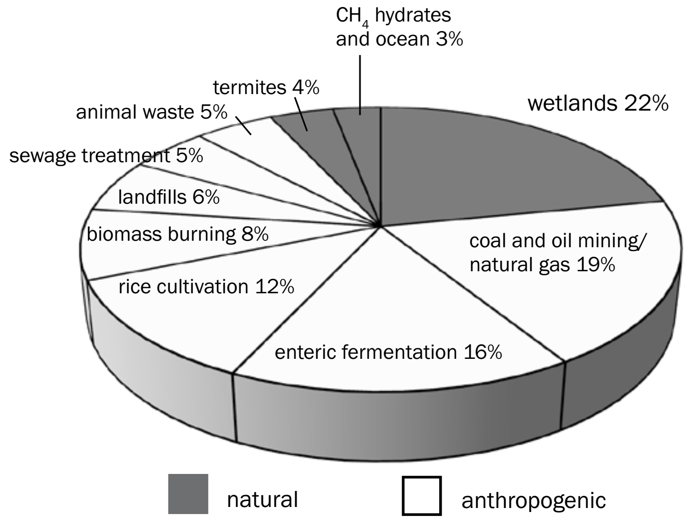
1 Seas at Risk/North Sea Foundation, www.seas-at-risk.org/1mages/Carbon%20footprint%20brochure%20final%20final.pdf

26 90% of soya is used to produce animal feed.

27 Plants can use both the ammonium and nitrate forms of nitrogen, but the nitrate form is more susceptible to leaching and thus enters groundwater more readily. Nitrification inhibitors are chemicals designed to slow the process by which bacteria convert ammonium forms of nitrogen into nitrate forms.

28 See special issue of *Seedling* on livestock, January 2008, http://tinyurl.com/qbod9s (http://www.grain.org/seedling_files/seed-08-01.pdf)

Figure 1: Methane sources



Source: Harvey Augenbraun, Elaine Matthews and David Sarne, "The Global Methane Cycle", Goddard Institute for Space Studies, http://icp.giss.nasa.gov/education/methane/intro/cycle.html

replaced locally available feed, such as grass, other roughage and nutrient-rich waste from farms and households. From the beginning, industrial livestock farming has caused serious water, soil and air pollution, and seriously compromised animal health and welfare. These problems remain largely unsolved. Aquaculture will add to the headaches, as it is increasingly turning to the same feed resources as livestock. In the North, 70 per cent of fish farms require fishmeal and fish oil. Depletion of small pelagic fish for fishmeal and fish oil has fundamentally disturbed the oceans' food web. Because fish are running out (and feeding fish to fish seems crazy, even to some industrialists), more and more fish farms are using grains. In Asia, where 80 per cent of global aquaculture production takes place, compound feed use is increasing. (For the implications of industrial fishing for GHG emissions, *see* Box 1 on p. 27.)

Intensification as a mitigation approach is just a call for more of the same in policy terms: those who have only a hammer will look only for nails, as Dennis Meadows, an author of the Club of Rome's "Limits to Growth" put it. The new biotechnologies for selection seek increased uniformity within even shorter time periods. They are aiming at higher selection intensity (for example, DNA marker-assisted selection), shorter generation intervals (for example, selection from embryo, not adult animals), more females than males in cattle and pigs ("sexed semen") and replication of the same animals (clones). The result of such livestock biotechnologies is predictable: increased genetic uniformity, greater dependency on a few genetics corporations, greater vulnerability to diseases, more demands for subsidies, more pressure on animal welfare, more environmental pollution and more climate change. In sum, more of the same problems that are already an implicit part of the production system.

A similar high-tech approach is being taken to the problem of methane emissions. Ruminants (which are cud-chewing, hoofed mammals such as cattle, sheep and goats) produce methane through enteric fermentation – that is, fermentation that takes place in their rumen, their special stomach that enables them to eat tough plants and grains. Indeed, enteric fermentation is calculated to be responsible for about 16 per cent of the world's production of methane, both natural and anthropogenic. This is less, incidentally, than the amount produced by coal, gas and oil mining (*see* Figure1). A range of technical solutions are being investigated. Vaccines are being developed that would prevent ruminants from producing so much methane. Efforts, including by gene transfers, are being made to modify the methanogenic bacteria in the animals' rumen so that they change their 80 million year-old habit of producing methane. The leading research into these ideas is currently taking place in New Zealand and Australia, whose efforts to reduce their greenhouse gas emissions are being hampered by their simultaneous, contradictory desire to increase exports of meat and milk.

Industrial livestock farming has created a range of new problems that did not exist in the past. Manure deposited on fields and pastures, or otherwise handled in a dry form, does not produce significant amounts of methane, but this has changed with the large-scale industrial production of livestock in factory farms and feedlots. Producing manure in liquid form, these units release 18 million tonnes of methane annually.[29] At present, these emissions amount to only 3 per cent of global anthropogenic methane emissions, but they may double, as China, where half of the world's pigs are reared, is currently replacing smallholder systems with factory farms. Another problem is nitrogen emissions. Animals in general are inefficient nitrogen users, and the nitrogen excretion of ruminants is high. When they are fed roughage, however, and their excreta return to the soils, their nitrogen inefficiency has no negative impact on the environment.[30] Factory farming has changed this: nitrogen emissions from factory farms, together with emissions of phosphate, potassium, drug residues, heavy metals and pathogens, have become a major problem. Animals are also fed on crops grown with chemical fertiliser, and half of the synthetic nitrogen used on

29 H. Steinfeld *et al.*, *Livestock's long shadow: Environmental issues and options*, Rome, FAO, http://tinyurl.com/7yzdoy

30 *Ibid.*

the fields is not being absorbed by the plants, so the excessive nitrogen is polluting ecosystems.

There seems no way of escaping the conclusion that the consumption of an unlimited amount of meat, milk and eggs cannot be a development goal in times of changing climate and should not be supported by tax breaks, subsidies, externalised cost and favorable regulations. In any case, contrary to widespread belief, animal products are not essential for a healthy diet, and FAO has never recommended a minimum intake. Indeed, there is no doubt that consumption is far too high in most industrialised countries and is a major cause of the so-called "diseases of civilisation". The world needs to reduce its consumption of all kinds of meat, and to move away from the current unsustainable methods of industrial production in which livestock are fed on grain (which could be fed to people) instead of on roughage or waste, and in which the "productivity" of poultry, pig and cattle has been increased to such an extent that their genetics are depleted, their health depends on "biosecurity"[31] and antibiotics, and their overall welfare has been compromised to a level that is unacceptable to most people. The excessive number of livestock today means that it is impossible to keep the climate cool (and people healthy, as is attested by the one billion obese people).

Traditional systems of livestock production help to conserve ecosystems as well as to reduce greenhouse gas emissions. The roots of plants in pampas, prairies and tundra are a major CO_2 sink. Indeed, grasslands are believed to account for 34 per cent of the carbon absorbed by carbon sinks.[32] Animals and ecology work in harmony in a system that they have both helped to create. It is a mutually beneficial system, for ruminants like cattle, goats, sheep, buffaloes and camels need grass to turn into food, while seasonal grazing clearly contributes to biodiversity conservation.

It is a virtuous circle: biodiversity is conserved, a major CO_2 sink is maintained and a valuable food is created. Traditional pastoralists have, at times, been accused of over-grazing but now major environmental organisations, including IUCN,[33] are challenging this assertion and are calling for better regulatory support for mobile systems of grazing, such as pastoralism and transhumance. But these systems are in the process of being annihilated: grasslands that have evolved to co-exist with livestock are being turned into cropland for more feed for ever more livestock. This destruction must end. Removing between half and three quarters of the animal products from the Northern diet has become an imperative, not an option.

31 A term coined by the livestock industry for provisions (structural or organisational) to keep disease out of factory farms. Biosecurity forms an increasing part of production costs.

32 T. Tennigkeit and A. Wilkes, *An Assessment of the Potential for Carbon Finance in Rangelands*, ICRAF Working Paper no. 68, 2008, http://tinyurl.com/oxtwga

33 IUCN, "Misconceptions surrounding pastoralism", 21 November 2008 (accessed 20 May 2009), http://tinyurl.com/l5b253

Photo: Practical Action

Family members take refuge on their roof during severe flooding in Bangladesh. The perennial hazard is made much worse by climate change