Agriculture and Climate Change:
Real Problems, False Solutions

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Box 1: Abbreviations

ADE	Amazonian Dark Earth
BIO	Biotechnology Industry Organisation
CBD	Convention for Biological Diversity
CDM	Clean Development Mechanism
CO_2e	CO_2 equivalent
CRP	Conservation Reserve Programme
CTIC	Conservation Technology Information Center
FAO	Food and Agriculture Organization of the United Nations
GHG	greenhouse gases
GM	genetically modified
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IBI	International Biochar Initiative
IFAP	International Federation of Agricultural Producers
IPCC	Intergovernmental Panel on Climate Change
NAMA	Nationally Appropriate Mitigation Actions
NT	no-till, no-tillage
PES	payment for environmental services
REDD	Reducing Emissions from Deforestation and Degradation
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

Few would deny that agriculture is especially severely affected by climate change and that the right practices contribute to mitigate it, yet expectations of the new climate agreement diverge sharply, as well as notions on what are good and what are bad agricultural practices and whether soil carbon sequestration should be part of carbon trading.

Many Annex I countries want (virtually) all funding to come from carbon offsets, emissions trading and projects in Non-Annex 1 Countries (largely the South). In 2008 a record 4.9 billion tonnes of carbon dioxide equivalent (CO_2e) emission reductions were traded on global carbon markets, and carbon trading increased by 83% in just one year, but this trading has not led to a reduction in emissions. Since the Kyoto Protocol came into force in 2005, global CO_2 emissions continued to increase until the advent of the current global economic crisis.

Carbon trading thus does nothing to prevent emissions from fossil fuel burning in the North and there is strong evidence that Clean Development Mechanism (CDM) credits are being used to subsidise some of the most polluting industries in the South. Not surprisingly therefore, carbon trading has not delivered emissions reductions. Few have realized that there are already several agricultural methodologies under the CDM, and many projects exist, particularly in relation to pig farms and oil palm plantations. These are contested for many reasons such as biodiversity destruction and soil and water pollution. These methodologies approved by the United Nations Framework Convention on Climate Change (UNFCCC) actually help to subsidize and legitimise intensive industrial pig farms and plantations while allowing polluting industries in the North to avoid emission reductions. The situation is set to worsen quickly as new CDM methodologies for agrofuels, for charcoal from industrial tree plantations used as a fuel, and for the inoculation of soya and other legumes have recently been adopted by the CDM Board.

Offsetting is based entirely on the hypothetical reduction of emissions that would supposedly have occurred had the project not been in place. Hitherto there have been certain limits to the scope of CDM projects. Parties to the Kyoto Protocol had ruled that soil carbon sequestration and avoided deforestation are not eligible for CDM credits and furthermore, afforestation and reforestation (a term, misleadingly applied to industrial tree plantations) can only account for 1% of Certified Emission Reductions. Now there is pressure to remove all these limits to offsetting. One reason given is that capacity to measure, report and verify emission reductions has improved. However, after having had to bail out the banks, there is little appetite in the industrialised countries to provide public funding for dealing with climate change. Instead they hope to raise private funds by offsetting and trading of Certified Emission Reductions. Meanwhile, the doubts regarding the sustainability of the methods themselves still remain.

There are attempts in the Copenhagen negotiation drafts to render agricultural offsetting far easier than in the first phase of the Kyoto Protocol by making soil carbon sequestration eligible for carbon-trade finance and by including agriculture, including soil carbon, into new mechanisms, which most Northern governments want also to be funded through carbon trading. Negotiation texts suggest that certain parties are endeavouring to get agriculture into the language wherever possible, so that they can more easily increase the role of carbon finance in agriculture.

Not surprisingly, businesses proposing hypothetical emission reductions are proliferating, such as the 25x'25 Coalition that predicts additional annual gross revenues for the US agriculture and forestry sector of over $100 billion from US domestic offsets alone, corresponding to

50% of the total value of US agricultural production.

Although the potent gases nitrous oxide (N_2O) and methane represent the largest direct emissions from agriculture, the emphasis of the agriculture debate in the context of a climate agreement is based on carbon sequestration in soils, a consequence of the dominance of the offset approach. The 2007 IPCC 4th Assessment report, which quotes a calculation of the technical mitigation potential of carbon in soils of up to 6,000 Mt CO_2e/yr and suggests that the greatest mitigation potential is in developing countries, is being quoted widely as an alleged endorsement of proposals for agricultural offsets including soil carbon sequestration. However, the IPCC stressed that there is a difference between a 'technical' and an economic' potential and that there are also social considerations. It also cited evidence that 'financial incentives and regulations' can help with climate change mitigation in agriculture - something very different from what is being proposed for any new climate agreement.

Soils are complex systems with rich biodiversity, organic matter, water flows, complex layers and aggregates. Degradation comes fast, while the building of soils, particularly the organic matter content, takes decades or centuries. While few would deny a relationship between soil degradation and climate change, most of the methods for soil carbon sequestration discussed in the context of recent UNFCCC climate talks are likely to further increase soil degradation. Restoration of degraded soils invariably requires increasing soil organic matter, which the proposed methods do not provide.

The inclusion of soil carbon sequestration in carbon trading has been proposed by the United Nations Convention to Combat Desertification (UNCCD) and several governments, with biochar explicitly mentioned. Even though the word has now disappeared from draft negotiation texts, that does not mean it is off the table. If soil carbon sequestration was included in the CDM, for example, the CDM Board could adopt methodologies for a wide range of practices, including biochar, without any further discussion by governments.

No-till, which has repeatedly been proposed by biotech and agribusiness companies, is included ‘by default’. Proposals in UNFCCC workshops and side events have also included agricultural practices such as intensification of industrial livestock production, GM crops, a further move towards a bioeconomy, and the use of so-called marginal land.

In **no-till agriculture** (non-tillage or NT, also called conservation agriculture), soil carbon emissions are supposed to be reduced by not tilling the soil. The term is often used in conjunction with ‘reduced tillage’. Weeds are usually killed off through the application of herbicides instead, and genetically modified (GM) crops tolerant to herbicides lend themselves to this practice. But experience from existing large scale no-till agriculture (especially with GM soya in Argentina and other GM crops in the US) reveals negative impacts on the environment and climate, while, according to IPCC and others, the carbon sequestration capacity of no-till soils is not conclusively proven. The impacts on soil respiration, de-nitrification, N_2O emissions and thus overall greenhouse gas emissions, and how no-till compares to other management systems are also largely unknown. In view of the inconclusive mitigation data, a call for offsets from NT or “conservation agriculture” is not appropriate.

Biochar is proposed as a new form of soil carbon sequestration in which fine-grained charcoal is applied to the soil. This carbon is identical to the *black carbon* which is known for its negative impacts on climate change when airborne. The International Biochar Initiative (IBI) argues that applying charcoal to soils would create a reliable and virtually permanent carbon sink, mitigate climate change, and make soils more fertile. In support, the IBI cites past applications of charcoal such as Amazonian Dark Earths in which charcoal was combined with varied organic residues over long periods. These, however, bear little resemblance to what is currently being proposed. Even studies by scientists who are members of the IBI indicate high levels of uncertainty. The burning of biomass to produce charcoal is described as close to carbon neutral because greenhouse gas (GHG) emissions during combustion are supposedly offset by CO_2 absorption during new growth, but this ignores the impacts of conversion or degradation of the large areas of land needed to produce the quantities of biochar proposed by many advocates. Estimates range from half to one billion hectares, an amount that would cover between 1,5 and 3 times the land area of India. Furthermore, regardless of land-use impacts, burning or charring trees releases CO_2 which new trees can decades to sequester again.

It is also unclear what percentage of black carbon will remain in the soil, for how long, and how much will be turned into CO_2 and emitted again. Recent research shows that adding charcoal to soil could even *increase* soil organic carbon losses, resulting in CO_2 emissions. Significant black carbon losses during biochar application have been documented and soil erosion is another way for them to become airborne, when they could significantly increase global warming as well as potentially posing a risk to people's health.

Nevertheless, biochar has been proposed among others by the UNCCD, by a number of African countries and Belize, Costa Rica, Micronesia and, with a qualification, Australia. In support, UNCCD cites IPCC, which, however, has not come to any conclusion on biochar and did not comment on it in its most recent Assessment Report. Over 150 civil society organisations have rejected biochar as an offset method.

Industrial livestock production is a major emitter of greenhouse gases, mainly nitrous oxide and methane. Grain feed production currently uses one third of global cropland and relies on chemical fertilizers that are responsible for most anthropogenic nitrous oxide emissions. Yet the response is to propose further intensification of industrial livestock production. Aquaculture is also turning increasingly to grain feed. Both threaten to increase land required for grain feed production, often at the expense of grasslands. However, grasslands represent a significant proportion of terrestrial carbon stores, mainly in their root mass, and they evolved in co-existence with livestock. Traditional extensive grazing is wrongly blamed for harming the climate. When grasslands are turned over to crops, often for more feed for ever more livestock, they release their carbon stores to the atmosphere.

Animal products are not required for a healthy diet, contrary to widespread belief. The intensification of industrial livestock and aquaculture is not a sustainable option. However, reducing production of industrial livestock and fish could help to reduce emissions rapidly while other climate change mitigation policies, including in the energy, and transport sectors are implemented. This is because methane has a half life of only seven to eight years whereas some 25% of the CO_2 emitted today will remain in the atmosphere for 100,000 years or longer, so cutting methane emissions drastically now would have a rapid impact on stabilising climate change.

GM crops have not yet been formally proposed as such for offsetting, but they are being advocated as likely solutions to a wide range of problems linked to climate change. In particular GM is presented as a means to increase yields on existing agricultural land, even though no crops have actually been engineered for yield increase and current GM crops have not led to increased yields but only to some temporary reduction of losses. Hundreds of patent applications have been made for so-called "climate ready" GM crops. Other promised solutions include extending the geographic and climatic range of crops and their capacity to tolerate salt, drought, heat and floods, as well as engineering plants so that applications of nitrogen fertilizer can be reduced. In fact, such crops have been heralded since the 1980s, promising drought and salt tolerant crops and nitrogen-fixation as a means to combat hunger but no such GM crops have yet been launched. At the same time GM crops have led to problems such as serious herbicide resistance among weeds, requiring additional herbicide applications, with negative impacts on environment and climate. Other projects include trying to genetically modify micro-organisms and enzymes to reduce the energy required to break down biomass into agrofuels and other fossil oil substitutes, although the consequences of their potential escape and multiplication in the environment are incalculable. There are ambitious plans to develop a new bioeconomy based on biomass refineries to produce substitutes for fossil oil. The biotech industry clearly sees climate change as an unlimited opportunity for expansion and is lobbying for GM to be recognised as offering key solutions that must be protected by strong intellectual property rights.

Another proposal is to increase the acreage for agriculture by using so-called "**marginal", "degraded"or "waste" lands**. However, unused land is rare. What's seen as marginal land is often land used by marginalized people, by economically weaker sectors of communities, especially women. Much of it is communal land, collectively used by local people who might not have an individual land title, but for whom it is a vital resource for water, feed, food, medicines, fuel and other purposes. Such land is also essential for biodiversity, water supplies, soil and ecosystem regeneration. In some cases, governments have even classed diverse forests on which communities depend as 'wastelands'.

FAO was in favour of major increases in funding for agriculture in a Copenhagen agreement arguing that "millions of farmers around the globe could also become agents of change helping to reduce greenhouse gas emissions". Their land may now become the target of businesses that intend to sequester carbon in soils.

The importance of agricultural biodiversity: In addition to threats to their land, and policies that are hostile to their interests, small farmers also face increased erosion through climate change of the agricultural biodiversity that they have selected and developed over centuries. Yet it is increasingly obvious that their practices and knowledge can help to stabilise climate, conserve water and secure food supplies. The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) of 2008, emphasises the multifunctional role of agriculture and the importance of empowering, not marginalising, farmers, especially women farmers, to manage resources and the need to recognise them "as producers and managers of ecosystems". Resilient ecosystems are fundamental to addressing climate change, water scarcity and food insecurity. Yet farmers continue to be forced off their land and climate change adds to their problems. Once the link between communities and ecosystems is broken it may be impossible to restore.

This report does not focus on the existing positive options for an agriculture that mitigates climate change. They have long been advocated by, for example, the world's largest organisation of smallholder farmers, Via Campesina and received recent scientific backing by the IAASTD. These options have hardly been registered by the climate talks in the run up to Copenhagen. The challenge for a post-2012 climate agreement besides setting meaningful policies for reducing emissions, is to withstand the lobbying of companies seeking to extract carbon credits by including agriculture in a new climate agreement. Agriculture must be excluded from carbon market mechanisms.

1. Introduction

This report discusses some of the ways in which industrial agriculture is proposed to mitigate and promote adaptation to climate change under the UN Framework Convention on Climate Change (UNFCCC). The Copenhagen draft documents cover adaptation, but are more concerned with mitigation.

> In brief, **mitigation** means addressing the causes of climate change, while **adaptation** attempts to tackle its effects. The Intergovernmental Panel on Climate Change (IPCC) defines mitigation as “an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases” and adaptation as “the adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.”[1]

The IPCC cites the ‘technical potential’ of up to 6,000 Mt CO_2e/yr “if considering no economic or other barriers.”[2] Many others, however, forget to cite the economic and other limitations. The IPCC itself sees the economic potential at only 60% of the technical potential, and does not specify the regional location of the economic potential. Environmental and social implications are mentioned but not factored in. If it were decided to include agriculture in a new climate agreement on this basis alone, environmental and social limitations and impacts would be practically ignored. The IPCC also cites evidence that 'financial incentives and regulations' can help with climate change mitigation in agriculture - something very different from what is being proposed for a new climate agreement.

Different proposals for mitigation methods include the agricultural practise of no-till (NT or conservation agriculture), the exploitation of biomass as bio- or agrofuels[3] and 'biochar' to counter climate change as well as the intensification of industrial livestock production; adaptation on the other hand includes the development and cultivation of genetically modified (GM) 'climate ready' crops and the exploitation of so-called marginal land. This report also discusses the likely consequences of including agriculture and soils in carbon trading.

Agriculture is a major contributor to climate change. According to the Stern Review, in 2000, about 35% of greenhouse gas emissions came from non-energy emissions: 14% were nitrous oxide and methane from agriculture, 18% from land use change mainly from deforestation for agricultural purposes, although there is a high margin of uncertainty. Those figures do not include large emissions from soil carbon losses, including peat degradation and peat fires.[4] They also omit other important figures; for example the US food system accounts for some 17% of US energy consumption.[5]

There are some scientists who believe that the above figures for emissions from livestock may be a gross underestimate and methane has a much greater short-term warming impact than is suggested by calculating its impact over a century, as is commonly done.[6] At the same time, the impacts of climate change on agriculture are already serious. Seasons and weather are becoming increasingly unpredictable and extreme. This can lead to major losses as farmers no longer know what or when to plant. If climate change continues unabated, the increasing extremes could lead to the collapse of whole agricultural regions. Climate change also disrupts and alters pest and disease patterns, posing risks to agriculture everywhere.

It is widely accepted that industrial agriculture has had destructive impacts on climate, ecosystems, soil, water and biodiversity resources. However, in many quarters, including the UNFCCC itself, further intensification of industrial agriculture is now proposed as part of the solution to the problems of climate change to which it

1 IPCC (2001): Climate Change 2001: Mitigation. Annex II Glossary. http://www.ipcc.ch/ipccreports/tar/wg3/454.htm

2 Smith P. et al. (2007): Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: Metz B. et al. (eds), Cambridge University Press, Cambridge

3 The use of crop plants as fuels is often described as “biofuel”. In this report we use the term “agrofuel” to describe them clearly as agricultural products. For details on the relationship between agrofuels and climate change see also Chapter 1 of “Agrofuels: Towards a reality check in nine key areas” by Ernsting et al. (2007): http://www.econexus.info

4 Stern N. (2006): Stern Review on the Economics of Climate Change. Executive Summary. HM treasury. http://www.hm-treasury.gov.uk/d/Executive_Summary.pdf and Annex 7.g: Emissions from agriculture sector http://www.hm-treasury.gov.uk/d/annex7g_agriculture.pdf. Greenhouse gas emissions 2000: energy emissions: power 24%, industry 14%, transport 14%, buildings 8%, other 5%; non-energy emissions: land use 18% , agriculture 14%, waste 3%.

5 Grain (2007): Stop the Agrofuel Craze. Seedling July 2007: 2-9; http://www.grain.org/seedling_files/seed-07-07-2-en.pdf

6 Goodland R. & Anhang J. (2009): Livestock and Climate Change: What if the key actors in climate change are...cows, pigs, and chickens? Worldwatch Institute, Washington

has contributed in the first place.[7] Intensive industrial (largely monoculture) production, for example, is proposed as a means to produce agrofuels and biochar on a massive scale as well as to develop a bioeconomy, in which a large percentage of fuels and industrial materials are produced from biomass instead of from fossil fuels.

Agriculture for the carbon market

During the negotiations for a new climate agreement, proposals were made to include agriculture in carbon trade mechanisms, particularly soil carbon sequestration, which, according to one estimate has "the potential to offset some 5-15% of global fossil-fuel emissions".[8]

The International Food Policy Research Institute (IFPRI) and FAO have both endorsed this.[9] The Assistant Director General Alexander Müller[10] even argued for an inclusion of soil carbon sequestration by stating that "*soil carbon sequestration, through which nearly 90% of agriculture's climate change mitigation potential could be realized, is outside the scope of the Clean Development Mechanism under the Kyoto Protocol*" but that carbon markets should be introduced to "*provide strong incentives for public and private carbon funds in developed countries to buy agriculture-related emission reductions from developing countries [...].*"[11]

In recent months, the United Nations Convention to Combat Desertification (UNCCD) followed by a number of African countries, Micronesia, Costa Rica and Belize have begun to promote biochar for carbon sequestration and as a soil additive.[12] Biochar is basically fine-grained charcoal, but it can also be a by-product of methods currently explored to convert solid biomass into liquid and gaseous fuel and into so-called second generation agrofuels (see chapter 5).

The Food and Agriculture Organization of the United Nations (FAO) sees the aforementioned 'agriculture-related emission reductions from developing countries' as a chance to "*provide important investments to spur rural development and sustainable agriculture in developing countries. Product standards and labels could be developed to certify the mitigation impact of agricultural goods.*"[13]

However, verifying and certifying claimed emissions reductions, as well as reliance on carbon markets will be problem in themselves and could lead to massive corruption, with for example two CDM validators having recently been suspended due to concerns over apparent irregularities (see box 2). According to researcher Dan Welch, "Offsets are an imaginary commodity created by deducting what you hope happens from what you guess would have happened."[14] In agriculture, the inherent problems with quantifying the effects of carbon offsets are compounded by particularly high uncertainties over measuring and predicting greenhouse gas emissions and carbon sequestration. Carbon trading is biased towards methods that are cheap, more than effective, and there is strong evidence of 'creative carbon accounting'. Emission trading thus hinders emission reduction and efficiency improvements.[15]

Perhaps even more important, the existence of carbon markets will offer developed countries and their industries the opportunity to use offset programmes and similar mechanisms to evade their obligation to reduce their own climate emissions. Trading services in agriculture will not address the fundamental problems of relying on a model of permanent economic growth on a planet of finite resources. Instead, having just experienced the impacts of a subprime property market, we now run the risk of building a subprime carbon

7 United Nations (2008): Challenges and opportunities for mitigation in the agricultural sector UNFCCC: FCCC/TP/2008/8.

8 Lal R. (2004): Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science 304, 1623-1627.

9 Nelson G.C. (2009): Agriculture and climate change: An agenda for negotiation in Copenhagen. IFPRI, Focus 16. http://www.ifpri.org/2020/focus/focus16/Focus16_01.pdf ; FAO (2009): Climate change talks should include farmers. Press release, 2 April 2009. http://www.fao.org/news/story/en/item/11356/icode/

10 at the the climate negotiations in Bonn in April 2009

11 FAO (2009): Climate change talks should include farmers. Press release, 2 April 2009. http://www.fao.org/news/story/en/item/11356/icode/

12 UNCCD (2009): Submission by the United Nations Convention to Combat Desertification, 5th Session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA 5), Bonn, Germany, 29 March – 8 April 2009; http://www.unccd.int/publicinfo/AWGLCA5/UNCCD_2nd_submission_land_soils_and_UNFCCC_process_05Feb.pdf
African governments (2009): Submission of African Governments to the 5th Session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA 5), Bonn, Germany, 29 March - April 2009 : The Gambia, Ghana, Lesotho, Mozambique, Niger, Senegal, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe; http://unfccc.int/files/kyoto_protocol/application/pdf/swazilandonbehalfof060209.pdf

13 FAO (2009): Climate change talks should include farmers. Press release, 2 April 2009. http://www.fao.org/news/story/en/item/11356/icode/

14 Davies N. (2007): The inconvenient truth about the carbon offset industry. The Guardian, 16 June 2007. www.guardian.co.uk/environment/2007/jun/16/climatechange.climatechange

15 EurActiv.com (2009): Carbon trading 'stifling EU energy-savings potential'. 22 April 2009. http://www.euractiv.com/en/energy-efficiency/carbon-trading-stifling-eu-energy-savings-potential/article-181502

market whose impacts could be far deadlier.[16] But worst of all we are speeding up the destruction of the biodiversity and ecosystems that are crucial if we are to stabilize climate, produce food and leave a habitable planet to future generations.

Alternative models

There are alternative models for the future of agriculture, but they are currently neglected in the UNFCCC process. They include biodiverse ecological agriculture and agroforestry, which can increase food production and reduce the climate footprint of agriculture, as well as playing a major role in ecosystem restoration and maintenance and undoing at least some of the harm which industrial agriculture has done to the climate. Agriculture should be recognized more clearly as a multifunctional activity. It not only produces food, medicine, materials, fibres etc. and can effectively recycle wastes into soil restoration, but also has many other roles. This includes protecting biodiversity, soils, water sources in tune with the local ecology (ecosystem functions) and has additional cultural, landscape, and well-being values for people, over and above their need for nourishment. Finally, it is a repository for knowledge built up over generations that we lose at our peril.

Messages like these come for example from farmers themselves, such as in La Via Campesina's report on how small-scale sustainable farmers are cooling down the earth[17] or in Practical Action's paper on biodiverse agriculture for a changing climate.[18] Also the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) report,[19] prepared by 400 scientists in a cooperative process between a wide range of UN institutions and approved by 57 governments prior to publication, notes:

> "A powerful tool for meeting development and sustainability goals resides in empowering farmers to innovatively manage soils, water, biological resources, pests, disease vectors, genetic diversity, and conserve natural resources in a culturally appropriate manner."[20]

The UN Special Rapporteur on the Right to Food in October 2009 called for more coherence and action for food security and climate change:

> "The current input-intensive agricultural system is struggling under the combined pressures of climate change and food insecurity, exacerbated by large-scale agro-fuel production and increased speculation on land. This type of agriculture depends heavily on fossil fuels that generate excessive greenhouse gas emissions. It also leads to the expulsion of rural populations and to inefficient and wasteful food chains. This system does not provide equitable access to food. Policy makers have other choices."[21]

Great caution is needed around adopting agriculture practices and techniques for climate change mitigation. Policy makers should not assume that solutions to climate change are necessarily technical. Many of them are social ,economic and cultural – they require structural changes, not techno-fixes. We urgently need to shift our focus away from technology 'futures' promises to the readily available knowledge, experience and resourcefulness of local communities. This is urgent as the displacement and de-skilling of such communities and small food producers proceeds apace.

2. Copenhagen and beyond

Opinions among governments are divided as to whether - and if so how – agriculture and especially soils (see chapter 5) should be addressed in a new climate agreement. There are proposals for funds, for trading and for a mixture of the two. The prospect of funding support is very attractive to governments and NGOs alike. Some have suggested that agriculture should be part of Nationally Appropriate Mitigation Actions (NAMAs) and possibly included in REDD-plus, with many Northern governments calling for those mechanisms to be funded through the carbon markets.[22] The inclusion of soil carbon sequestration including biochar, even if not explicitly mentioned, and increased support for other

16 Friends of the Earth (2008): Subprime Carbon? Re-thinking the world's largest new derivatives market., Friends of the Earth, http://www.foe.org/subprime-carbon

17 Via Campesina (2007): Small scale sustainable farmers are cooling down the earth. Background paper; (accessed 20.5.2009) http://viacampesina.org/main_en/index.php?option=com_content&task=view&id=457&Itemid=37

18 Practical Action (f2009): Biodiverse agriculture for a changing climate. http://practicalaction.org/?id=biodiverse_agriculture_paper

19 IAASTD (2009): Summary for Decision Makers of the Global Report. Island Press, Washington, USA. http://www.agassessment.org/docs/SR_Exec_Sum_280508_English.htm

20 IAASTD (2009)

21 Cordoba Declaration (2009): A Call from the Cordoba Group1 for Coherence and Action on Food Security and Climate Change. http://www.fian.org/news/press-releases/cordoba-group-calls-for-coherence-and-action-on-food-security-and-climate-change/pdf

22 Definition from AWGLCA: REDD-plus defined as in paragraph 1 (b) (iii) of the Bali Action Plan (issues related to policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries)

Box 2: Fraudulent carbon trading

The distinction between fraudulent and other carbon trading is already dubious in itself because trade takes place with something entirely illusory. As Larry Lohmann stated: “This unverifiability makes it relatively easy for a skilful and well-paid carbon accountant whose work is largely shielded from public scrutiny to help fabricate huge numbers of pollution rights for sale to Northern fossil fuel polluters. At the same time, it makes impossible any distinction between fraud and non-fraud, rendering any attempt at reform ultimately pointless.”[1]

Apparently the options for policy failures are numerous, as a report from the UK in August 2008 shows:

“Carbon Traders Arrested for Tax Fraud: British customs officials arrested seven people near London on Wednesday Thursday who are suspected of dodging taxes that should have been paid for selling large amounts of carbon dioxide permits - the main currency in the European Union’s Emissions Trading System.[2] The suspected fraud amounted to £38 million, or nearly $63 million, the British tax agency, HM Revenue & Customs, said in a statement. [...]

Many polluting businesses in Europe are required to buy the permits, which are part of a cap-and-trade system similar to the one under consideration in the United States, and which currently trade for about 15 Euros ($21) for each ton of CO_2 emitted. [...] The companies in the network are suspected of adding the VAT. to the price of the permits, which they sold in Britain. The companies then disappeared before paying the tax to British authorities. [...] Last month, Britain exempted carbon trading from the VAT to curb the possibility of similar cases in the future. France and the Netherlands took similar steps earlier in the summer. Even so, the tax agency said it “still intends to pursue relentlessly those that may have used carbon credit trading to cheat the public purse.”[3]

1 Lohmann L.: Climate Crisis: Social Science Crisis. in Der Klimawandel: Sozialwissenschaftliche Perspektiven (forthcoming]). http://www.tni.org/archives/lohmann/sciencecrisis.pdf

2 EU: Emission Trading System (EU ETS); http://ec.europa.eu/environment/climat/emission/index_en.htm

3 Kanter J. (2009): Carbon traders arrested for tax fraud. NewYork Times, 20.8.2009; http://greeninc.blogs.nytimes.com/author/james-kanter; accessed 24.8.2009

agricultural activities could in themselves lead to perverse outcomes, regardless of the financing mechanism, as other chapters in this report show.

In the different text proposals, references to climate change mitigation from agriculture as well as soil carbon sequestration (often referred to as ‘enhanced [carbon] removals from agriculture’) tend to be separate from the debate about funding mechanisms. While support for certain agricultural activities could indeed be desirable, it presently seems unlikely that the US, the EU or many other Northern governments will agree to any funding mechanism in which carbon trading does not play a major role - even though many Southern governments strongly object to this approach. As discussed in chapter 3, apart from the general concerns about carbon trading, there are strong reasons to expect agribusiness and plantation companies to be the main beneficiaries of further carbon credits for agriculture, at the expense of small farmers and indigenous peoples who have a wealth of knowledge and experience of sustainable, climate-friendly farming.

Because of this bias, which is inherent to carbon trading, the agricultural methods most likely to be funded this way are ones which will generate income for agribusiness and plantation companies, such as no-till monocultures, tree plantations for biochar and minor technical adjustments by the industrial livestock industry. They fit into the industrial agriculture model, which, as shown above, is a major driver of climate change. At the same time, funding for such methods can be expected to have serious negative impacts on climate, communities and the environment even, regardless of where it comes through the carbon markets or from a government fund. Proposals for further subsidies for plantations and industrial agriculture through UNFCCC coincide with a major push for a ‘bioeconomy’ and in fact the CDM Board has already agreed to highly controversial methodologies for agrofuel plantations and for industrial tree plantations to produce charcoal as a fuel.

Even support for the inclusion of positive and desirable activities, such as soil carbon in organic farming, into a United Nations Framework Convention on Climate Change (UNFCCC) agreement needs to be viewed with great caution.

Current proposals: fund and/or flexible mechanism for funding and trade.

In order to finance REDD as well as National Mitigation Activities (NAMAs) and possibly Sectoral Agreements, there are proposals for funds, market mechanisms (i.e. carbon offsets,) a combination of the two and even carbon trading linked to auctions. Many countries in the South call for the facilitation of technology-transfer to tackle climate change for many areas of work including agriculture and at the same time there are calls to prevent performance standards or any actions in agriculture from acting as barriers to trade. Finally there has been a call for patent exemption for access to mitigation technologies and for no patents to be granted on genetic resources essential to climate change adaptation. Groups such as the Biotechnology Industry Organisation (BIO) are lobbying strongly against such proposals (see chapter 7).

During the climate talks in Barcelona, agriculture appeared to lose priority in the negotiations, while developed countries sought to get rid of the Kyoto Protocol but retain its offsetting and carbon market mechanisms. It also became apparent that there might be no binding agreement, but only a political statement in Copenhagen, because positions remain profoundly divided between the G77 and China and the others including the EU, the US and Australia. The main struggles are now two: should the Kyoto Protocol's market mechanisms be transferred to the Convention track, leaving it possible for Northern countries to try and kill off Kyoto without losing the carbon market; and can Northern countries continue to avoid real emission cuts during the second commitment period under Kyoto.

References to agriculture remain scattered through the "non-papers" that constitute the current negotiating texts.

3. Carbon Trading Proposals for Agriculture

In 2008, 4.9 billion tonnes of carbon dioxide equivalent (CO_2e) emission reductions were traded on global carbon markets. Overall, carbon trading increased by 83% in just one year.[23] However, trade in emissions reductions does not imply emissions being reduced. Since the Kyoto Protocol came into force in 2005, global CO_2 emissions, including from fossil fuel burning and cement production, increased, at least prior to the current economic crisis. The growing carbon markets have not led to overall emission reductions in the industrialized nations which are committed to reducing their greenhouse gas emissions under the Kyoto Protocol, the so-called Annex 1 countries.[24] Instead, the world is now on course for the worst emissions scenario predicted by the Intergovernmental Panel on Climate Change (IPCC), or perhaps an even worse one.[25] According to an article in Euractiv, 22nd April 2009: "*The EU's emissions trading scheme has so far failed to deliver any reductions in CO_2 emissions while at the same time strangling energy-efficiency investment in the electricity sector, according to a former European Commission official*."[26]

23 Environmentalleader.com (2009): Carbon market up 83% In 2008, value hits $125 billion. 14.1.2009; accessed 20.5.2009; www.environmentalleader.com/2009/01/14/carbon-market-up-83-in-2008-value-hits-125-billion/

24 Netherlands Environmental Assessment Agency (2008): Global CO2 emissions: increase continued in 2007. 13.6.2009, accessed 20.5.2009; www.pbl.nl/en/publications/2008/GlobalCO2emissionsthrough2007.html

25 International Scientific Congress Climate Change: Global Risks, Challenges & Decisions (2009): Key messages from the congress. 12.3.2009, accessed 20.5.2009; http://climatecongress.ku.dk/newsroom/congress_key_messages/

26 Eur.Active.com (2009): Carbon trading 'stifling EU energy-savings potential'. 22 April 2009. www.euractiv.com/en/energy-efficiency/carbon-trading-stifling-eu-energy-savings-potential/article-181502

The aim is clearly to ensure that work to install agriculture and soils in the carbon market can continue at a later point, even if it is not achieved at Copenhagen. Nonetheless, there is still a possibility that references to agriculture in general and soil carbon sequestration in particular could be included even in a very basic new climate agreement. Furthermore, if the previous decisions to exclude soil carbon sequestration from the CDM was reversed, this would allow the CDM Board to approve methodologies for no-till monocultures or biochar plantations without any further discussion by governments.

Nonetheless, the great majority of proposals for a post-2012 climate change agreement aim at a significant increase in carbon trading, including in the so-called Clean Development Mechanism (CDM), administered by the United Nations Framework Convention on Climate Change (UNFCCC). The CDM plays a crucial role within the carbon markets because CDM credits can be traded on other carbon markets, including the European Emissions Trading Scheme, which accounts for two thirds of all carbon trading. The only exceptions are CDM credits for "afforestation and reforestation", which cannot be traded under the European scheme.

The CDM has come under sustained criticism, amongst other issues, for funding projects which are not 'additional' and would have gone ahead anyway, for "being routinely abused by chemical, wind, gas and hydro companies who are claiming emission reduction credits for projects that should not qualify",[27] and for funding projects which *increase* greenhouse gas emissions, such as hydro dams.[28] Looking beyond these specific concerns, the principle of carbon-offsetting, which includes the CDM, is fundamentally flawed because any offset is used to license fossil fuel burning elsewhere, thus permitting an overall increase in carbon dioxide concentrations. Despite this, many of the proposals made by Parties for a post-2012 climate change agreement entail a major expansion of the CDM and a weakening of such safeguards as exist at present. On the one hand, the CDM could cover new technologies, such as carbon capture and storage, nuclear power or soil carbon sequestration (such as no-till agriculture as discussed in chapter 4 or biochar as discussed in chapter 5); on the other hand, the rules could be changed so that it could become easier for projects to be approved for funding. Furthermore, there are attempts to lift the current restriction for the proportion of CDM credits that can come from carbon sequestration (carbon storage). At present, a maximum of 1% of CDM credits can come from sequestration in forests, whereby the term 'forest' includes tree and shrub

27 Vidal J. (2008): Billions wasted on UN climate programme. The Guardian, 26.5.2008.

28 Langman J. (2008): Generating Conflict. Newsweek International, 13.9.2008

plantations and no CDM credits for carbon sequestration in soils are allowed. Soil carbon credits, however, are seen as key to including agriculture into a new climate agreement. Among others, the United Nations Convention to Combat Desertification (UNCCD) now calls to raise the 1% limit and to include soil carbon sequestration into the CDM.

There are three further proposals which might greatly increase carbon trading and erode or even abolish any rules which are supposed to link the CDM to emissions reductions. So far, no funding decisions have been made – many Annex 1 governments favour carbon trading as a key mechanism whereas many non-Annex 1 governments oppose this. Agriculture is likely to be affected by each one of those proposals.

- **Sectoral Agreements** whereby emissions in Annex 1 countries could potentially be offset against wider policies in a particular sector (such as agriculture) in a non-Annex 1 country,
- **Nationally Appropriate Mitigation Actions (NAMAs)** to which non-Annex 2 countries s (i.e. mainly developing countries) voluntarily agree and which could be funded through public funds or be used to offset Annex 1 countries emissions, or both. As with Sectoral Agreements, these policies could be designed to result in a lower increase in emissions than forecast rather than in any emissions reductions.[29]
- **REDD-plus:** REDD (Reducing Emissions from Deforestation and Degradation) involves funding for reducing deforestation and degradation. The 'plus' refers to funding for forest conservation, sustainable forest management (a term routinely used for industrial logging) and for 'carbon stock enhancement', a term routinely used for industrial tree plantations. There is a strong push, particularly from Annex I countries for funding to come partly or in full through carbon trading.[30] There are increasing numbers of proposals to widen REDD-plus to cover other land use change and in particular agriculture.

A further proposal would also boost carbon market funding for agriculture: It could become illegal for national regional emissions trading schemes to discriminate between different types of emissions reductions approved by UNFCCC. At the moment, the EU Emissions Trading Scheme excludes agriculture and forestry projects. If the EU agreed to the proposals and thus obliged itself to include both, this could quickly direct large funding streams to agribusiness and plantation companies.

3.1. The role of agriculture in carbon trading today

CDM projects

Carbon trading has created windfall profits for power companies in Annex 1 countries, particularly in Europe, and for fossil fuel companies and other industries responsible for high levels of greenhouse gas emissions and serious environmental and social impacts in non-Annex I countries. At present, around 6% of CDM funding goes to agricultural projects, plus a significant additional amount to biomass energy projects.[31] Those credits include livestock manure management (including biogas from swine manure) heat generation from palm oil mill effluents, and the use of agricultural residues for biomass. There are big winners. For example, in 2007, 90% of all approved CDM projects in Malaysia benefited palm oil companies[32] whereas in Mexico, half of all CDM projects involve pig farms. However, soil carbon sequestration is widely seen as having the biggest potential for future carbon credits for agriculture (perhaps with the exception of bioenergy), provided that its exclusion from the CDM is lifted at some point. Part of the reason is that the IPCC considers soil carbon sequestration to offer the greatest potential for climate change mitigation in agriculture; the other reason is the vast subsidy potential, should soil carbon credits for no-till farming or biochar be approved: Over 100 million hectares of land worldwide are under no-till farming, most of it industrial monocultures,[33] and agribusiness hopes to convert far more land to such systems, whereas the potential for biochar is[34] claimed to be as high as 9.5 billion tonnes of carbon per year.

Large agribusiness firms like Monsanto have so far obtained very little funding through carbon markets including the CDM, despite a long-standing lobbying campaign for no-till agriculture to be classed as a way of

29 Reyes O. (2008): Ad Hoc Working Group on Kyoto Protocol update, aka how to expand carbon markets and count emissions increases as reductions. Carbon Trade Watch, 17.4.2009, accessed 20.5.209; http://www.carbontradewatch.org/index.php?option=com_content&task=view&id=261&Itemid=36

30 REDD-Monitor (without date): REDD: An introduction. accessed 20.5.2009; www.redd-monitor.org/redd-an-introduction/

31 Clean Development Mechanism – Appraisal of GHG standards and issues for agricultural mitigation, Neeta Hooda, UNFCCC Secretariat, presented at Conservation Agriculture Consultation, October 2008

32 Biofuelwatch (2007): South East Asia's peat fires and global warming. Factsheet 1, Biofuelwatch, 6.6.2007, www.biofuelwatch.org.uk/peatfiresbackground060607.pdf

33 Goddard T., Zoebisch M., Gan Y., Ellis W., Watson A. & Sombatpanit, S. (2008): No till farming systems, World Association of Soil and Water Conservation, Special Publication No. 3. www.afd-cambodge.org/jahia/webdav/site/ffem/users/admiffem/public/Rapports_biodiversite/NO_TILL_FARMING_SYSTEMS_WASWC_oct07.pdf

34 Lehmann J. et al. (2006): Bio-char Sequestration in Terrestrial Ecosystems: A Review. Mitigation and Adaptation Strategies for Global Change 11: 403–427

Box 3: US Carbon Trading versus the Conservation Reserve Programme

In the US, the Conservation Reserve Programme (CRP) and the Wetlands Reserve Programme (WRP) are highly successful environmental schemes. Farmers enter into agreements lasting 5-30 years whereby they receive government subsidies for taking land out of production and planting trees, shrubs or grass, or for restoring wetlands. According to US government system, the CRP sequesters 21 million tonnes of carbon every year and prevents 408 million tonnes of soil being eroded annually, as well as protecting a large number of plant and animal species and 40% of commercial beehives. Yet the schemes are being eroded fast, largely as a result of ethanol and agribusiness industry lobbying

The 25x'25 Coalition has called for carbon offsets for the conversion of cropland to grassland, riparian buffers, forests and wetlands, i.e. for activities now covered by the CRP and WRP. Proposed US climate legislation includes offsets for some of those activities, namely afforestation and reforestation and conservation of grasslands, wetlands and peatlands and it leaves the door open to more activities being included in future.

Initially offsets are likely to be additional to the CRP and WRP, however existing pressures on both schemes could well cause them to be replaced by offsets. Under a carbon offsetting scheme farmers would have to submit applications which are likely to be far more complicated for returns that are far less predictable than those from current government funding, since the price of a tonne of carbon continuously changes. Applications to the CDM or to national or regional carbon trading schemes are very difficult without help from specialist consultants. Whereas funding for the CRP and WRP is ring-fenced, carbon credits for similar projects would not be. Farmers hoping to get help to restore wetlands or riparian buffers would be competing with large agribusiness companies vying for money for no-till soya. Furthermore, converting their land to monoculture tree plantations might well attract far more funding. This shows the difficulty of placing a successful government policy in competition with business interests.

sequestering carbon and reducing emissions. There is no CDM methodology for greenhouse gas reductions from agricultural methods such as no till, even though greenhouse gas reductions from agriculture are not included in the CDM, due to the high uncertainties, for example relating to carbon dioxide fluxes and nitrous oxide emissions linked to no-till. CDM credits for soil carbon sequestration from cropland or forest management were ruled out in 2003.[35] Only the Chicago Climate Exchange and a few carbon offsetting companies and schemes, such as C-Lock Technology Canada provide carbon credits for soil carbon sequestration. So far, the agrofuel industry has not profited from carbon trading either and no CDM credits have been given to dedicated plantations for bioenergy (although many biomass projects involving by-products from plantations have been funded this way).

However, this situation is set to change dramatically, even without any new decisions at or after Copenhagen. In July 2009, the CDM Board approved a CDM methodology for charcoal made from dedicated tree plantations, used as a fuel in iron ore production. The proposal was submitted by Plantar, a company whose eucalyptus plantations in Minas Gerais, Brazil, have been the subject of major local opposition and national and international criticism linked to human and land rights abuses, water and soil pollution, fresh water depletion and the destruction of native forests. During the same month, a small-scale CDM methodology for 'nitrogen inoculation of legumes' was approved. So-called *small-scale* methodologies are simplified and apply to projects with fewer Certified Emissions Reductions (i.e. with limited carbon credits). Since there also happens to be a patent on rhizobia resistant to glyphosate, it is easy to see how technology and biotech/agribusiness companies such as Monsanto might profit from this CDM. In October this year, the CDM Board approved a methodology for biodiesel from dedicated plantations on 'degraded or degrading land', a definition so wide that it would cover most agricultural soils and many natural ecosystems, including most of South-east Asia's peatlands. The same definition was previously approved for industrial tree plantations, misleadingly classed as 'afforestation and reforestation' by the FAO and UNFCCC definitions. Both industrial tree plantations and industrial crop plantations have thus been boosted by recent CDM Board decisions.

So far, only one larger carbon trading scheme, the Chicago Climate Exchange, has included agricultural soils and specifically no-till farming. In Saskatchewan, a pilot project was set up in 2005 which allowed trading in credits from no-till farming, but this was later abandoned. In Australia, Carbon Farmers have set up the Australian Soil Carbon Grower Register which assesses conditional carbon credits, however those are not being traded as yet and the Australian Government has so far been reluctant to give in to calls by the opposition leader to set and meet a high climate target largely with biochar and other soil carbon sequestration methods. However, the World Bank and the Voluntary Carbon Standards Agency are working on various soil carbon sequestration methodologies, so outside the CDM the situation is also likely to change soon.

35 see http://www.rubberboard.org.in/articles/websitematerialDDPhysiology.doc

3.2. Agribusiness hopes for windfall profits from carbon trading

In theory, the reasons against including soil carbon sequestration in the CDM remain. The UNFCCC Secretariat confirmed in a recent presentation that lack of permanence (for example because a change in agricultural practices could release the soil carbon), and a high level of uncertainty regarding emissions, remain serious obstacles.[36] New scientific studies have confirmed rather than resolved major uncertainties over the role of soils in climate change. Including agricultural soil carbon sequestration schemes and methods such as no-till agriculture or biochar despite fundamental concerns would further undermine the credibility of a climate agreement. It would allow certain and irreversible emissions from fossil fuel burning to be offset against highly uncertain soil carbon sequestration methods. In the case of no-till, not only is there – uncertainty about the impacts on the climate, but also the land could be tilled at any time if agriculturally required , for example, to eradicate weeds that have become herbicide tolerant. In the case of biochar, there is no consistent information about its fate in soils and about its impact on soil carbon and soil fertility.

Nonetheless, agribusiness companies as well as biochar firms and advocates are optimistic about reaping a windfall from carbon trading. In the US, the 25x25 Coalition has been instrumental in influencing the new administration's climate change policy. They comprise leading figures in the US soya and maize lobby, as well as forestry companies. Their aim is to see 25% of US primary energy by 2025 produced not from renewable energy in general but from "America's farms, forests and ranches."[37] Proposed US climate change legislation includes nearly all of the demands made by this lobby for carbon offsets from agriculture and forestry. Those sectors are expected to provide the vast majority of domestic offsets, yet their own emissions are not capped. US climate legislation has been delayed until 2010 and the Chamber of Commerce, in which climate change deniers play a prominent role, however, proposals for agricultural and forestry offsets continue to enjoy broad support within the US Senate and House of Representatives, and specific proposals have been put forward for this which include both no-till and biochar. Those provisions, if endorsed, are unprecedented and take carbon trading to new levels of absurdity: for the first time an industrial country is close to introducing a partial 'greenhouse gas reduction target', and 'offset' emissions from 'capped sectors' with unproven methods used in uncapped sectors in the same country.

Furthermore, according to the US Energy Information Administration, proposed legislation will boost agrofuels and solid biomass to a far greater extent than wind or solar energy and proposed offsetting provisions alone would ensure that there would be no emissions reductions even from the 'capped sectors' for several decades.[38] If US domestic proposals for agricultural offsets are implemented then, as 25x'25 predict "the [US] agriculture and forestry sector could realise over $100 billion in additional annual gross revenue" - 50% of the total value of US agriculture.[39] The US government also follows the agribusiness lobby by calling for major funding for agriculture through a post-2012 climate agreement.

3.3. Which type of agricultural projects could be funded through carbon trading in future?

The UNFCCC Secretariat has summed up the types of agricultural activities which could in future be subsidised through carbon trading: No-till and low-till, agricultural set asides, agroforestry, conversion of cropland to grassland or forests, carbon sequestration in agro-ecosystems, agrofuels and other types of industrial bioenergy, peatland restoration, restoration of degraded land, water management, improved rice management, improved livestock and manure management, nitrification inhibitors (chemicals added to nitrate fertilizers to slow down the release of the nitrate) and changes to the way in which synthetic fertilizers are

36 UNFCCC Secretariat (2009): Technical paper: Challenges and opportunities for mitigation in the agricultural sector. presentation at AWG-LCA workshop on opportunities and challenges for mitigation in the agricultural sector , Bonn, 4.4.2009; http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/1_unfccc.pdf

37 25x'25 website; http://www.25x25.org

38 Energy Information Administration (2009): Impacts of a 25-percent renewable electricity standard as proposed in the American clean energy and security act discussion draft; http://www.eia.doe.gov/oiaf/servicerpt/acesa/index.html

39 25x'25 (2009): Agriculture and Forestry in a Reduced Carbon Economy: Solutions from the Land. A Discussion Guide. 1 April 2009

used. The governments of eleven African countries, Belize, Micronesia and Costa Rica as well as UNCCD have specifically called for the inclusion of biochar into the CDM.

Agrofuels and other bioenergy from crop and tree monocultures, possibly combined with biochar, no-till plantations of genetically modified crops and the industrial livestock industry, are likely to attract a large proportion if not the bulk of future carbon credits for agriculture – and yet more funding will go to tree plantations under 'afforestation and reforestation' and most likely REDD-plus. Current REDD proposals would even allow the conversion of primary forests to oil palm and other tree and shrub plantations (including jatropha) to be subsidised as 'forest protection'. This means that the majority of funding for agriculture is likely to go towards intensive industrial agriculture and in the case of biochar, industrial tree plantations. Agrofuels, for example, are likely to be supported as climate friendly despite overwhelming evidence, including in peer-reviewed studies, that they *accelerate* global warming through land-use change and agro-chemical use.[40]

Raising per hectare yields, a term often equated with industrial intensification based on greater agro-chemical inputs, is often seen as an effective means of reducing greenhouse gas emissions, for example by the IPCC and by the UNFCCC Secretariat, even though it is commonly associated with high energy and fossil-fuel based fertilizer use.[41] The idea is that raising per hectare yields will reduce pressure on ecosystems. However, agrofuels and other types of bioenergy, supported by the same agencies, create an unlimited new market for agricultural and forest products. This dashes any hopes that higher yields will result in less pressure on ecosystems. Even if yields could be raised despite droughts and floods becoming more common due to climate change and despite soil and freshwater depletion, the increased demand for bioenergy will translate higher yields into higher profits and land prices, providing further incentives for companies to expand monocultures.

3.4. REDD: Helping forests or plantation?

In May 2009, the Biochar Fund succeeded in obtaining funding from the Congo Basin Forest Fund for reducing deforestation in DR Congo.[42] The idea is that small farmers who currently practice so-called slash-and-burn agriculture can permanently improve their crop yields by turning biomass into fine-grained charcoal (biochar) and can therefore abandon their current practices. The funding was awarded despite the lack of evidence that biochar use will improve those farmers' crop yields particularly over the long-term. However, biochar and different agricultural practices, together with tree plantations could yet be included into the REDD-plus mechanism without any requirement for deforestation to be reduced.

The definition of forests that applies to the CDM is wider than even that of the Food and Agricultural Organisation (FAO) or the Convention for Biological Diversity (CBD), which encompasses industrial tree plantations but excludes those agricultural production systems (such as oil palm) and plantations with an average height of less than five metres. In contrast, under the CDM any plantation of trees or shrubs of more than 2 metres in height, including by default GE trees and shrubs, can be classed as a 'forest'. Planting oil palm or jatropha plantations could thus be classed as afforestation and reforestation, particularly if rules for such schemes continue to be relaxed. The Mexican government already promotes palm oil and jatropha expansion and intends to include its agricultural sector in its national REDD strategy.[43]

The US government goes a step further: it calls for REDD-plus to cover not just forests but all types of land use. Countries should be able to choose which sector they wish to include first. Under a recent US REDD-plus proposal, it would become legitimate for countries to channel funding exclusively to agribusiness without any

40 See for example: Fargione J., Hill J., Tilman D., Polasky St. & Hawthrone P (2008): Land clearing and the biofuel carbon debt. Science 319(5867): 1235-1238; and Searchinger et al. (2008): Use of US cropland for biofuels increases greenhouse gases through emissions from land use change. Science 319(5867): 1238-1240.

41 See UNFCCC (2009): Workshop on opportunities and challenges for mitigation in the agricultural sector. 4.4.2009; http://unfccc.int/meetings/ad_hoc_working_groups/lca/items/4815.php

42 Congo Basin Forest Fund (2009): Successful projects (2009) > Projects to receive funding from the CBFF. accessed 20.5.2009; http://www.cbf-fund.org/site_assets/downloads/pdf/projects_receiving_funding.pdf

43 Mexico (2009): Mexico: Challenges & Opportunities for mitigation in the agricultural sector. Presentation given at AWG-LCA 5th Session, Workshop on opportunities and challenges for mitigation in the agricultural sector, Bonn, Germany. 4.4.2009; http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/8_mexico.pdf

attempt to protect forests at all.[44] At the UNFCCC talks in Bonn in August this year, Australia, New Zealand and South Africa also called for REDD-plus to be extended beyond forests. Support for integrating agriculture into REDD also comes from the International Agricultural and Food Trade Council, (which includes Monsanto, Cargill, Syngenta and Unilever as well as WWF). Their joint report with the International Centre for Trade and Sustainable Development proposes broadening REDD-plus to include agriculture as one option and also supports the inclusion of soil carbon sequestration into the CDM.[45] The inclusion of agriculture into REDD remains amongst several proposals contained in the negotiating texts.

Conclusions

In 2000, the US proposed that under the Kyoto Protocol an unlimited percentage of the total emission reductions should be allowed to come from tree plantations and agricultural practices instead of Annex I countries having to reduce emissions from other sources like energy, industry and transport. This was rejected by the EU and many other Parties as undermining attempts to address the causes of climate change.

Proposals which are now being discussed for a post-2012 agreement resemble the former US proposal in that they would allow requirements for a large or even uncapped proportion of emission reductions to be met from questionable agricultural and forestry activities, without ending deforestation and other ecosystem destruction.

The market-based proposals relating to REDD-plus, “afforestation and reforestation”, biochar (i.e. charcoal applied to soils) and agriculture would greatly increase the classification of agricultural lands, forests and plantations as carbon sinks to offset emissions from fossil fuel burning. Furthermore, the inclusion of agriculture as well as industrial tree plantations into the REDD mechanism would undermine any REDD agreement and would allow countries to profit from tree or shrub plantations and, if proposals for including agriculture into REDD-plus are adopted, even from GM soya plantations regardless of continued deforestation. The aim of preserving forests would thus be completely undermined.

Proposals for the agricultural sector suggest that funding would primarily be channelled towards industrial monocultures, combined with agrofuel and agroenergy expansion. Non-industrial, biodiverse farming by small-scale farmers is unlikely to benefit. As Larry Lohmann from Corner House states: “The CDM’s market structure biases it against small community based projects, which tend not to be able to afford the high transaction costs necessary for each scheme.”[46] The high transaction costs, however, arise from the requirement to (at least on paper) demonstrate climate benefits as well as the wider sustainability of projects. There is already strong evidence that CDM projects are routinely approved which do not meet these criteria. Further relaxing the requirements would make the system even more open for abuse. The bias towards large projects and companies rather than communities is thus inherent in the CDM.

Allowing general policy-based or sector-based carbon credits, rather than just project-based ones, would further uncouple so-called offsets from any emission reductions. The proposed market-based policies are likely to benefit large-scale industrial agriculture, rather than non-industrial, integrated farming which has a high potential for mitigating climate change as well as preserving biodiversity. The emphasis on market-based options threatens successful government-funded and regulatory policies, such as the US Conservation Reserve Programme.

Proposals for agriculture to play a significant role in carbon trading and in wider market-based policies in a post-2012 climate agreement thus threaten to undermine any effective response to climate change.

On the one hand, the large-scale inclusion of agriculture and soil carbon sequestration into carbon trading as offsets will further weaken any incentives to reduce fossil fuel emissions. On the other hand the agricultural practices most likely to benefit are those such as no-till monocultures and biochar. Not only have those not been proven to benefit the climate but also they are very likely to exacerbate climate change if used on a large scale.

44 United States of America (2009): United States Input to the Negotiating Text for Consideration at the 6th Session of the AWG-LCA. Copenhagen Decision Adopting the Implementing Agreement. submitted on 4.5.2009; http://unfccc.int/files/kyoto_protocol/application/pdf/usa040509.pdf

45 CTSD-IPC Platform on Climate Change, Agriculture and Trade (2009): International Climate Change Negotiations and Agriculture. Policy Focus, May 2009. www.agritrade.org/documents/IPCPolicyBrief527final.pdf

46 Lohmann L. (2006): Carbon Trading: A critical conversation on climate change, privatisation and power. Development dialogue 48.

The main beneficiaries of the proposals are likely to be industries such as animal feed, agrofuels, biochar, pulp and paper and all that seek to supply the emerging bioeconomy. These industries are likely to continue large-scale deforestation and other ecosystem destruction, so accelerating climate change, the pollution of air, soil and water, and the displacement of indigenous peoples, small farmers and other communities.

4. Does no-till agriculture reduce carbon emissions?

No-till agriculture has been promoted for some years as a means to sequester and build up carbon in the soil, as well as improve its structure and water retention capacity. International bodies such as the Food and Agriculture Organisation have made submissions to the United Nations Framework Convention on Climate Change (UNFCCC) calling for its large-scale adoption, and for this to be stimulated by the recognition of soils as carbon sinks. Monsanto backed no-till agriculture for recognition under the UNFCCC many years ago: "Since COP4 at Buenos Aires in 1998, Monsanto has promoted its model of conservation tillage, which it claims could meet up to 30% of USA reduction targets. Robert B. Horsch, Monsanto's President for Sustainable Development, explained that: 'Monsanto and others worked hard and successfully at the meeting to persuade delegates to look into agricultural carbon 'sinks' as a way to reduce atmospheric greenhouse gases'."[47] Meanwhile, the Intergovernmental Panel on Climate Change (IPCC) has been more cautious and recognises that there is conflicting evidence and considerable uncertainty about the benefits of no-till agriculture. However, there is a strong lobby for the recognition and reward of no-till practices under the UNFCCC from organisation such as FAO, agrochemical companies or their associations (e.g. BIO), and organisations of large farmers (e.g. IFAP).

What is no-till agriculture?

No-till agriculture (NT), also known as conservation agriculture or zero tillage, is a cultivation method that avoids turning the soil. Prior to its development, it was assumed that tillage is necessary to improve water infiltration and soil aeration as well as to control weeds. Modern development of NT began after ICI developed the herbicide paraquat in 1955. In the beginning, this technique was applied mainly in eroded and depleted soils because one of its main advantages is that the soil is rarely left bare, making it less vulnerable to erosion and evaporation. NT is also said to improve the soil-aggregate formation, and microbial activity as well as water infiltration and storage.

In NT the new crop is sown into the residues of the previous crop. Without ploughing to control weed growth, most NT agriculture uses herbicides to kill weeds and the remains of the previous crop.[48] NT was developed before the advent of genetically modified (GM) crops but GM herbicide tolerant crops lend themselves to the system because they are not destroyed by the herbicide application. It is also claimed that NT requires less labour as seed, fertilizer and herbicide can all be applied on a single journey by one direct drilling machine.

There are other forms of no-till agriculture, some of which are organic. These include for example planting a cover crop that is then crushed and uprooted using a "crimper roller".[49] Exact data about the use of no-till practices are difficult to obtain because different agricultural practices can be summarized under the term, and because a farmer might choose to till the land every few years to control weeds, while practising no-till in other years. This could reverse any possible carbon sequestration.

Because there are a number of terms for the practice related to no-till (low-till, zero-till, conservation tillage), some of which involve a certain amount of tillage[50] we have decided to use the term *chemical no-till* to describe no-till practices for which there is data available. These rely on the application of non-selective/broad spectrum/ herbicides (like glyphosate and glufosinate), often in combination with GM crops.

Current estimates amount to about 100 million ha of no-till world-wide: mainly in North and South America, and mainly chemical no-till with GM crops. While in South America, NT is pervasive, there is a large potential for increase in the US, besides Russia and Ukraine.[51]

47 Harbinson R. (2001): Conservation tillage and climate change. Biotechnology and Development Monitor 46: 12-17.

48 A form of NT weed control is also used in organic agriculture. However, it is not used extensively, because it involves considerable work and because usually the cover crop residue is not able to smother weeds effectively.

49 Rodale Institute (2009): No-till revolution. http://www.rodaleinstitute.org/no-till_revolution; accessed 11 September 2009

50 Harbinson (2001): Conservation tillage and climate change. Biotechnology and Development Monitor 46: 12-17

51 Rolf Derpsch, Theodor Friedrich (2009): Global Overview of Conservation Agriculture Adoption. Paper presented to IV World Congress on Conservation Agriculture, New Delhi, India, February 2009 http://www.fao.org/ag/ca/doc/Global-overview-CA-adoption-Derpschcomp2.pdf

Box 4: Chemical NT soybean cultivation in Argentina

In Argentina, nearly 17 million hectares are cultivated with GM soya under chemcial no-till systems at present (2009). This represents 20% of the total acreage under no-till practice worldwide.[1]

Due to the increased availability of seeds and technology and due to a lower price for agrochemicals, GM agriculture was adopted in Argentina in the 1990s. The NT system was perceived as a solution to the soil degradation present in the Pampas region.[2] At that time, NT was mainly known for the conservation of organic matter and better water utilization.

However, after more than ten years of using NT for the cultivation of mainly GM soya,[3] profoundly negative environmental impacts are occurring. The use of pesticides induces resistance in weeds, leading to an increase in the quantity and variety of pesticides used. Soil fertility is declining due to intense production, and soil demineralisation is addressed by the use of synthetic fertilizers, The production of such fertilizers itself is energy intensive and some of them are generating greenhouse gase (GHG) emissions after being applied to the soil.. The large quantity of chemicals, sprayed from tractors and planes, has negative impacts on biodiversity, water, soil, human and animal health. Furthermore, the adaptation of NT methods have been directly linked to greater deforestation in the seasonally dry forests in the north-west and thus to accelerated regional and global climate change.[4]

49% of all soya in Argentina is grown as monoculture without rotation, while 30.6% is rotated with wheat and a much smaller proportion with maize (corn) or sunflower.[5] Reports from two Argentinian regions show that productivity decreased by 32% during the 2008/09 season, due to drought and a conflict between farmers and government over soy bean taxation. Soy acreage is expected to increase to 19 million hectares again in 2009/10 because soya is still cheaper than other crops to produce.

However, the economics of NT soya production externalize a range of cost factors. Not included are the long term soil fertility loss, the cost of decontaminating polluted water supplies and costs to the health care system related to human and animal illnesses emerging from this production system.

1 AAPRESID (2008): Siembra directa, con visión holística. 17.1.2008; accessed on 18.5.2009. http://www.concienciarural.com.ar/articulos/agricultura/siembra-directa-con-vision-holistica/art283.aspx

2 Casas R. (2003): Sustentabilidad de la agricultura en la región pampeana. Clima y Agua, Castelar. Instituto Nacional de Tecnología Agropecuaria; http://www.inta.gov.ar/balcarce/info/documentos/recnat/suelos/casas.htm

3 The lack of rotations in the Argentinean soya region it is mainly due to two factors: (a) high international demand and the comparative greater profits from soya, and (b) productive lands are rented to exogenous companies, who are not looking at soil as a resource to preserve.

4 Grau H.R., Gasparri N.I. & Aide T.M. (2005): Agriculture expansion and deforestation in seasonally dry forests of north-west Argentina. Environmental Conservation 32: 140-148.

5 Panichelli L., Dauriat A. & Gnansounou E. (2008): Life cycle assessment of soybean-based biodiesel in Argentina for export. The International Journal of Life Cycle Assessment 14: 144-159; http://www.springerlink.com/content/gq31272407530111

Smallscale no till is promoted for example by the African Conservation Tillage Network and at a FAO side event in Barcelona, no-till in China on more than 1 million ha involving major herbicide use, was presented.

4.1. Can no-till reduce CO_2 in the atmosphere through storage in soil sinks?

A number of international organisations claim that no-till can have highly beneficial effects by reducing greenhouse gas emissions and helping to store carbon in the soils. The Food and Agricultural Organisation (FAO) states in one of its 2009 submissions to the UNFCCC:

> “Soil carbon sequestration through the restoration of soil organic matter can further reverse land degradation and restore soil “health” through restoring soil biota and the array of associated ecological processes. In particular, through improved soil water storage and nutrient cycling, land use practices that sequester carbon will also contribute to stabilising or enhancing food production and optimizing the use of synthetic fertilizer inputs, thereby reducing emissions of nitrous oxides from agricultural land. Conservation tillage practices also reduce significantly the use of fuel and hence gaseous emissions.”[52]

A similar call from the International Federation of Agricultural Producers (IFAP)[53] proposes carbon sequestration through (among others) no or reduced tillage.

As yet, there is no certainty as to the impact of NT farming on the soil. The 2006 IPCC *Greenhouse Gas Inventory Guidelines* suggest that conversion from conventional tillage to NT systems would lead to a 10% increase in the estimated sequestration of carbon in the soil, while quoting an error margin of 4-50% depending

52 FAO (2009): *The carbon sequestration potential in agricultural soils.* Submission by Food and Agriculture Organization of the United Nations to AWG-LCA3; 19.8.2009; http://unfccc.int/resource/docs/2008/smsn/igo/010.pdf

53 IFAP (2008): *Challenges and opportunities for mitigation in the agricultural sector*. Submission to the Chair of the AWG-LCA with respect to the fulfilment of the Bali Action Plan and taking into consideration document FCCC/TP/2008/8 http://unfccc.int/resource/docs/2009/smsn/ngo/085.pdf

on climate zone.[54] However, the IPCC's more recent Assessment Report 4 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 may also affect N_2O, emissions but the net effects are inconsistent and not well-quantified globally."[55]

Indeed, recent studies make it clear that there is, as yet, little understanding of how tillage controls soil respiration in relation to CO_2 and N_2O emissions. Higher CO_2 and N_2O fluxes were registered in NT soil than in conventional tillage soil irrespective of nitrogen source and soil moisture content.[56]

Furthermore new studies have cast doubt on the carbon sequestration claims.[57] A review of studies on carbon sequestration in NT systems found that sampling protocols produced biased results. In the majority of the studies reviewed by Baker *et al.*,[58] soils were only sampled to a depth of 30 cm or less. The few studies that sampled at deeper levels found that NT showed no consistent build up of soil organic carbon. Conversely studies that involved deeper sampling generally show no carbon sequestration advantage for conservation tillage, and in fact often show more carbon in conventionally tilled soils. John M. Baker, research leader at the USDA Agricultural Research Service, Soil and Water Management Unit, concluded in his 2007 study on non-tillage and carbon sequestration that the evidence for increased carbon sequestration in NT systems is not conclusive.

> "It is premature to predict the C sequestration potential of agricultural systems on the basis of projected changes in tillage practices, or to stimulate such changes with policies or market instruments designed to sequester C. The risk to thescientific community is a loss of credibility that may make it more difficult to foster adoption of other land use and management practices that demonstrably mitigate rising atmospheric concentrations of greenhouse gases."[59]

4.2. Effects on the soil

It is clear that the climate benefits of chemical no-till are still in doubt, and at the same time there are growing concerns about the impacts of NT and the herbicide glyphosate on the soil, on water resources and weeds and pests. In addition there are serious impacts on local populations' health and food security, with many being driven off the land altogether. Most experiences with environmental effects of chemical NT comes from Argentina where due to local political and economic factors GM herbicide tolerant soybeans using glyphosate (Roundup) have been cultivated on a massive scale since the 1990s (see box 4). Recent evidence of agricultural problems also comes from NT systems with GM cotton in the US (see box 5).

Soil demineralisation and fertilizers: The application of synthetic fertilizers in agriculture is identified by the IPCC as a major contributor to N_20 emissions. N_20 is around 300 times as powerful a greenhouse gas as carbon dioxide over a century.

> "Worldwide consumption of synthetic N fertilizers has increased by about 150% since 1970 to about 82 Tg N/year in 1996. Animal wastes used as fertilizer supplied an estimated additional 65 Tg N/year in 1996, compared with 37 Tg N/year in 1950. This increase in N use is now widely recognised as a major factor in the increase in N_2O emissions indicated by increases in atmospheric concentration."[60]

Contrary to the assumption that because soya is a nitrogen nitrogen fixing plant, it will improve soil nitrogen levels, continued increases in soya yields in the Argentinean Pampas region have been accompanied by

54 with a 5% uncertainty factor

55 Smith P. et al. (2007): 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://www.ipcc.ch/ipccreports/ar4-wg3.htm

56 Liu X.J., Mosier A.R., Halvorson A.D., Reule C.A. & Zhang F. (2007): Dinitrogen and N_2O emission in arable soils: Effect of tillage, N source and soil moisture. Journal of Soil Biology and Biochemistry 39: 2362-2370.

57 Yang X.M., Drury C.F., Wander M.M. & Kay B.D. (2008): Evaluating the effect of tillage on carbon sequestration using the minimum detectable difference concept. Pedosphere 18: 421-430.
Franzluebbers A.J. & Studemann J.A. (2009): Soil-profile organic carbon and total nitrogen during 12 years of pasture management in the Southern Piedmont USA. Agriculture, Ecosystems and Environment 129: 28-36.

58 Baker J.M., Ochsner T.E., Venterea R.T. & Griffis T.J. (2007): Tillage and soil carbon sequestration – what do we really know? Agriculture, Ecosystems and Environment 118: 1-5.

59 Baker et al. 2007, see above.

60 Smith K, Bouwman L. & Braatz B. (2003): N_2O: Direct emissions from agricultural soils. In: IPCC (eds): Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_5_N2O_Agricultural_Soils.pdf

Box 5: Chemical NT of cotton and soya in the USA
According to press reports from the USA in 2009, hundreds of thousands of acres of cotton and soybean fields have been infested with Palmer pigweed resistant to glyphosate (Roundup) used for chemical NT.
"In Arkansas alone, the weed has invaded some 750,000 acres of crops, including half the 250,000 acres of cotton. In Tennessee, nearly 500,000 acres have some degree of infestation [...]. The infestation is cutting farmers' cotton yields by up to one-third and in some cases doubling or tripling their weed-control costs. [...] Rising up to 10 feet tall, with stalks as thick as baseball bats, the plant also can wreck any mechanical cottonpickers sent into heavily infested fields. Since it outcompetes cotton for water and other resources, infestation easily can cut yields by 300 pounds per acre."1
Already in 2005, Monsanto, the producer of Roundup and of the herbicide tolerant crop seeds had advised farmers to use three additional herbicide applications against possibly resistant pigweed. That this problem was to be expected is illustrated by the fact that as early as 2001 Monsanto was granted a patent on tank mixes of glyphosate (Roundup) with other herbicides.2
By now at least 16 different weed species are listed as herbicide resistant to glyphosate (Roundup) on several continents. Some of them show combined resistances of up to four herbicides.3

1 Chalier T. (2009): 'The perfect weed': An old botanical nemesis refuses to be rounded up. Memphis Commercial Appeal, 9.8.2009; http://www.commercialappeal.com/news/2009/aug/09/the-perfect-weed/
2 Dechant D. (2003): Monsanto sees opportunity in glyphosate resistant volunteers. CropChoice.com http://www.cropchoice.com/leadstry9204.html?recid=1299 accessed 13.9.2009
3 WeedSience: Glycines (G/9) resistant weeds. http://www.weedscience.

steep declines in soil nitrogen (N), phosphorus (P), potassium (K) and sulphur (S). It appears that there is insufficient nitrogen in the soil for the requirements of the GM soya monocultures, which means both a decline in soil fertility and the need for substantial applications of chemical fertilizer.

Soil compaction is due both to no-till practices and to the weight of the machinery used.[61] This causes numerous problems such as water-logging and reduction in fertility because the nutrients at deeper soil levels are not brought up by tillage to a level where the crop roots can reach them.[62] Compacted soils also contribute to higher N_2O emissions because de-nitrification is more intense in water-filled pore spaces. A study from the Argentinian Pampas suggests that higher N_2O emissions in NT managed agricultural systems of the humid portion of the Pampas might cancel out the benefits of carbon sequestration within several decades.[63]

Chemical no-till agriculture also contaminates soil and water and damages biodiversity in aquatic systems, soils and all ecosystems, which may well lead to less resilience in the face of climate change. In some parts of Argentina and in the Brazilian Amazon, no-till is connected with increased rates of forest clearance with obvious impacts on climate stability and rainfall. GM agriculture, through its reliance on the continuous application of a single herbicide, has also facilitated the development of herbicide tolerant weeds which are an increasing problem. Pest patterns have also changed, with new pests emerging. Both these phenomena have led to increased applications of herbicides and the use of a wide range of supplementary herbicides and other agrotoxics.

It is also claimed that no-till agriculture means less fuel consumed because of "single pass" tractor use for planting,[64] but there is little data to support this. On the contrary, applications of pesticides have increased to 3 or 4 per season, and herbicide applications from airplanes are common in chemical no-till.

4.3. No-till offset propositions

All this shows that even though it was initially claimed that chemical NT could reduce greenhouse gas emissions by not leaving soil vulnerable to erosion and sequestering carbon in the soil, the practice can also increase greenhouse gas emissions through the use of additional agrochemicals (herbicides, fertilizers) and through higher N_2O emissions where soils have become waterlogged and by making soya production at the expense of forests more lucrative in some areas.

Despite the current uncertainty, some international organisations are calling for chemical NT farming to be considered a carbon sink activity and for carbon offsets to be permitted for it. Reasons put forward include

61 Gerster G., Bacigaluppo S., De Battista J. & Cerana J. (2008): *Distribución de la Compactación en el Perfil del Suelo utilizando diferentes Neumáticos. Consecuencias sobre el Enraizamiento del Cultivo de Soja.* Instituto Nacional de Tecnologia Agropecuaria, Econoagro; http://www.econoagro.com:80/verArticulo.php?contenidoID=646

62 ConCiencia (2005): *¿Quien se acuerda del suelo? Universidad Nacional del Litoral, Santa Fe, Argentina,* ConCiencia Nro.13, 4.2.2005; http://www.rel-uita.org/agricultura/suelo.htm

63 Steinbach H.S. & Alvarez R. (2006): *Changes in soil Organic carbon contents and N_2O emissions after introduction of no-till in Pampean agroecosystems.* Journal of Environmental Quality 35: 3-13

64 See for example Monsanto (2006): *Conservation tillage*. http://www.monsanto.com/biotech-gmo/asp/topic.asp?id=ConservationTillage

climate change mitigation and the reversal of environmental degradation in agricultural soils.[65]

Argentina is the country with the largest proportion of chemical (GM) no-till in the world. It is therefore not surprising perhaps that in 1997, the Argentinean National Inventory report for the UNFCCC accepted the soils under no-till GM soya fields as possible carbon sinks. In its report the no-till producers association AAPRESID was the UNFCCC inventory rapporteur for the emissions for the change for the use of land.[66]

Argentina has been asking the UNFCCC since 1998 for the introduction of no-till agriculture into the carbon market "as it is in the country's interest as world-wide leader of NT"[67] - at least according to Hernan Carlino, Argentinean member of the UNFCCC Executive Board Committee of the Clean Development Mechanism (CDM) and until recently chairman of the CDM Accreditation Panel.

In August 2008, FAO made a submission to the UNFCCC to propose a number of practices to reduce the rate of CO_2 released through soil respiration and to increase soil carbon sequestration, including conservation tillage.[68] In October 2008 this was followed by the publication of a briefing with the title *Framework for Valuing Soil Carbon as a Critical Ecosystem Service*, published by FAO and the Conservation Technology Information Center (CTIC). The two organisations called for a wider adoption of conservation agricultural systems and recommend the inclusion of carbon offsets from conservation agriculture.[69]

The biotech industry is well represented in the CTIC board of directors: Monsanto, Syngenta America and Crop Life America all have seats. This fact endorses the conclusion that the FAO-CTIC call for agricultural offsets aims mainly to favour GM crops.

Conclusion

The capacity to sequester carbon in soil under no-till agriculture is not conclusively proven and could also be undone by greater N_2O emissions. Moreover, the application of heavy machinery, herbicides, and herbicide resistant GM crops have led to soil and water contamination and soil compaction. The fact that in such an inconclusive situation, the FAO calls for offsets from no-till agriculture together with the biotech industry shows vested interests that compromise the independence required from a UN organisation.

5. Biochar: What can we expect from adding charcoal to the soil?[70]

Biochar is fine-grained charcoal which is applied to soil. It is a euphemistic term coined by Peter Read of the International Biochar Initiative. Biochar is generally derived as a by-product of pyrolysis (see below) although research programmes are producing biochar by steam-heating biomass under high pressure (hydrothermal carbonisation or HTC). The type of carbon contained in biochar is **black carbon**.

Biomass pyrolysis is a type of bioenergy production in which biomass is exposed to high temperatures for short periods, with little or no oxygen. Besides biochar, this produces syngas and bio-oil, both of which can be used for heat and power or be further refined into road transport or possibly aviation fuel. Pyrolysis can be done in large plants and small kilns or stoves.

5.1. Proposals and claims

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 have signed up to claims by the International Biochar Initiative (IBI), a lobby organisation made up largely of biochar entrepreneurs as well as scientists, many of them with close industry

65 FAO (2009): *The carbon sequestration potential in agricultural soils.* Submission by Food and Agriculture Organization of the United to AWG-LCA3; 19.8.2009; http://unfccc.int/resource/docs/2008/smsn/igo/010.pdf

66 Ministerio de desarrollo social y medio ambiente Secretaria de Desarrollo Sustentable ypolitica ambiental (1999): Inventario de Emisiones de Gases de Efecto Invernadero de la Republica Argentina. Proyecto Metas de Emision Arg/99/003-PNUD-SRNyDS; http://www.medioambiente.gov.ar/archivos/web/UCC/File/inventario%20de%20gases%20en%20la%20argentina%201997.pdf

67 clarin.com (2005): El agro juega limpio. Clarin, 25.6.2005; http://www.clarin.com/suplementos/rural/2005/06/25/r-00901.htm

68 FAO (2008): Submission by Food and Agriculture Organization 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 26.5.2009; http://unfccc.int/resource/docs/2008/smsn/igo/010.pdf

69 FAO (2008): *Soil Carbon Sequestration In Conservation Agriculture. A Framework for Valuing Soil Carbon as a Critical Ecosystem.* Summary document derived from the Conservation Agriculture Carbon Offset Consultation, West Lafayette, USA, 28-30.10.2008; http://www.fao.org/ag/ca/doc/CA_SSC_Overview.pdf

70 This chapter is based on the briefing paper: Ernsting A. & Smolker R. (2009): Biochar for Climate Change Mitigation: Fact or Fiction? Biofuelwatch; http://www.biofuelwatch.org.uk/docs/biocharbriefing.pdf

links.[71] The IBI regularly lobbies delegates at UNFCCC meetings. However, the United Nations Environment Programme (UNEP) has warned that biochar is a 'a new and poorly understood technology', that feedstock for large-scale biomass is likely to come from 'biofuels' (agrofuels), i.e. dedicated tree and crop plantations which "should be approached with great caution" and that the impacts on biodiversity and long-term agricultural sustainability are unknown.[72] When the IPCC finalised its Fourth Assessment Report, it did not find sufficient evidence to reach any conclusion about biochar. UNCCD's claims about IPCC support for biochar, contained in their recent submissions to UNFCCC are therefore incorrect.

The IBI argues that applying charcoal to soil creates a reliable and permanent 'carbon sink' and mitigates climate change. It also argues that biochar makes soils more fertile and better able to hold water, thus helping farmers adapt to climate change. Proposals for 'climate change mitigation' with biochar involve such large quantities of biomass that at least 500 million hectares of dedicated plantations would be required, as well as agricultural land and forests being stripped of so-called 'residues'. As the experience with agrofuels shows, the creation of a large new market for biomass can be expected to move the 'agricultural frontier' (including tree plantations) further into forests and other ecosystems, causing agricultural intensification leading to more nitrous oxide emissions, as well as displacing communities and food production. The overall impacts on climate, the environment and on people of such increased demand for land and biomass are likely to undo any possible but unproven benefits from small-scale use.

Studies by leading IBI members themselves, point to high levels of uncertainty regarding the claims made about biochar, due in large part to a lack of rigorous scientific field studies. This applies also to small-scale biochar use.

Is biochar carbon negative?

Biochar lobbyists describe bioenergy with biochar production as 'carbon-negative.' This is based on a belief that biomass burning is carbon neutral or close to it, i.e. that it results in no significant greenhouse gas emissions since emissions during combustion are supposedly offset by new growth. Such a belief ignores the wider level impacts associated with the conversion of large areas of land and thus, directly or indirectly, the destruction of ecosystems which are essential for regulating the climate. Where "wastes and residues" are used, the impacts on climate and ecosystems of removing these crucial amounts of organic matter from soils are ignored, even though there is little 'waste' available for biochar anyway. Given the climate impacts of ecosystems conversion and forest and soil degradation, any large scale demand for biomass cannot reasonably be considered carbon neutral. Biochar advocates, however, tend to ignore this and further claim that the carbon contained in biochar will permanently remain in soils and that the technology can therefore be considered carbon negative because it would sink CO_2 from the atmosphere. Both the carbon neutral and the carbon negative assumptions are highly dubious. Indeed a recent article by Timothy Searchinger et al, published in Science[73] illustrates the reasons: "The accounting now used for assessing compliance with carbon limits in the Kyoto Protocol and in climate legislation contains a far-reaching but fixable flaw that will severely undermine greenhouse gas reduction goals"

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.[74] 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.

What is known about the impact of charcoal on soil fertility and carbon sequestration?

While carbon in charcoal can remain in soil for long periods, it can also be lost within decades, a few years, or even faster. Soil scientists consider black carbon from fires to be at least comparable to black carbon in biochar. Charcoal residues from wildfires and other sources have been found in soils which date back thousands of years, for example in the North American prairies, in Germany and Australia. It is therefore certain that some carbon in charcoal can - under certain circumstances that we do not yet understand - be retained in soils for thousands of years. Eventually however, it will be released as CO_2 and warm the atmosphere. The fact that some carbon from charcoal

71 For membership of the IBI Board and Science Advisory Committee see http://www.biochar-international.org/about/board

72 UNEP (2009):The Natural Fix? The role of ecosystems in climate mitigation. http://www.unep.org/publications/search/pub_details_s.asp?ID=4027

73 Searchinger, T et al, Fixing a Critical Climate Accounting Error", 23rd October 2009, Science, Vol. 326. no. 5952, pp. 527 - 528

74 Lehmann et al. (2003): Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: fertilizer, manure and charcoal amendments. Plant and Soil 249: 343-357; and Steiner et al. (2007): 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 291:275–290; based on the same field experiment near Manaus.

remains in the soil however, does not mean all or even most of it will.

Black carbon 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.[75] Johannes Lehmann, Chair of the IBI Board, claims that only 1-20% 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.[76] Yet one study about the fate of black carbon from vegetation burning in Western Kenya suggests that 72% of the carbon was lost within 20-30 years.[77] Furthermore, in a recent (unpublished) study[78] researchers were unable to show that soil in old forests which have burned regularly over centuries hold more black carbon than soils from young forests which have not experienced repeated burning. The authors speculate that the black carbon could have oxidised (and thus entered the atmosphere as CO_2) during subsequent fires, or alternatively could have been distributed more widely instead of having been lost from the soil. The 'missing' black carbon could of course have been transported outside the area. However, a study which looked at a global black carbon budget found that far more black carbon in charcoal must be produced through wildfires than can be found in soils or in marine sediments.[79] An open question is also how biochar has different impacts in 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 organic or synthetic fertilizers.[80] In other words: there could be a trade-off between biochar which can raise soil fertility and biochar which can sequester 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.[81] Conceivably, if biochar was applied to large areas of land, these microbes might multiply and break down black carbon more easily than currently occurs; others might adapt.

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 were lost which the authors concluded must have been soil organic carbon. They suggest that the biochar would have stimulated greater microbial activity which would have degraded soil organic carbon and have caused it to be emitted as carbon dioxide.[82]

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 carbon dioxide emissions.[83] The authors hypothesized that this effect would normally be offset by greater plant growth adding new carbon to soils; however during the study no plants were grown. Although some studies suggest that charcoal additions can reduce nitrous oxide emissions, the evidence on this is neither conclusive nor consistent. [84]

Is charcoal a fertilizer?

Ash from swidden (so-called slash-and-burn) agriculture holds nutrients and minerals that can boost plant growth, but soils treated in this manner are depleted after one or two harvests. Fresh biochar also contains some ash and biochar proponents recognise that nutrients and minerals are quickly depleted, but maintain that biochar can nonetheless improve yields by enhancing the uptake of nutrients from organic or synthetic fertilizers, improving water retention and encouraging beneficial fungi. This has been proven for *terra preta*, however the evidence for modern biochar is, yet again, inconclusive. In some cases, biochar can inhibit rather than aid beneficial

75 Cheng C., Lehmann J.C., Thies J.E., Burton S.D. & Engelhard M.H. (2006): Oxidation of black carbon by biotic and abiotic processes, Organic Geochemistry 37:1477-1488.

76 Lehmann et al. (2008): Stability of black carbon/biochar. presentation at SSSA Conference, October 2008; http://www.biochar-international.org/images/Lehmann_Biochar_ASA2008.pdf

77 Nguyen et al. (2003): Long-term black carbon dynamics in cultivated soil. Biogeochemistry 89: 295-308.

78 Lorenz et al. (2008): Black carbon in seasonally dry forests of Costa Rica. presentation at SSSA Conference, October 2008

79 C.A. Masiello (2004): New directions in black carbon organic chemistry, Marine Chemistry 92

80 Novak et al. (2008) Influence of pecan-derived biochar on chemical properties of a Norfolk loamy sand soil. presentation at SSSA Conference, October 2008.

81 Hammer U., Marschner B., Brodowski S. & Ameung, W. (2004): Interactive priming of black carbon and glucose mineralisation. Organic Geochemistry 35: 823-830.

82 Wardle D.A., Nilson M.Ch. & Zackrisson O. (2008): Fire-Derived Charcoal Causes Loss of Forest Humus. Science 320(5876): 629; also see comment by J. Lehmann & S. Sohi, 10.1126/science.1160005 and authors' response. 10.1126/science.1160750; http://www.sciencemag.org/cgi/content/abstract/320/5876/629

83 Rogovska *et al.* (2008): *Greenhouse gas emissions from soils as affected by addition of biochar.* presentation at SSSA Conference, October 2008. http://www.biochar-international.org/images/Rogovska_et_al.pdf

84 Reijnders L. (in press): *Are forestation, bio-char and landfilled biomass adequate offsets for the climate effects of burning fossil fuels?* Energy Policy: doi:10.1016/j.enpol.2009.03.047

Box 6: *Terra preta*

Terra preta is now being overexploited and, since the indigenous practices which created it have largely been lost, we lack the knowledge of how create it or to maintain its fertility, nor can we assume that successful practices in a particular context can be transferred elsewhere.

Agrobiodiversity and the use of diverse organic residues were almost certainly important aspects of the sustainability of the terra preta system. Because of the fertility of the soils and the centuries of agricultural practices by indigenous peoples, a special ecosystem has developed at Amazonian Dark Earth (ADE) sites. The biodiversity of the soil itself appears to be unique as well. Recent evidence revealed a distinct and unique microbiological diversity associated with ADE. The specific habitat in ADE supported and preserved micro-organisms that are absent in surrounding ecosystems.

However, also ADE degrades, and it appears from the limited data currently available that after 10-40 years of intensive exploitation ADE soils lose their high nutrient availability and some of their organic carbon and become unproductive.[1]

1 FAO: terra preta - Amazonian Dark Earths (Brazil). http://www.fao.org/nr/giahs/other-systems/other/america/terra-preta /detailed-information2/en/; accessed 24 August 2009

fungi.[85] Furthermore, the lack of long-term field studies means that there is little evidence extending beyond the initial period when charcoal still retains nutrients and minerals. Even during this initial period, it has been shown that charcoal can in some cases reduce plant growth, depending on the type of biochar and the crops on which it is used.

Where biochar does increase yields - at least in the short-term - it appears to do so mainly by working in conjunction with nitrogen fertilizers.[86] Hence, companies such as Eprida are looking to add nitrogen and other compounds scrubbed from flue gases of coal power plants to the charcoal they produce. Such a technology bears little resemblance to terra preta and instead perpetuates fossil fuel burning and the use of fossil-fuel based fertilizers in industrial agriculture.

5.2. Airborne black carbon increases global warming

Although black carbon is being discussed as a carbon sink while it remains in the soil, airborne black carbon is a major cause of global warming. Proportionally, airborne black carbon has a global warming impact which, according to NASA scientist, is 500-800 times greater than that of CO_2 over a century.[87] Although it is not a greenhouse gas, black carbon reduces albedo, i.e. 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.

Biochar advocates argue that charcoal can help to reduce black carbon emissions if open cooking fires are replaced by charcoal-making stoves. However, any type of 'clean' biomass stove will reduce atmospheric black carbon emissions - not just charcoal making ones. Some also argue that biochar can reduce black carbon emissions from slash-and-burn fires by making soils permanently fertile. But as discussed above, such fertility improvements are far from proven.

Moreover, a serious concern is that some of the more finely powdered charcoal will become airborne during application and handling. On the one hand tilling biochar deep into soils could minimise biochar losses. On the other hand, tilling can damage soil structures and could cause breakdown and loss of pre-existing soil carbon. These problems are well illustrated in pictures from a study commissioned by the biochar company *Dynamotive*[88] which show large clouds of charcoal dust during transport and application. The researchers report that 30% of the charcoal was lost in this manner. The significance of airborne particles also illustrated by the fact that dust carried from the Sahara is routinely deposited in the Amazon Basin. Furthermore, biochar particles can quickly erode to a smaller size, similar to that of black soot. There is a risk of such small particles becoming airborne due to soil erosion. Even if a small percentage of the biochar that is lost becomes airborne, it would result in biochar worsening global warming irrespective of any carbon sequestration.

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85 See for example Warnock et al. (2008): Non-herbaceous biochars (BC) exert neutral or negative influence on arbuscular mycorrhizal fungal (AMF) abundance. presentation at SSSA Conference, October 2008. http://www.biochar-international.org/images/Warnock_SSSA_2008_Biochar_Presentation_V._1.pdf

86 See for example Chan K.Y.,Van Zwieten L., Meszaros I., DownieA. & Joseph S. (2007): Agronomic values of greenwaste biochar as a soil amendment. Australian Journal of Soil Research 45: 629-634.

87 See: Bond T.C. & Sun H. (2005): Can Reducing Black Carbon Emissions Counteract Global Warming? Environmental Science & Technology 39: 5921-5926;and James H., Sato M., Kharecha P., Russel G., Lea D.W. & Siddal M. (2007): Climate Change and Trace Gases. Philosophical Transactions of the Royal Society 365(1856):1925-1954.

88 Husk B. (2009): Preliminary Evaluation of Biochar in a Commercial Farming Operation in Canada. Study by BlueLeaf Inc. http://www.blue-leaf.ca/main-en/report_a3.php

5.3. The myth of 'sustainable' small-scale biochar

Several biochar advocates and companies, such as Carbon Gold, now promote 'small-scale' biochar, particularly from 'waste and residues', perhaps at least partly in response to growing concerns about the move towards large-scale industrial production. The image of small-scale organic, permaculture-type biochar is part of a public relations strategy by the IBI. Biochar marketing company *Genesis Industries* (eGen) openly speaks about strategies for 'guerilla marketing' through a 'green' image and defines the key marketing slogan: "to help the small farmer gain greater financial security through increase in productivity and carbon credits, to feed the poor and starving, reduce carbon dioxide in the atmosphere and provide conservation for endangered species". Yet the aim of this strategy as they explain on the same page is to "help owners of Eprida [pyrolysis] machines market wholesale and retail products utilising the power of our technology."[89] Thus their website shows that this company regards the message that biochar will be of value to small farmers as an essential part of a commercial marketing strategy.

However, the picture regarding soil fertility and carbon in soils is the same regardless of the scale at which biochar is used.

A simple calculation shows why the idea of farmers and gardeners improving the fertility of their land with biochar is problematic, particularly in the case of DIY biochar[90] which is especially inefficient: it tends to convert just 10-20% of the biomass carbon into charcoal with the remainder being emitted as carbon dioxide, often without capturing any bioenergy. Exceptions are charcoal-making stoves, where the energy is used for cooking and up to 30% of biomass carbon is kept as charcoal. 50% conversion of biomass carbon to biochar is the maximum, possible only in larger more expensive pyrolysis plants. Between 4 and 20 tonnes of dry wood (more of other biomass) would thus be needed to create one tonne of biochar. Users of biochar cooking stoves would always have to collect more wood or biomass than they would require for cooking with an efficient biomass stove that uses all the energy for heat. In studies which have shown short-term soil fertility benefits from biochar, some 10-20 tonnes of charcoal were added to one hectare, as well as organic or synthetic fertilizers. This is far more than could be obtained from residues. For example, an industry estimate of corn stover is that one hectare yields around 5.66 tonnes of corn stover[91] annually, but only 2.83 tonnes which could be safely harvested.[92] Clearly, therefore, any (short-term) fertilisation with biochar would require residue removal over a much larger area than the land to which biochar is applied as well as the use of other fertilizers. On a larger scale, it would require dedicated plantations. In addition farmers would lose the option of using residues as animal feed or for other purposes. Stripping the soil to char organic residues is likely to leave farmers with increasingly depleted soils and is fundamentally different from the approach used by the farmers who created *terra preta* .

Finally, both large and small scale biochar carries a risk of pollution: Charcoal dust is a cause of pneomococoniosis, a potentially fatal lung disease.[93] Furthermore, some biochar projects, for example in Ethiopia, Ghana and Senegal, involve charring rice husks, yet dust from rice husk ash is linked to silicosis, also a progressive and in some cases fatal lung disease.[94]

5.4. Large scale biochar

Biochar advocates claim that they do not advocate deforestation for biochar plantations. However, the 1 billion tonnes of carbon sequestration per year quoted as a 'lower range' to address climate change make further pressure on ecosystems and land inevitable. Johannes Lehmann (IBI) for example states that the greatest potential would come from dedicated crops and trees,[95] and a discussion at the 2008 IBI Conference suggested that plantations would be required for scaling up biochar.[96] Advocates and companies promoting agrofuels also claim that they do not recommend practices that drive deforestation or degradation of ecosystems. Such impacts are well known to occur directly as well as indirectly. Meanwhile, demand for agrofuels is moving the agricultural frontier further into tropical forests, destroying remaining biodiversity, leading to the displacement and eviction of growing

89 Genesis Industries: Marketing Your CO_2 Neg products. http://www.egenindustries.com/Marketing_your_CO2_Negitive_Products.php, accessed 19.8.2009

90 Numerous DIY manuals for small scale biochar can be found online, and related photos and blog postings show how (inadvertently) problems are caused by faulty set-ups. See for example http://www.biocharfertilization.com/ or http://www.instructables.com/id/Make_your_own_BioChar_and_Terra_Preta/

91 Corn stover is the leaves and stalks of maize left on the field after harvest, similar to straw.

92 Agriculture and Agri-Food Canada: Corn Stover. www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1226595533096&lang=eng accessed 19.8.2009

93 Baveye, P. (2007): Soils and runaway global warming: Terra incognita, Journal of Soil and Water Conservation, Nov/Dec 2007

94 Liu S. (1996): Silicosis caused by rice husk ashes. Journal of Occupational Health 38(257): 62

95 Lehmann J., Gaunt J. & Rondon M. (2006): Biochar sequestration in terrestrial ecosystems. Mitigation and Adaptation Strategies for Global Change 11: 403–427.

96 IBI (2008): IBI Conference 2008; Session D: Biochar and bioenergy from purpose-grown crops and waste feedstocks/waste management. http://www.biochar-international.org/images/IBI_2008_Conference_Parallel_Discussion_Session_D.pdf

numbers of indigenous peoples, small farming communities and displacing food production.

Agrofuels and biochar can be produced from biomass using the same processes (pyrolysis). Together biochar and agrofuel provide a potent means of further accelerating the destruction already caused by agrofuels alone. This was - and still is - the major concern behind a declaration “Biochar: A new big threat to people, land and ecosystems” signed by over 150 organisations since April 2009.[97]

6. Industrial livestock production: Intensification is not an option

Livestock farming is a major producer of greenhouse gases: It is responsible for nearly 80% of all agriculture-related emissions and represents a larger share (18%) of total human-related emissions than transport (14%).[98] 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,[99] but they exclude the high carbon emissions that stem from clearing forests and other ecosystems to raise livestock. The Food and Agricultural Organisation (FAO) points out the fact that livestock’s real contribution to greenhouse gas emissions is even higher than the figures suggest due to the difficulty of estimating emissions from livestock-related land use changes.[100] Most of the deforestation in the Amazon is caused by clearance for cattle pasture, nearly 80% according to a recent Greenpeace report.[101]

As a result, it is hardly surprising that considerable attention is focused on the greenhouse gas footprint of livestock farming. The particular greenhouse gases from livestock farming include 65% of the total emissions of nitrous oxide, 64% of the ammonia, 37% of the methane[102] and 9% of the carbon dioxide.

However, proponents of industrial farming are now claiming that extensive livestock keeping is harming the climate and propose a further intensification of industrial livestock production. They claim that intensification and enclosure means emissions can be captured in factory farms and biogas can be used to produce energy. They also propose further increasing output per animal or per kg of feed, and bringing cattle from pastures into feedlots as solution. But is this credible?

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. Feeds derived from grains that could be consumed by people, and that are transported over long distances, have replaced locally available feed, like grass, other roughage and nutrient-rich waste from farms and households. From the beginning industrial livestock farming has caused water, soil and air pollution and seriously compromised animal health and animal welfare. These problems remain largely unsolved. Aquaculture will add to the headaches, as it increasingly turns to the same feed resources as livestock.

6.1. Greenhouse gas emissions from livestock

Methane from enteric fermentation and manure

Methane resulting from enteric fermentation of ruminants is often presented as the main livestock/climate problem, and a range of solutions are being proposed for further investigation. It is suggested that ruminants like cattle, sheep and goats should be vaccinated to produce less methane. Or, that the methanogenic bacteria in their rumen should be (genetically) modified. This would alter the 80 million year old process in which methane is produced in the rumen by bacteria belonging to the Archaea, one of the scientifically least understood group of bacteria. The leading research into these ideas currently takes places in New Zealand and Australia - countries whose interest in increased exports of meat and milk makes it difficult to reduce national emissions.

However, while manure deposited on fields and pastures, or otherwise handled in a dry form, does not produce significant amounts of methane, factory farms that produce manure in liquid form are releasing 18 million tonnes of methane annually.[103] These emissions amount to only a fraction (3%) of the total methane emissions but - in today’s critical situation - even this amount is important. But instead of reducing these emissions are bound to double soon. China where half of the world’s

97 Declaration: ‘Biochar’, a new big threat to people, land, and ecosystems. 26.3.2009; http://www.regenwald.org/international/englisch/news.php?id=1226

98 Steinfeld H., Gerber P., Wassenaar T., Castel V., Rosales M. & de Haan C. (2006): Livestock's long shadow. Environmental issues and options. FAO, Rome.

99 90% of soya is used to produce animal feed.

100 Steinfeld et al. (2006): Livestock's long shadow. Environmental issues and options. FAO, Rome.

101 Greenpeace (2009): Slaughtering the Amazon. updated report, July 2009. http://www.greenpeace.org/raw/content/international/press/reports/slaughtering-the-amazon.pdf

102 Mining of fossil fuel (incl coal) produces a similar amount of methane emissions than livestock. See pie chart on http://icp.giss.nasa.gov/education/methane/intro/cycle.html

103 Steinfeld et al. (2006), p. 97

pigs are kept, is currently replacing smallholder systems by factory farms. Dairy production in China is increasing by around 15% annually.

The half-life of methane in the atmosphere is only around seven to eight years, as compared to at least 100 years for CO_2, which means that the potential for mitigating climate change by reducing the demand for livestock is very high.

Industrial livestock is the leading emitter of nitrous oxide

Nitrous oxide is very persistent in the atmosphere where it may last for 150 years, and nitrous oxide is the most potent of the three major greenhouse gases, with almost 300 times the global warming potential of carbon dioxide. Livestock, with 65% of total nitrous oxides is the leading emitter. However, while the nitrogen cycle is out of balance when using feed grains grown with chemical fertilizer (an essential feature of industrial farming), this is not so in extensive livestock keeping.

Nitrogen plays a key role in the functioning of ecosystems and the cycling of carbon and soil minerals. Traditionally nitrogen for crop production has come from various sources, including nitrogen-fixing bacteria that live in the roots of leguminous plants and manure. Animals are inefficient nitrogen users and excrete high levels of nitrogen, in the form of nitrous oxide. The nitrogen cycle gets out of balance when feed is grown using chemical fertilizers, as about half of the synthetic nitrogen is not absorbed by the plants and this excessive nitrogen pollutes ecosystems.[104] As a result of continuing chemical fertilizer additions, the level of atmospheric nitrous oxide is increasing.

Most extensive livestock systems are more climate friendly and offer useful synergies. In contrast to the above, when animals are fed on feed grown without chemical fertilizer, and their manure returns to the soils, their nitrogen inefficiency has no negative impact on the environment – the nitrogen cycle is kept in balance.[105] Moreover, manure benefits soil fertility, its water retention capacity and its organic matter content that is essential to prevent soil degradation.

Extensive livestock keeping maintains a major carbon store: Grasslands

Moreover, most extensive 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. Grasslands cover over 45% of the earth's land surface - 1.5 times more than forest. Whilst forests may add only about 10% to their total weight each year, savannas can reproduce 150%of their weight annually. Tropical savannas have a greater potential to store carbon below ground than any other ecosystem.[106] Animals and grasslands have evolved together–Ruminants like cattle, goats, sheep, buffaloes and camels turn roughage into food for humans while seasonal grazing clearly contributes to biodiversity. It is a virtuous circle: biodiversity is enriched, a major CO_2 sink (grassland) is maintained and a valuable food is created. Traditional pastoralists have, at times, been accused of overgrazing but major environmental organisations, including IUCN,[107] are now challenging this assertion and call for better regulatory support for mobile systems of grazing, such as pastoralism and transhumance. Grasslands so far lack advocates. It was only when Wetlands International informed the public about the amount of carbon stored in peatlands, after the first biofuel plantations were set up in Indonesia, that the international climate community realized that peatland destruction must be stopped. We now need advocacy for grasslands/pastures.

6.2. Industrial aquaculture hastens climate change

Aquaculture is promoted as a climate-efficient user of feed. The feed industry claims that it only takes 2 kg of feed to produce 1 kg of live fish, while poultry requires 3 kg and cattle 8-10 kg. However, the feed resources promoted by industrial aquaculture are unsustainable. In the North, 70% of fish farms require fish meal and fish oil. Depletion of small pelagic fish for fish meal and fish oil has fundamentally disturbed the oceans' food web. Because pelagic fish supplies cannot be increased, fish farms are using more and more grains, turning to the same climate damaging feed as industrial livestock farming. Also in Asia, where 80% of global aquaculture production takes place, industrial feed is increasingly replacing local resources. Industrial fish farming has probably already created worse problems than livestock factory farms.

Take, for instance, salmon fish farms. The newly established and highly intensified industry in Chile has already broken down due to a pest (salmon lice) and a virus disease (Infectious Salmon Anaemia, ISA). Similarly, recurrent disease outbreaks in shrimps have caused economic problems to smallholders in Asia. For example, 80% of shrimp farmers in Thailand are now indebted. The growing numbers of farmers in Vietnam who export Pangasius catfish scarcely manage to cover their costs. Moreover, their communities' natural

104 Steinfeld et al. (2006), p. 103

105 Steinfeld et al. (2006)

106 Davies J. & Nori M. (2008): Managing and mitigating climate change through Pastoralism. Policy Matters, October 2008

107 IUCN/World Initiative for Sustainable Pastoralism (WISP)(2008): Misconceptions surrounding pastoralism. accessed 20.5.2009; http://www.iucn.org/wisp/whatwisp/why_a_global_initiative_on_pastoralism_/2313/Misconceptions-surrounding-pastoralism

resources, the mangroves, have been destroyed. Thus, "intensive" industrial fish production said to be climate efficient due to a low feed conversion rate, is not only using feed that either heats the climate (as does grain grown with chemical fertilizers) or depletes the marine food web (as does pelagic fish fed to shrimps and salmon), but also is economically questionable due to diseases, and is destroying local resources and livelihoods.[108]

Industrial livestock intensification is not an option

Industrial intensification as a mitigation approach is just a call for more of the same in policy terms. Those who only have a hammer will only look for nails, as Dennis Meadows, an author of the Club of Rome's *Limits to Growth*[109] put it. The new biotechnologies for "genetic improvement" seek increased uniformity of the animals within even shorter time periods. They are aiming at higher selection intensity (e.g. DNA marker-assisted selection), shorter generation intervals (e.g. 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, more problems with 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.[110]

Proponents claim that intensification and enclosure means emissions can be captured in factory farms and biogas can be used to produce energy. Indeed, Clean Development Mechanism (CDM) financing is available and has already been used in several dozens of registered projects in Brazil, Mexico, the Philippines and elsewhere. However at least in Mexico, the biodigesters have experienced many technical difficulties that place their future viability and continued development in question.[111] Moreover, they are only merely helping to justify industrial livestock production. More climate damaging feed will be fed, high nitrous oxide emissions will persist, as will all the other unsolved environmental, economic and social problems.

6.3. Pressurising smallholders instead of reducing over-consumption?

Wrongly, pastures or extensive livestock production are discussed as being less climate friendly than intensive industrial production because of their higher emissions per unit product or also per animal. Henning Steinfeld of FAO argued during UNFCCC climate talks in June 2009 in Bonn that it would be more climate friendly to produce a litre of milk in the US than in India. After all, the increasing world population would be demanding and entitled to more animal products. However, while an Indian citizen's consumption of animal products is limited to around a litre of milk per day (plus occasional egg or fish), a US citizen consumes a pound of meat (plus egg or fish) in addition to his milk products. Consumption patterns are closely connected to the production system.

Consuming an unlimited amount of meat, milk and eggs should not be a development goal supported by tax breaks, subsidies, externalized costs or favourable regulations, especially in times of climate change. Moreover, contrary to a widespread belief, animal products are not essential for a healthy diet and for good reasons FAO does not recommend a minimum intake. Instead consumption is considered far too high in most industrialized countries and is a major cause of 'diseases of civilization'.

Whether red meat, white meat or fish are best for the climate is often discussed but this is not the question that needs to be addressed. The real question is how to minimize their consumption and how to reduce their unsustainable industrial production in which livestock are fed on grain (which could, incidentally, be eaten by people), instead of on roughage or waste. The "productivity" of poultry, pig and cattle has been increased to such an extent and the range of varieties and breeds in commercial use so restricted that their genetics are depleted, their health depends on "biosecurity"[112] and antibiotics, and their overall welfare has been compromised to a level that is unacceptable to most people - even those who consume factory farm products. Prices for animal products that reflected the real costs would address unreasonable consumption.

According to the FAO, 70% of the poor keep livestock which are not only a source of food and income, but also a source of textiles, fertilizer, draught power, status, credit and cultural identity. A policy of further industrialization may negatively affect the smallholders in many ways. Examples are the export orientation of Brazilian animal health regulations, or the adverse impact on smallholders of Avian flu regulations, where

108 Gura S. (2009): Supporting Global Expansion of Aquaculture. The new strategy of the European Commission. In World Economy and Development 3/May-Jun 2009

109 Meadows D.H., Meadows D.I., Randers J. & Behrens III W.W. (1972): The Limits to Growth. A Report to The Club of Rome

110 Gura, S. (2009): Corporate livestock farming: A threat to global food security. In: Third World Resurgence, April 2009

111 Lokey E. (2009): The status and future of methane destruction projects in Mexico. In: Renewable Energy 34, 566–569

112 "Biosecurity" is a term coined by the livestock industry for (structural or organisational) provisions to keep disease out of factory farms. Biosecurity generates an increasing part of the production cost.

smallholders' animals remained healthy while carrying disease vectors and were therefore culled in order to protect weak industrial breeds from infections. All these factors have led to pressures on smallholders keeping livestock. Younger people often turn away from livestock keeping because of adverse policies.[113]

Conclusion

The excessive number of industrial livestock today are accelerating climate change and their products are helping to make one billion people obese. Livestock development must be based on its positive interaction with ecosystems, providing services along with produce, not based on the subsidized pursuit of ever increasing productivity per unit product or animal. Indeed, faster livestock growth and lower feed conversion ratios have been achieved over the past decades. However, subsidies, tax breaks, cost of epidemic control, and the huge externalized cost of environmental destruction and certain diseases of civilization have led many to the conclusion that there is no such thing as cheap meat. Moreover, local feed and roughage is increasingly replaced by feed grain grown with chemical fertilizer, the source of most anthropogenic nitrous oxide emissions. Climate efficiency claims for industrial methods are untenable in view of the production levels required to allow projected populations to eat as many animal products as they are assumed to desire.

Contrary to a widespread belief, animal proteins are not an essential part of a healthy diet. Removing most of the animal products from the Northern diet has become an imperative. Policy makers have not yet investigated its viability, but consumers have started its implementation. When seen from the climate perspective, food from industrial livestock has low quality and status, inferior to plant foods.

Grasslands are a major carbon sink and have evolved to co-exist with livestock. It would be a climate policy mistake to allow destroying grasslands for more crop land for more feed for ever more livestock. Far fetched proposals like changing the bacteria that help to turn grass into food within the ruminants' stomachs aim at reducing methane emissions, but will not reduce the number of cattle, excessive Northern consumption and the destruction of grassland as well as other carbon sinks. Climate damaging feed would still be used, high nitrous oxide emissions would persist (even if “nitrification inhibitors” would remove some), as would all the other nvironmental, economic and social problems caused by industrial livestock. Intensification is not an option.

113 Gura S. (2008): Industrial livestock production and its impact on smallholders in developing countries. Report to the League for Pastoral Peoples and Endogenous Livestock Development, www.pastoralpeoples.org

7. Can genetic engineering and the new “bioeconomy” provide solutions to climate change?

We are used to seeing genetically modified (GM) crops as an issue of biosafety and biodiversity protection, discussed under the Convention on Biodiversity and its Cartagena Protocol on Biosafety. However, genetic engineering is also being promised as a solution to some of the issues of climate change adaptation and mitigation. Furthermore, technologies related to it, such as genome sequencing and synthetic biology, go beyond what we have hitherto understood as genetic engineering. In addition, synthetic biology, also named by ETC Group as extreme genetic engineering, and promoted as a means to build novel organisms by re-assembling genetic material, is being promoted as a way to produce next generation agrofuels. More than this, it is advocated to assist in the development of a new bioeconomy, based on the increasing substitution of fossil fuels with non-fossil biological material, to address climate change and oil depletion.

The basic message as currently repeated by biotechnology and agrochemical companies goes something like this:

> Population is predicted to rise by 50% to some 9 billion by 2050, so we must increase food production by 50-100% in order to meet new aspirations for meat consumption. In addition, we face climate change and peak oil so we need to produce an increasing proportion of energy and fuels, including first and second generation agrofuels, from biomass. However, there are insufficient natural resources including land and water for this expansion, so we must produce and harvest more from each hectare of cropland and forest. For this we need crops with increased yields. At the same time, we must also respond to climate change so we need plants that can flourish in conditions of greater extremes of weather, heat, flood and drought. Because much land is saline, due to irrigation and flooding, we also need salt tolerant crops. Since synthetic nitrogen fertilizer in particular is energy intensive to produce and since not all of it is taken up by the crop plants, resulting in N_2O greenhouse gas emissions and nitrate leaching, biotech research also needs to develop crops that are capable of fixing their own nitrogen.
>
> In the area of energy production, we need to move away from fossil oil and must find an alternative source for all the products it yields, from fuels to plastics. Trees and other plants can play a major role in these developments, especially if modified in different ways

through genetic engineering and this can form a major part of a new economy, the bioeconomy. In addition a considerable amount of energy is required to break down the biomass from trees and other plants, including algae into the sugars and oils required for agrofuels and other industrial products. So we must have GM plants that will break down more easily, and genetically engineered enzymes and micro-organisms that will reduce the need for energy use, and therefore emissions, in industrial processing.

In sum, the biotech companies promise to feed the expanding human population, to replace fossil fuels and to tackle climate change through genetic engineering.[114] And if that should fail, they promise synthetic biology to custom-build micro-organisms to do it all.

The Biotechnology Industry Organisation (BIO) obviously sees the climate negotiations as an important platform and has laid out for its members the opportunities and risks involved.[115] It asserts that: “Biotechnology provides key solutions to mitigating climate change. This is our opportunity to make those solutions more widely known, while protecting the ability of innovators to maintain intellectual property rights!” BIO has also written to Hilary Clinton emphasizing the importance of intellectual property and expressing concern lest intellectual property protection be watered down in developing countries in the name of tackling climate change.[116]

In the following chapter we will briefly explore these promises and also look more closely at the concept of the 'bioeconomy'. The claim that herbicide tolerant GM crops in non-till agriculture are already a method to fight climate change is discussed in chapter 4.

114 For example: Monsanto (2009): Sustainable Agriculture. website, accessed 17.5.2009, http://www.monsanto.com/responsibility/sustainable-ag/default.asp; Syngenta (2009): Syngenta calls for greater international collaboration to address food security challenge. press release 21.4.2009,http://www.syngenta.com/en/media/mediareleases/en_090421.html; DuPont (2009): Welcome to DuPont biotechnology. website, accessed 17.5.2009, http://www2.dupont.com/Biotechnology/en_US/; Bayer (2009): Bayer CropScience calls for a "Second Green Revolution", press release, 17.4.2009; http://www.bayercropscience.com/BCSWeb/CropProtection.nsf/id/EN_20090417_1?open&l=EN&ccm=500020

115 BIO (2009): BIO Climate Change Convention Action Plan. 6.8.2009. http://www.nzbio.org.nz/page/industry-reports.aspx and http://www.nzbio.org.nz/portals/3/files/BIO%20updated%20action%20plan-UNFCCC.pdf

116 BIO (2009): Letter to US Secretary of State H. Clinton. 1.6.2009. http://bio.org/ip/international/documents/BIOLetterReUNFCCC6_2009.pdf

7.1. 'Climate-ready' crops and crops with higher yields

Increased yields

In response to the argument touched on above that there is insufficient land to feed a growing population with higher expectations, ever more intensive forms of agriculture are proposed while extensive or agroecological agriculture is often dismissed as having high emissions and low productivity.

At the same time there is competition for agricultural land for the production of animal feed (which already uses one third of cultivated land) and agrofuels. Under the scenarios projected by agribusiness, the demand for both is set to rise much further. This in turn will require new (agricultural) land on a large scale which is not available without extending agricultural production into so-called 'marginal land' (see chapter 8) or by intensifying food/feed production so that it can take place on fewer hectares.

Over the last 10 to 15 years, there have been attempts to develop GM crops for higher yield, but to date, no such crop has been proposed for commercial use, and little scientific information is available on how such yield increases could be achieved.[117]

Nevertheless, the biotech industry regularly claims that currently available genetically modified (GM) crops already show increased yield, even though their GM traits are herbicide tolerance and insecticide (Bt) production in soya, maize (corn) and cotton. However, careful examination shows that this is not the case. For some GM crops, such as herbicide tolerant soya,[118] even *lower* yields compared to conventional varieties have been observed.[119] It is also important to distinguish between actual (*intrinsic*) yield increase due to greater productivity from the plant and *operational* yield increase, brought about by a reduction of loss from pests and diseases or improved farming practices. The Union of Concerned Scientists notes in its recent report *Failure to Yield*[120] that “no currently available transgenic varieties enhance the intrinsic yield of any crops” and attributes rises in intrinsic yield to conventional breeding. On the other hand reduction of operational yields has been observed in cases when the GM trait ceased to work effectively, especially with the development of herbicide-resistant weeds. (For the

117 Steinbrecher R.A. & Lorch A. (2008): Feed the World? The Ecologist, Nov. 2008: 18-20.

118 RoundupReady (RR) soya, tolerant against glyphosate

119 Steinbrecher R.A. & Lorch A. (2008): Feed the World? The Ecologist, Nov. 2008: 18-20.

120 Gurian-Sherman D. (2009): Failure to Yield: Evaluating the Performance of Genetically Engineered Crops. Union of Concerned Scientists;http://www.ucsusa.org/food_and_agriculture/science_and_impacts/science/failure-to-yield.html

example of herbicide tolerant cotton and soya, see boxes 4 and 5.)

Abiotic stress tolerance

Most crops are restricted by temperature, water availability, day length, and seasons etc. as to where they can grow. Genetic engineering has already been promised as an option for modifying plants to grow under less favourable conditions in order to extend acreage or produce on depleted or marginal soils. Even though these promises have failed to materialize so far, they are now repeated in the context of climate change for food/feed crops and for plants for other purposes.

Abiotic stress tolerance: For many years the biotech industry has promised salt, heat, flood and drought tolerant crops to deal with soil and water degradation due to land-use change, over-exploitation and industrial monocultures. Climate change has intensified the focus on abiotic stress tolerance in crops, but this does not mean that stress tolerant GM crops are the solution. Abiotic stress tolerance can also be developed through conventional breeding and already exists in some locally adapted crop varieties.[121]

The current generations of herbicide tolerant and insecticide expressing (Bt) crops are modified to produce an additional protein, and even that cannot be done precisely, with unexpected effects. Projected new GM traits like stress tolerance involve complex interactions among many genes and molecular signal pathways. Indeed, the simple equivalence between a gene and a trait is the exception rather than the rule, and the interactions between (groups of) genes, proteins and chemical compounds involved in conferring abiotic stress tolerance are neither fully understood nor predictable. Even when single genes are identified that are correlated with stress tolerances, this is still a long way from actually being able to develop and test a GM plant.

According to Osama El-Tayeb, Professor Emeritus of Industrial Biotechnology at Cairo University

> “transgenicity for drought tolerance and other environmental stresses (or, for that matter, biological nitrogen fixation) are too complex to be attainable in the foreseeable future, taking into consideration our extremely limited knowledge of biological systems and how genetic/metabolic functions operate.”[122]

Altered temperature/geographic range is meant to enable plants to grow outside their usual climatic conditions and regions; for example cold-tolerant eucalyptus trees. The dangers of such an approach have not yet been assessed but since eucalyptus is an invasive species, there is a risk of extending its capacity to invade and disrupt ecosystems by displacing native species and because it is highly flammable and thus increases wildfire risks. GM trees and other plants growing in a new environment are likely to interact unpredictably with other organisms, including pests.[123]

Converting C3 plants into C4 plants: In brief, C4 plants such as maize, sugarcane and millet are considered to photosynthesise, tolerate heat and use water more efficiently than C3 plants (e.g. potato, rice, wheat and barley), and therefore might be adapted better to climate change conditions. Yet conversion from C3 to C4 would involve modifying the complex photosynthetic system of the plant, which again is not yet fully understood.

Nitrogen and other fertilizers

Plants need nitrogen to grow but in general are quite inefficient in taking it up through their roots. At the same time soils under constant cultivation become depleted of nitrogen. This is even the case with plants known for their ability to fix nitrogen in the soil (like soya and other leguminous plants) if these plants are cultivated intensively and without appropriate crop rotation. On the other hand the production and application of nitrogen and other fertilizers has been identified by the Intergovernmental Panel on Climate Change (IPCC) as the main cause of anthropogenic nitrous oxide emissions.[124] (see chapter 4). This is because the manufacture of nitrogen fertilizer is energy intensive and nitrous oxide emissions from the soil due to the failure of plants to absorb applied nitrogen are also high.

Enhanced uptake and utilization of nitrogen is meant to enable plants to make full use of all the nitrogen present in the soil, no matter whether these are nutrient poor or strongly fertilized soils. While such plants were already projected in the late 1980s, none of them have

121 Practical Action (2009): Biodiverse agriculture for a changing climate. http://practicalaction.org/?id=biodiverse_agriculture_paper

122 El-Tayeb O. (2007): Alternatives to genetic modification in solving water scarcity; email comment 28.3.2007 Electronic Forum on Biotechnology in Food and Agriculture; http://www.fao.org/biotech/logs/C14/280307.htm

123 The issue is also discussed in: Steinbrecher R.A. (2009): Cold tolerant GE eucalyptus - comments concerning field trial application in the US. Comment APHIS-2008-0059-0287 on USDA Docket APHIS-2008-0059-0001: ArborGen, LLC; Availability of an Environmental Assessment for Controlled Release of a Genetically Engineered Eucalyptus Hybrid - http://www.econexus.info/submissions and http://www.regulations.gov/search/Regs/home.html#documentDetail?R=09000064809eaf68

124 Smith K, Bouwman L. & Braatz B. (2003): N_2O: Direct emissions from agricultural soils. In: IPCC (eds): Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_5_N2O_Agricultural_Soils.pdf

been developed. Attempts to genetically modify rice and other crops for high nutrient use are still in early stages, as currently there is poor understanding of how the genes involved are regulated.

Promises for future GM crops include **nitrogen-fixing for non-leguminous plants** to reduce dependence on chemical nitrogen fertilizers. As El-Tayeb pointed out above, this trait too depends on complex interaction of several genes, and any attempts have failed so far.

Assessing the promises

Patents, confidentiality and funding for climate-ready crops: A major problem with research into new GM crop developments is that "besides general statements and website announcements, there is no information available about the scientific basis of this work."[125] Indeed Confidential Business Information (CBI) claims applied to GM techniques as well as to genes and DNA sequences reduce public access to information about novel crops and their claimed impact on climate issues. Pending patent applications have the same effect, while granted patents and other intellectual property devices limit access by scientific researchers to both information and genetic material. Yet we have seen from the preoccupations of BIO how important patents are to corporate interests. ETC group describes how the five major biotech corporations between them have filed more than 500 patents "on so-called 'climate-ready' genes at patent offices around the world."[126] In addition, agricultural research and development is increasingly carried out by the private sector, which obviously has a vested interest in monopolizing rather than sharing any inventions or discoveries they may make. All this makes it more difficult and costly to access information and material for research. Absence of information about new developments makes it hard to assess them. In a world faced with climate change, information needs to be freely and fairly shared.

In a current example - the application to release at least 150,000 GM eucalyptus trees by the company Arborgen in the US with different traits including extended geographic range[127] - basic information about the traits, genes or GM events involved was not even disclosed to the public or independent scientists, making any meaningful risk assessment impossible. At the same time such levels of secrecy mean that policy makers have only the statements of the producing companies on which to base their decisions about the potential of such approaches for climate change mitigation and adaptation.

So, while there are numerous suggestions for future GM crops to address climate change, none of them seem to be feasible at the moment. Were they to be developed, the thorough risk assessments required before the introduction of fundamentally new GM crops means that any practical application is a long way off. Concentrating on such GM crops therefore carries high opportunity costs, losing time and money that could be invested in other, more promising, already proven and less risky approaches.

Such GM crops, if developed, would also be likely to be associated with the model of industrialized, monoculture agriculture, which is where they have been most successful to date, yet this is the most fossil fuel and emission intensive type of agriculture with obvious negative effects on climate change.

7.2. Biomass production to replace fossil fuels

GM crops, enzymes and microbes for next generation agrofuels

Genetic engineering is also experimentally applied to the conversion of biomass (including whole crop plants and residues) into agrofuels and other alternatives to fossil fuels. These are also called second generation, next generation and advanced agrofuels. The aim is to use less energy in the process and reduce emissions of greenhouse gases. This is also the area for which synthetic biology is promoted. Experimental applications include:

- changing the ratio of lignin to cellulose in the biomass so that it can be more easily broken down and converted into products such as agrofuels or bioplastics. In general woody plant material is difficult to process due to its high lignin levels, and research is underway for example with poplars to reduce lignin levels in favour of cellulose levels. The risks of GM trees for global forest ecosystems is regarded as potentially very high, for example, pests are likely attack trees with reduced lignin;[128]
- GM algae to produce agrofuels, since existing algae do not offer consistent commercial yields;

125 Steinbrecher R.A. & Lorch A. (2008): Feed the World? The Ecologist, Nov. 2008: 18-20.

126 etc group (2008): Patenting the "Climate Genes"... And Capturing the Climate Agenda. Communiqué May/June 2008. http://www.etcgroup.org/en/materials/publications.html?pub_id=687

127 Steinbrecher R.A. (2009): Cold tolerant GE eucalyptus - comments concerning field trial application in the US. Comment APHIS-2008-0059-0287 on USDA Docket APHIS-2008-0059-0001: ArborGen, LLC; Availability of an Environmental Assessment for Controlled Release of a Genetically Engineered Eucalyptus Hybrid - http://www.econexus.info/submissions

128 Steinbrecher R.A. & Lorch A. (2008): *Genetically engineered trees & risk assessment. An overview of risk assessment and risk management issues.* Vereinigung Deutscher Wissenschaftler, Berlin, Germany. http://www.econexus.info/pdf/GE-Tree_FGS_2008.pdf

•GM enzymes and/or microbes for insertion into crops or for use in processing plants to promote breakdown of biomass; and

•artificial (synthetic) micro-organisms for multiple purposes.

All this work is based on the premise that fossil fuels can be replaced by agrofuels, to enable the continuation of the current paradigm of industrial development based on intensive energy use while addressing climate change. Genetic engineering biotechnology is therefore advocated to underpin this proposition. However, responding to climate change may require a far more radical change to industrialized ways of life, and we need to be turning our ingenuity to these, rather than perpetuating a model which may have reached its limits. Indeed, a study published in October 2009 by the Marine Biological Laboratory of Woods Hole in the US that seeks to project scenarios of global agrofuel programmes to the end of the 21st century, indicates that emissions caused by the direct and indirect land use changes required would be exceedingly large. Land devoted to agrofuels would exceed the area devoted to food crops by the end of the century, once more calling into question the whole basis for the argument in favour of agrofuels of any generation.[129]

Bioeconomy

The bioeconomy is a multifaceted concept primarily based on the idea of replacing finite and fossil fuel reserves with potentially infinitely so-called renewable sources of biological material. In the case of plants and trees, we are told, there is the added advantage that this raw material also sequestrates carbon as it grows. Faced with decreasing discoveries of new fossil oil reserves coupled with growing demand, rising prices and rising emissions, a wide range of corporations has begun to project a future of unlimited growth based on the new bioeconomy.

The large scale production of biomass therefore is a prerequisite of a successful *bioeconomy* - a term coined to describe attempts to understand plant processes at the genetic and molecular levels and to apply them in industrial processing. The bioeconomy also projects itself as building systems in which the waste material of one process can be used to fuel others in a way that more closely replicates how healthy ecosystems function.

The OECD, EU and US currently invest considerable intellectual and financial resources in various bioeconomy projects. EuropaBio, the European biotechnology industry association, describes *biorefineries* as the central concept of the bioeconomy:

> "A biorefinery transforms biomass derived from renewable raw materials into a wide range of commodities by the means of advanced biotechnological processes such as enzymatic hydrolysis. The biomass comes from a variety of sources such as trees, energy crops such as switchgrass and agricultural products such as grain, maize and waste products such as municipal waste. Biorefineries can produce commodities such as bioethanol, bioplastics, biochemicals and ingredients for the food and feed industry."[130]

The biorefinery concept symbolises the manner in which the pursuit of the bioeconomy brings together the interests and experience of the major agricultural and chemical industries (e.g. seed, fertilizer, pesticide, commodities and biotechnology) with the energy sector, including the oil, power and automotive industries. Other industries already based on biomass production, such as the timber and paper industries already see the possibility of using their waste materials profitably as raw materials for energy production or for reducing their own emissions.

The development of the bioeconomy therefore implies that huge areas of the planet will be turned over to monocultures of crops and tree plantations for processing in biorefineries and that forests will be far more intensively exploited in many parts of the world. Biotechnology is set to play a major role in such a scenario, however the escalating demand for woodchips and wood pellets for new industrial biomass power stations, as well as second generation agrofuels made through thermal processes are also likely to play a major role. This prioritizes the use of biomass for economic purposes over ecological purposes such as protecting biodiversity and water sources, regenerating soils with humus, retaining moisture in soils or protecting the integrity of ecosystems. Furthermore, demand is potentially limitless, as massive increases in energy consumption are predicted if we continue the current paradigm on which the bioeconomy is predicated. This is compounded by the fact that plant biomass has low energy density in comparison with the fossil fuels it is meant to replace.

The development of the bioeconomy would further extend all the well-documented impacts of industrial agriculture on soils, water, biodiversity, ecosystem

129 Melillo J.M. et al. (2009): Indirect Emissions from Biofuels: How Important? Science DOI: 10.1126/science.1180251. http://www.sciencemag.org/cgi/content/abstract/sci;1180251v1?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&fulltext=Kicklighter+Melillo&searchid=1&FIRSTINDEX=0&resourcetype=HWCIT and http://www.mbl.edu/news/press_releases/2009_pr_10_22b.html

130 EuropaBio (2009): Today's applications. Biorefinery. website, accessed 17.5.2009. http://www.bio-economy.net/applications/applications_biorefinery.html and EuropaBio (2007): Biofuels in Europe. EuropaBio position and specific recommendations. June 2007. http://www.europabio.org/positions/Biofuels_EuropaBio%20position_Final.pdf

integrity, small-scale farmers, local communities and indigenous peoples. It could signal the end of major tracts of forest and other vital ecosystems. It would certainly mean the development of still more monoculture tree plantations, likely to be genetically modified to suit the needs of industrial processing and harvested by large energy intensive machines. The demands on water supplies of such developments would be massive. Even less discussed are the challenges of moving all this biomass from where it is produced to the biorefinery, demanding road infrastructure and fleets of trucks. The proponents of biochar, which is just one small part of the proposed bioeconomy, propose that biomass can be locally processed into basic fuels and charcoal, the latter to be added to the soil. The inescapable image is of a completely cleared landscape whose forest is now underground supposedly sequestrating carbon for hundreds of years. The irony is that much of this would take place in the name of tackling climate change.

Conclusions

Some of the risks of climate-ready crops, GM plants and GM enzymes for biorefineries can already be anticipated, but many will be completely new and potentially far greater because more complex genetic engineering events will inevitably carry more complex and unpredictable risks. Already, studies show that even comparatively simple forms of genetic engineering throw up completely unexpected effects.[131] Currently risk assessment relies on assumptions of equivalence and familiarity but such a basis will not be available for microorganisms, algae, crops and trees with fundamentally different traits, different cell regulation and/or different synthetic pathways.

Regardless of whether such complex GM crops can ever be developed, they are not ready now and may not be for many years, if at all. But we need action *now* to counter climate change and to stop the destruction of biodiverse ecosystems that help to regulate climate.

There are other ways to address the problems for which GM crops are proposed as solutions, but they are in the public domain where information and experience can be shared, rather than patented and sold. Publicly funded research in agriculture has been dwindling rapidly over the last decades.[132] Naturally enough, considering how they are currently structured, the large corporations and venture companies that increasingly dominate agricultural research seek short-term returns for their shareholders, which is, after all, their major obligation. Hence there is a lack of research and development into forms of agriculture that can protect and rebuild resources for the future in the common interest.

8. What are the climate implications of grabbing 'marginal land' worldwide?

Much of the debate about climate change mitigation and adaptation is premised on gaining access to land. Land is claimed for agrofuel and food production by corporations and foreign governments, for speculation by funds seeking to attract investors into agriculture[133] - and also in the name of protecting biodiversity from all these pressures. In some cases governments are zoning national land for conservation or exploitation and possibly looking to trade one against the other. In the last few months news stories about the grabbing of land worldwide have been increasing rapidly and can be followed at a number of sites.[134] In Africa alone, they range from deals by oil-producing nations plus China, India, Korea, Vietnam and others for food production to investment funds such as Emergent Asset Management seeking big returns on acquisitions of land in Africa at minimal prices. At the same time, deals involving millions of hectares of land for the production of agrofuels are also under discussion. Potential deals include 2.8 million ha in the Democratic Republic of Congo (DRC) for oil palm agrofuel and 2 million ha for jatropha agrofuel in Zambia, both for China.[135] Countries targeted include Ethiopia, Mozambique, and Tanzania as well as the conflict torn Sudan and DRC. In both Mozambique and Tanzania, the land-grab has now been put on hold. In Mozambique, over 18 months, some 13 million ha were bid for and investigations soon revealed that targeted land overlapped with land vital to local communities. Now the conflicting claims have to be resolved. Meanwhile, some 2.5 million ha are under cultivation for agrofuels. When the talk turns to amounts of land required to produce biochar, areas between half and one billion hectares have been mentioned.[136,137]

131 Wilson A.K,, Latham J.R. & Steinbrecher R.A. (2006): Transformation-induced Mutations in Transgenic Plants: Analysis and Biosafety Implications. Biotechnology and Genetic Engineering Reviews, 23: 209-237

132 Paul H. & Steinbrecher R. (2003): Hungry Corporations. ZED Books; http://www.econexus.info/Hungry_Corporations.html

133 See for example the investment management firm Emergent and their Emergent Africa Land Fund; http://www.eaml.net/templates/Emergent/home.asp?PageId=7&LanguageId=0

134 For uptodate information see GRAIN's website Food crisis and the global land grab. http://farmlandgrab.org

135 von Braun J. & Meinzen-Dick R. (2009): “Land Grabbing” by foreign investors in developing countries: Risks and opportunities. IFPRI Policy Brief 13; http://www.ifpri.org/pubs/bp/bp013Table01.pdf; and http://www.ifpri.org/pubs/bp/bp013.pdf

136 Read D. (2006): Treasury review of the economics of climate change. Submission from Dr Peter Read. Stern review evidence, 12.3.2006; http://www.hm-treasury.gov.uk/d/massy_uni_2.pdf

A recent report confirms that forest may also be treated like marginal land if its people are sufficiently marginalised and there is little public awareness. The Environmental Investigation Agency (EIA) and Telapak launched a report in November 2009 entitled “Up for Grabs” that exposes how five million hectares of land in Indonesian Papua, most of it forested, is being targeted by powerful companies seeking to profit from projected demand for biofuels and wood-pellets, derived from crops such as oil palm, and other commodities.[138] So it is hardly surprising that we are constantly told that there are vast extents of marginal, degraded, under-used, abandoned, sleeping and waste land, that will not compete with food production and are just waiting to be brought into production for agrofuels and biochar as co-products. Additionally, we are also told that this land can potentially be restored by planting so-called advanced agrofuel and/or biochar crops, creating a “win-win” situation.[139]

However, much of this land is actually collective land long used by local people[140] to whom it may be a vital resource for water, food in times of drought, medicine and materials, especially to the most marginalised people.[141] Frequently these people have no formal title of ownership to the land but are exercising their long-exercised customary rights. Jonathan Davies, global co-ordinator of the World Initiative for Sustainable Pastoralism, Nairobi, Kenya, comments:

> “These marginal lands do not exist on the scale people think. In Africa, most of the lands in question are actively managed by pastoralists, hunter-gatherers and sometimes dryland farmers […] There may be wastelands lying around to be put under the plough, but I doubt that they are very extensive.”[142,143]

137 Chung E. (2009): Ancient fertilizer technique could help poor farmers, store carbon. CBC News, 23.3.2009; http://www.cbc.ca/technology/story/2009/04/23/tech-090423-biochar-carbon-trading.html

138 Full version of the report ‘Up for Grabs’ available at www.eia-international.org and www.telapak.org

139 Gallagher E. (2008): The Gallagher Review of the indirect effects of biofuels production. Renewable Fuels Agency; http://www.renewablefuelsagency.org/reportsandpublications/reviewoftheindirecteffectsofbiofuels.cfm

140 Mausam, July-September 2008; http://www.thecornerhouse.org.uk/pdf/document/Mausam_July-Sept2008.pdf

141 Nyari B. (2008): Biofuel land grabbing in Northern Ghana. http://www.biofuelwatch.org.uk/files/biofuels_ghana.pdf

142 The Gaia Foundation, Biofuelwatch, the African Biodiversity Network, Salva La Selva, Watch Indonesia & EcoNexus (2008): *Agrofuels and the Myth of the Marginal Lands.* Briefing paper; http://www.econexus.info/pdf/Agrofuels_&_Marginal-Land-Myth.pdf;

‘Marginal land’ is not usually rich and fertile, but more often nutrient poor with harsh environmental conditions. Though many rely on it for their survival, they require detailed knowledge and experience to do so sustainably. On the other hand, natural forests used by communities and good agricultural land can end up being falsely classed as ‘marginal’ in order to open it up for example to agrofuels. The CDM definition of ‘degraded and degrading lands’ is so broad that it covers all land with any degree of reductions in vegetation cover, soil erosion, compaction, salination or depletion - thus much of the world’s cropland and even most of South-east Asia’s carbon rich peatlands. Yet land conversion to plantations, now encouraged by the CDM, will cause severe land and soil degradation.

What are the impacts of turning “marginal” or “degraded” land over to monocultures?

There are a wide variety of impacts on people, ecosystems and biodiversity, and the relationship between them. The people who inhabit such areas are often themselves marginal, largely invisible to policy-makers and international institutions. Among those likely to suffer most from expropriation of such lands are **women**, who often have no property rights or access to land. As a FAO report of 2008 states: “The conversion of these lands to plantations for agrofuels production might therefore cause the partial or total displacement of women’s agricultural activities towards increasingly marginal lands.”[144]

Another group that suffers are **pastoralists**. Both they and their way of life are widely misunderstood, increasingly marginalised and hemmed in by settlements, international borders and parks, yet they should be actively be involved in discussions about adaptation to climate change:

> “Mobile pastoralists are amongst those most at risk to climate change, yet they are amongst those with the greatest potential to adapt to climate change, and they may also offer one of the greatest hopes for mitigating climate change.”[145]

143 Donizeth D.J. (2008): India’s Policy on Jatropha-based Biofuels: Between Hopes and Disillusionment. Focus on the Global South, 22.9.2008; http://focusweb.org/india/index.php?option=com_content&task=view&id=1069&Itemid=26
Navdanya (2007): *Biofuel hoax: Jatropha and land grab.* Press release, 5.12.2007; http://www.navdanya.org/news/5dec07.htm

144 Rossi A. & Lambrou Y. (2008): *Gender and equity issues in liquid agrofuels production - Minimising the risks to maximise the opportunities.* FAO; www.fao.org/docrep/010/ai503e/ai503e00.HTM

145 Davies J. & Nori M. (2008): Managing and mitigating climate change through pastoralism. Policy Matters 16:

Yet there is ongoing pressure to convert their land to more 'productive' uses, such as crop cultivation, without paying attention to the potential climate impacts of so doing. A recent study "provides evidence of the complex connection between regional changes in climate and changes in land cover and land use. New study results are warning that the conversion of huge areas of pasture lands to croplands in east Africa will be a major contributor to global warming in the region."[146]

Like pastoralists, **indigenous peoples** and **small-scale farmers** are extremely vulnerable to climate change with its associated extremes of droughts, floods and storms, as well as shifts in local climate and vegetation. Like pastoralists, they are also in danger of being expropriated, with the additional excuse that this would be done to protect the climate. However, policy-makers are inclined to forget that the relationship between people and marginal land may be subtle and complex and the insights of the people may be crucial for protecting water resources, biodiversity and the integrity of ecosystems, which are vital buffers against the impacts of climate change.

The recognition of their land rights is a fundamental need for marginalised peoples and small-holder farmers. However, Olivier De Schutter, the Special Rapporteur on the Right to Food, noted in his report to the UN General Assembly that "no governmental delegation present at the High-Level Conference on World Food Security (held in June 2008 as the food crisis increased) mentioned agrarian reform or the need to protect the security of land tenure."[147]

Marginal lands: biodiversity resources for adaptation

Marginal land with poor soils can be home to a highly biodiverse population of plants and animals in dynamic interaction. Although little studied, such marginal areas may prove to be extremely important in providing insights about adapting to climate change. The plants must continuously adapt to harsh, often rapidly changing conditions, so such land could be a vital reserve genetic diversity for resistance to stresses such as drought, disease and pests in the future, especially as climate change threatens the viability even of locally adapted farmer varieties of crops.[148]

In Europe and the US, land designated as set-aside or belonging to the Conservation Reserve Program (CRP) may also be a crucial refuge for biodiversity. However, it is often considered marginal and may readily be sacrificed to boost production of food crops or agrofuels. Set-asides have already been fully abolished in the EU[149] and in the US the CRP is being gradually run down, prompting immediate fears over the fate of wildlife, including pollinators which are vital to agriculture and human survival. In the US, there are proposals from researchers to turn vast regions of marginal, unused and fallow land over to genetically modified poplar trees with altered or reduced lignin for the production of second generation fuels[150] - supposedly to address climate change. Such contradictions are embedded in the proposition that biomass production should be scaled up, particularly on so-called marginal lands, and need to be urgently addressed.

Conclusions

Land that is dismissed as marginal often has great value to people, biodiversity and ecosystems and for stabilising climate, water resources and rainfall. Turning it over to industrial cropping for food, fuel or biochar may increase regional and global climate change. Instead of relying on false solutions such as biochar and agrofuels we should put the knowledge of small-scale farmers, pastoralists and indigenous people at the centre of the debate about marginal land and how to restore the integrity of ecosystems, especially in dry regions.

9. Can agricultural biodiversity strengthen small farmers' resilience to climate change?

by Rosalba Ortiz, Kristin Ulrud & Teshome Hunduma; The Development Fund Norway

Climate change exacerbates existing risks for farmers, such as water stress, diseases and food insecurity. The Intergovernmental Panel on Climate Change (IPCC) estimates that in the near future we will experience increased temperatures, changes in rainfall patterns, more droughts, floods and recurrent extreme weather

127-141. http://cmsdata.iucn.org/downloads/pm16_section_3.pdf

146 Maitima J.M. (2008): Climate Land Interaction Project. International Livestock Research Institute (ILRI); http://www.ilri.org/ILRIPubAware/ShowDetail.asp?CategoryID=TS&ProductReferenceNo=TS_080722_001

147 De Schutter O. (2008): Report of the Special Rapporteur on the right to food, Olivier De Schutter: Building resilience: a human rights framework for world food and nutrition security. UNHCR, A/HRC/9/23, 8 September 2008.

148 Melaku Worede, Ethiopian geneticist, one of the founders of Seeds of Survival and a specialist in uncultivated biodiversity, pers communication.

149 Smith J. (2007): EU moves to scrap set-aside to boost grain supply. Reuters, 16 July 2009; http://uk.reuters.com/article/latestCrisis/idUKL1633601820070716

150 Purdue University (2006): Fast-growing trees could take root as future energy source. http://www.monsanto.co.uk/news/ukshowlib.phtml?uid=10618

conditions. Such changes are happening at a much faster rate than first predicted[151]. Furthermore, IPCC adds that the resilience of many ecosystems - their ability to adapt naturally to external pressures - will be weakened due to disturbances caused by climate change. This will compound the impacts from other global change pressures such as land-use change, pollution and over-exploitation of resources.[152]

Warmer temperatures, changes in rainfall and more extreme weather events already affect agriculture. Although the effects on agricultural yields over the next few decades will vary from region to region, unchecked warming could result in the collapse of agriculture in a number of regions. Already, in many rural communities on marginal farming land, more frequent floods and droughts and in some regions rising sea levels are seriously affecting farm productivity and livelihoods. There is an increased risk of conflicts over water and productive land.153 Climate change encourages the spread of pests and invasive species and is already increasing the geographical range of some diseases.[154] According to the Food and Agriculture Organization (FAO) genetic resources for food and agriculture will come under further threat, as global climate change will erode genetic diversity and destabilize agro-ecosystems significantly. Yet sustainable use of genetic resources for food and agriculture is the foundation for many of the adaptation strategies required in food and agriculture, when facing climate change.155

Rural communities will not be able to recover from repeated crop losses. Poorer households are more vulnerable and more likely to end up in a food insecurity trap, becoming the first losers of climate change.

On-farm management of genetic diversity has traditionally allowed farmers to cope with climatic variation. Smallholder farmers, most of whom are women, have always played a vital role in conserving agricultural diversity in their farms and territories. "*More than half of all species exist in agricultural landscapes outside protected areas; biodiversity can be preserved only through initiatives with and by farmers*".156 Smallholder farmers, who also include indigenous peoples, have domesticated, developed, improved and exchanged these genetic resources for centuries. This has helped farming communities to continue improving local varieties and to keep a wide diversity of crops and animals in their fields, which at the same time have allowed them to rapidly adapt to changes in local climate.

However agricultural policies, which promote the dependence of agriculture on a few crops in monocultures with agro-chemicals, plus market concentration, are accelerating the loss of agricultural diversity and leading to species extinctions and declines. This hinders farmers' capacity to adapt to changing local environments, reducing farmers' resource base and food security, and with it impoverishing even more farming communities in developing countries. Furthermore, negative impacts on species, such as habitat loss and fragmentation, climate change and pesticides, can reinforce each other and lead to much greater population and species losses than would otherwise be expected, including for example of vital pollinators. Climate change reinforces the call to action from the agricultural sector.

9.1. Monoculture and agricultural diversity

Industrialization of agriculture has led to monocultures, reduced crop diversity in farmers' fields and constraints on the role of farmers in plant breeding.

> "Although hundreds of edible plant species have been important in traditional crop systems, today just three crops - rice, wheat, and corn - provide 60% of our plant-based diet worldwide. Diversity within crops has also declined because traditional varieties have been replaced by a few high-response varieties. This process is called genetic erosion. According to the Food and Agriculture Organization of the United Nations, 75% of crop diversity was lost during the twentieth century. Modern varieties have supplanted traditional varieties for 70% of the word's corn, 75% of Asian rice, and half of the wheat in Africa, Latin America, and Asia. In 1950, India had 30,000 wild varieties of rice, but by 2015 only 50 are expected to remain."[157]

As a result of the industrialization of agriculture, seeds have become a commodity. High response varieties depend on fertilizers and often on irrigation. The expansion of monocultures to agricultural frontiers and

151 Pew Center on Global Climate Change (2009): Key scientific developments since the IPCC Fourth Assessment Report. Science Brief 2. http://www.pewclimate.org/docUploads/Key-Scientific-Developments-Since-IPCC-4th-Assessment.pdf

152 IPCC (2007): Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II: to the Fourth Assessment.

153 Millennium Ecosystem Assessment (2005): Millennium Ecosystem Assessment: Ecosystems and Human Well-Being. Wetlands and Water. Synthesis, World Resources Institute, Washington DC (USA).

154 World Bank (2007): World Development Report 2008: Agriculture for development. World Bank, Washington DC.

155 FAO (2008): Climate Change and Biodiversity for food and agriculture technical background document for expert consultation. February 2008. FAO, Rome.

156 FAO 2008

157 Picone C. & Van Tassel D. (2002): Agriculture and Biodiversity Loss: Industrial Agriculture. Land Institute, Whashington DC.

deforested territories, often described as "marginal" has resulted in a number of local varieties and their wild relatives becoming endangered and lost.

Increased agrochemical use in monocultures also results in reduced populations of the natural enemies of pests, such as spiders, wasps, dragonflies, and predatory beetles. Intensification of industrial agriculture has reduced biodiversity, mismanaged irrigation water, and caused agrochemical pollution and health problems related to intensive use of pesticides,[158] while farmers' dependence on pesticides and fertilizer has increased.

Reduced agricultural diversity makes it more difficult for farmers to develop new locally-adapted varieties that can adapt to the changing environment.

At the same time, important sources of nutrition, and related traditional knowledge and practices are lost, increasing vulnerability among farmers and their communities. at the same time, the pressure from commercial companies for using modern technologies to solve food and climate crisis is increasing. However, monocultures and agro-chemical use are a major contributor to loss of species, for example the mass extinction of amphibians around the world. As biologist Professor Peter Hudson has said: *"We are facing a cataclysmic global decline in amphibians caused primarily by the effect of a fungus that was historically not important, but the emergence of which might be associated with climate change, along with the use of herbicides and pesticides."*[159] Such species declines and losses in turn reduce the ability of ecosystems to function and to sequester carbon – monocultures and agro-chemical use thus have a knock-on effect on ecoystems and the climate which goes well beyond their boundaries.

9.2. Are genetically modified crops a solution or a problem?

Technologies such as Genetically Modified (GM) crops are promoted as a possible solution to the world's food crisis and for climate mitigation and adaptation. Even though some farmers' varieties are resistant to drought and salinity, GM crops are also promoted as a way to develop drought and salt resistant varieties (see chapter 7).

The recent report, International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) urges caution when it comes to the use of GM crops.[160] According to this report, GM crops have so far not made any substantial contribution to meeting the needs of smallholder farmers in developing countries.

A study conducted on farmer perceptions of the economic benefits and risks associated with the use of GM crops in Mexico, Guatemala and Cuba, concluded that farmers preferred their own varieties to GM crops for sowing, and especially for eating. It turns out that farmer attitudes towards GM crops are cautious,[161] as against the traditional thinking that farmers will easily adopt GM crops.

Indeed farmers argue that GM crops lack nutritional value, resistance to diseases and pests, and are less adaptable to changing environments. Smallholder farmers have also witnessed the negative impacts of pesticides, used along with the GM crops, on animal and human health and the development of herbicide resistant weeds.. Recent studies support these concerns.[162]

These farmers are demanding the right to choose the crops they want to grow and the type of agriculture they want to adopt. IAASTD's summary of the synthesis report also states: "A powerful tool for meeting development and sustainability goals resides in empowering farmers to innovatively manage soils, water, biological resources, pests, disease vectors, genetic diversity, and conserve natural resources in a culturally appropriate manner."[163] This is the kind of support farmers seek in order to adapt to climate changes rather than having GM crops imposed on them.

9.3. Intellectual Property Rights versus Farmers' Rights

Intellectual Property Rights (IPR) regimes are becoming critical with regards to farmer access to genetic resources for food and agriculture. IPR on genetic resources are increasingly posing barriers to the conservation and sustainable use of agricultural diversity, reducing the diversity of seeds available,

158 Byerlee D., de Janvry A. & Sadoulet E. (2009): Agriculture for Development: Toward a New Paradigm Annual Review of Resource Economics, 2009(1): 15-31.

159 Hudson P. et al. (2008): Global warming link to amphibian declines in doubt. Science Daily, 13 November 2008. Penn State University www.sciencedaily.com/releases/2008/11/081112113708.htm

160 McIntyre, B. D., Herren, H.R., Wakhungu, J. and Watson, R. T., 2009. Agriculture at Crossroads. International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), Global report (synthesis report). Island Press, Washington DC.

161 Soleri D. et al (2008): Testing assumption under economic research on transgenic food crops for Third World farmers: Evidence from Cuba, Guatemala and Mexico. Ecological Economics 67: 667-682

162 Gasnier C. et al. (2009): Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines. Toxicology 262:184-91.

163 IAASTD (2009): Executive Summary of the Synthesis Report, Island Press, Washington DC. www.agassessment.org/docs/SR_Exec_Sum_280508_English.pdf

increasing prices, and thus limiting farmers' capacity to adapt to climate change.

The two most common types of intellectual property (IP) protection affecting seeds are Plant Variety Protection (PVP) of the International Union for the Protection of New Varieties of Plants (UPOV) and patents. The UPOV-78 Act allows farmers to freely use harvested material from a protected variety for any purpose. however, UPOV-91 limits farmers' rights to save and exchange seeds. Countries are not allowed to join UPOV-78 any longer, and patents prohibit farmers' rights to save, re-use, exchange and sell seeds. Thus IPRs on genetic resources promote a more uniform, less diverse, global market, and result in high seed prices.

The implementation of farmers' rights to save, use, exchange and sell farm-saved seed and propagating material under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) has not materialized at national level because of the challenges of IPR regimes.[164] National governments find it difficult to fine-tune national laws because of the contrasting nature of farmers' rights and breeders' rights. However, promoters of IPRs on genetic resources do not take into account whether the obligations set under the Convention on Biological Diversity (CBD) and ITPGRFA are met or not. Besides, the Trade Related Intellectual Property Rights agreement (TRIPs) of the World Trade Organisation (WTO) has extended the reach of IPRs, as a country must ratify the agreement to join the WTO and comply with its provisions or face trade sanctions. In recent years, bilateral trade agreements have also played significant roles in promoting stringent IP regimes in agriculture sectors that go beyond the standards required by TRIPS, demanding from countries a "TRIPS plus regime". PVP laws grow tighter (e.g. UPOV 91) and patent applications on conventional breeding are increasing, not just patents on GMOs.[165] This is resulting in a monopolization of genetic resources by private companies, limitation of farmer rights to genetic resources, so weakening the capacity of farmers to respond to climatic constraints in agriculture and food production.

Limiting the rights of farmers to conserve, use, exchange and develop agricultural diversity is a most effective way to reduce agricultural diversity, and to make small-scale farmers less adaptable to changes in climate and more food insecure.

9.4. *What kind of agriculture do we need?*

Managing the connections between agriculture, natural resource conservation and the environment, is an integral part of agriculture both for development[166] and adaptation to a changing climate. Biodiversity, including agricultural diversity is crucial for maintaining agricultural production and ecosystem resilience. Conservation of crop diversity in farmers' fields is therefore a key factor in strengthening climate resilience among poor farming communities. Wild relatives of domestic crops provide genetic variability that may be crucial for overcoming outbreaks of pests and pathogens and new environmental stresses.

Many agricultural communities consider increased local diversity a critical factor for the long-term productivity and viability of their agricultural systems. Farmers' fields in developing countries are often characterized by large plant genetic diversity. Not only is this diversity of great importance for nutrition and cultural values. It is also the source of plant varieties with valuable traits that are resistant to diseases and pest as well as changing climatic conditions. Farmers around the world have conserved traditional varieties based on local knowledge, culture and as a food security strategy. Furthermore, overall productivity has been shown to increase with crop diversity.[167]

Farmers have always needed to understand and adapt to their changing environment. Predicting changes of climate has been a key factor in planning and carrying out agricultural activities. However, extreme climate events such as droughts and flooding are less predictable, more pests and diseases emerge and farmers need to find varieties that tolerate stronger climate stresses. Farming communities already know that the most effective strategy to adapt to changes in local climate is conserving their natural resources, and their associated ecological functions.

Enhancing on-farm conservation of agricultural diversity is crucial for the future of agriculture. This is

not only a way to secure food supplies, but is also a strategy to cope with a changing climate. Conservation

164 McIntyre,B.D., Herren H.R., Wakhungu J. & Watson R.T. (2009): Agriculture at Crossroads. International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), Global report (synthesis report). Island Press, Washington DC,

165 Then C. & Tippe R. (2009): The future of seeds and food under the growing threat of patents and market concentration, published by coalition for "no-patents-on-seeds". http://www.no-patents-on-seeds.org/

166 Byerlee D., de Janvry A. & Sadoulet E. (2009): Agriculture for Development: Toward a New Paradigm Annual Review of Resource Economics, 2009(1): 15-31.

167 R.A. Steinbrecher & A. Lorch (2008): Feed the World? The Ecologist, November 2008.

of animal and plant genetic resources, use and development of new seeds are part of the strategies for many smallholders farming communities in developing countries.

9.5. Traditional knowledge is vital for adaptation to climate change

Farmers have conserved a wide range of crop varieties because of their special attributes, such as taste, colour, resistance to plant diseases, and drought, among others. *"The traditional knowledge has managed to conserve natural resources in a sustainable way in many communities around the world. Much agricultural production is sustainable, and in some cases large areas have been under continuous cultivation for centuries."*[168]

It is vital to focus on traditional farmer knowledge and build collaborative alliances between farmers and local research institutes whereby farmers can experiment with crop varieties, adapted to the local environment and to their social and economic conditions.

Participatory Plant Breeding (PPB) is a strategy used by smallholder farming communities worldwide. By using PPB, thousands of smallholder farmers are conserving and developing crop varieties that are more resistant to plant diseases or tolerate long dry seasons and at the same time produce higher yields. Participatory processes are used during the planning, implementation and decision-making involved in selecting and developing new varieties. Traditional and modern technologies are combined, but farmers themselves decide on the attributes to be improved and the final outcomes. The results are high quality seeds owned by farming communities; and seeds with characteristics desired by farmers, such as resistance to pests, plant diseases, and drought or flooding, and increased yields. The transition to producing and sowing high quality seeds is a key result, but farmer control of the process during its initial stages is perhaps the most crucial factor; this enables farmers to both recover and produce seeds again if they are hit by a natural disaster.

Enhancing local knowledge is crucial for the conservation and development of crop diversity in farmers' fields. However, the right economic incentives and institutional collaboration must also be in place.

168 World Bank (2007): World Bank report on Agricultural and Development 2008.

9.6. Technologies of easy access to farming communities

The Community Seed Banks (CSBs) support on-farm conservation through utilization of genetic resources. This is a dynamic process that relies on constant use of genetic materials by farmers in the communities, which ensures sustainability, and reduces the risk of losing genetic material in the case of natural disasters. Since CSBs are located near and run by communities, seeds are available when required, and farmers are able to plant when the sowing and weather conditions are favorable. The challenge is to focus on conservation of those crop varieties which have little commercial value, but which are rich in genes and will provide a guarantee for the future in vulnerable farming communities around the world. *"Communal underground seed storage is a common practice in Ethiopia where communities during famine, by tradition, bury large quantities of seed (and migrate elsewhere as the case may be) and reclaim land for planting later when the drought crisis is over, usually within a three year period."*[169]

Community Seed Banks strengthen farmers' traditional knowledge, enhance conservation of agricultural diversity and are intended to attain a fair management of Plant Genetic Resources (PGR) among small farming communities. CSBs provide multiple benefits to small-farming communities, and provide high quality seeds to poor farmers. CSBs also provide opportune relief services under extreme climatic stresses, since seeds are easily and rapidly available for farmers in need of support. In Honduras, due to an intense rainfall in 2008, farmers from Yorito - Western Honduras – lost all their crops the immediate solution was getting seeds from the local CSB. *"No other relief service came as quickly to our community as we did, because we are there. The seeds provided were of high quality, and money was not requested immediately. The CSB is therefore protected and the materials are constantly renewed by the communities. This is our life insurance."* (Luis Alonzo Meza-farmer and manager of CSB in Yorito, Honduras).

However, lack of recognition of farmers' knowledge, as well as lack of political and scientific support to CSB is undermining the contribution of these traditional systems to agriculture and food security. Strengthening the use and development of traditional seed systems for in-situ conservation is urgent; otherwise the final outcome will be loss of crop biodiversity in farmer's fields and hunger among poor farming communities.

169 Dr. Melaku Worede at a USC Canada's side event during the Third Session of the Governing Body meeting of the International Plant Treaty for Genetic resources for Food and Agriculture (IPTGRFA) held in Tunisia, June 2009.

Combating pests and diseases in Central America

Black Chiquito and especially Red Chiquito Beans are important sources of income and food security for many Central Americans. When the Participatory Plant Breeding Program started in 2000, all farmers argued their problem was to control two major plagues of beans: Mosaico Dorado (MD) and Mosca Blanca (MB). Most commercial seed varieties used in 2000 failed to effectively combat MD and MB, and in addition they did not have the colour desired by farmers and the market. Combating these two problems became one of the main goals of the program, along with enhanced yields and the maintenance of desirable colour, and conservation of traditional varieties.

After seven years, the outcomes are positive. Problems such as MD and MB are controlled through farmers' own developed varieties, and yields have also increased on average from 690 kg/ha to 920kg/ha in Costa Rica; from 1617kg/ha to 1941kg/ha in Honduras and from 800kg/ha to 1181kg/ha in Nicaragua. The desired colour has also been maintained.

Conclusions

Crop diversity in farmers' fields is vital to the future of agriculture and the food security of the world's population. Furthermore, agro-biodiversity conservation in the hands of farmers and their communities makes farmers more capable of responding with sustainable options to climate change threats. But this capability requires the commitment of governments to recognize the contribution of farmers to the agriculture of the future, and their role in maintaining ecological functions that sustain food supply for all human beings. There is a need for responses to policy challenges affecting the ability of farmers to adapt to climate change. Biodiverse farming systems which do not rely on agro-chemicals are also essential for maintaining global biodiversity and ecosystem resilience which in turn plays an essential role in regulating the climate.

On-farm conservation and the use of technology controlled by smallholders communities such as Participatory Plant breeding and Community Seed Banks are good examples of community solutions to increase food production, conserve agricultural diversity, and at the same time enhance farmer resilience to climate variability. Continued access to genetic resources is therefore essential, and farmer rights to genetic resources should be assured both at the national and international level. All conventions related to genetic resources should acknowledge and require the implementation of farmers' rights. All this is needed in order to strengthen the ability of farmers to produce food and to adapt to a changing climate.

GM crops have not proved to be the solution either for agricultural conservation or for food security. The environmental risks of GM crops have not been properly assessed yet, and this creates uncertainty among decision-makers and communities on the real benefits of such technology. Smallholder farmers and their communities prefer farmers' varieties, and control over their own seeds. GM crops are seen as a threat to traditional agriculture and to maintaining crop diversity.

In terms of research and development, there should be an improved linkages and coordination between farmers, via farmers' organizations (FOs), agricultural research agencies and extension services. Such linkages and coordination is needed at all levels and not only at the farm level. This can be facilitated through periodic consultations among these key stakeholders. FOs should participate in planning meetings and, where possible, serve on the boards of research agencies to have a greater say in the research agenda and to ensure that trials are designed to address the needs of small-scale farmers particularly in the view of the changing climate. Knowledge, information and technical advice on climate change can reach farmers at the grassroots level more effectively if agricultural research and extension institutions proactively involve FOs.

10. Towards an Alternative Vision

We risk paradigm maintenance. Current proposals for responses to climate change seek to maintain current power structures and basically amount to business as usual or worse. This must change.

The destruction of ecosystems is accelerating, reducing their resilience to the stresses of climate change and converting them instead to emitters of greenhouse gases. The failure to recognise land rights and to institute genuine agrarian reform is breaking the relationship between local communities and their land, and leading to the further loss of cultural knowledge of critical value to us all. Much of the knowledge and experiences of how communities can live sustainably and without harming the climate is being lost this way.

The solutions currently proposed offer only a reductionist approach to the complexities of climate change, converting every issue to greenhouse gas measurements. Most governments and institutions choose to rely on markets to guide action and propose that agriculture should be included in carbon trading. However, government attempts to shift responsibility to the market compounded by market failures are likely to result in subprime carbon, so destroying their own flawed attempts to engineer a solution.

Carbon markets also allow Annex1 countries to evade their own obligations to reduce their emissions and their consumption of energy. This failure to assume responsibility damages prospects for cooperation and encourages cynicism. All this is likely to result in a collective failure to address climate change positively and to use it as a stimulus for real change. Greenhouse gas calculations drawn up for the purpose of carbon trading often amount to little other than creative carbon accounting.

Market mechanisms mask a lack of genuine collective commitment to change, particularly in Annex I countries. The Clean Development Mechanism (CDM) and offsets must not be further extended to agriculture.[170] Even current CDM methodologies, including for agrofuels, will lead to major new subsidies for industrial plantations which harm the climate, the environment and communities. Any proposal to extend REDD or REDD-plus mechanisms to agriculture is premature and amounts to a policy failure. Similarly, payments for environmental services in agriculture must not be allowed to become a means for donors, both public and private, to avoid real action. Furthermore, to include soils in carbon trading would tend to stimulate funding for techno-fixes such as biochar or no-till agriculture, rather than promoting any real attempt to make the long term commitment to soil research and restoration that is so urgently needed. To continue reducing the need for effective collective action to a botched market mechanism would be a sad failure of imagination and a serious aberration, setting short-term economics above the realities and constraints of the planetary system on which we depend. We cannot rely on market mechanisms to address climate change: carbon trading is a dangerous distraction from what we should really be doing and should be suspended.

To sum up:

- We need far deeper understanding of ecosystem functions and their multiple and interactive benefits. For this we need to recognise the multi-functional nature of agriculture.
- Biodiversity is essential for a stable climate and must no longer be sacrificed in the name of climate change mitigation.
- We should cease to undermine and instead support small-scale farming within an ecosystem approach.
- Small farmers, indigenous peoples and local communities should be at the heart of policy-making.
- We need local production for local markets, and a far broader and richer concept of productivity.
- We need agrarian reform, security of land tenure and recognition of farmers' and small breeders' collective/common rights to seeds, breeds, land, water and soil.
- Freedom to share information and build insights, without being blocked by patent barriers and confidential business information claims, is vital.
- Funding should be directed to farmer-centred research rather than just for the priorities of agribusiness.

For all these we need coherent government policies, not market mechanisms. There are many policy changes that could have an immediate positive impact. Above all we need government commitments and policies to support land reform, agro-ecological approaches and small-scale agriculture.

170 CDM is already applied to pig and poultry factory farms.