

# Biochar – a climate smart solution?

by Almuth Ernsting



## About this paper series

► Climate change is one of the biggest challenges facing our globalized world today. The poor population in developing countries will be particularly affected by global warming, of which developed countries are the major drivers. Science clearly indicates that a global temperature rise of 2°C above pre-industrial levels may change the face of the world irreversibly. A range of mitigation solutions is needed to avoid exceeding the 2°C limit. The need for truly sustainable and climate-friendly development is clear.

A glance at global mitigation potentials shows that changes in agriculture and land use, including deforestation in tropical areas, currently account for one-third



Deforested areas in Brazil.

Photo: Meisner/MISEREOR

Figure 1

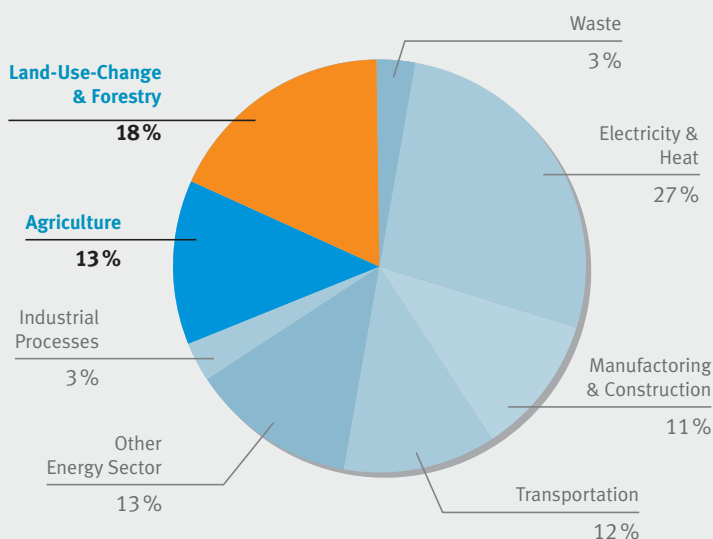


Figure 1: Sources of Global Greenhouse Gas Emissions. Agriculture is the primary driver of land use change and deforestation. Source: EarthTrends, 2008; using data from the the Climate Analysis Indicators Tool (CAIT)

of global greenhouse gas emissions (see Figure 1). Increasingly, therefore, agriculture is being recognized as part of the problem in international climate negotiations. While developed countries' emissions result mostly from industry, energy consumption and transport, FAO figures reveal that 74% of all agricultural emissions originate in developing countries, and 70% of the agricultural mitigation potential can be realized in these same countries.

Could agriculture therefore be part of the solution, particularly in developing countries? Globally, three-quarters of all malnourished people depend on agriculture and would be directly affected by international mitigation agreements aimed at agriculture. Various "climate-friendly" agricultural solutions have already been proposed: they include biochar and no-tillage agriculture. Against this background, MISEREOR uses this series of papers to examine whether these solutions actually lead to climate-friendly and equitable agriculture with a clear commitment to a pro-poor approach. ◀

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## Imprint

**Published by:**  
Bischöfliches Hilfswerk MISEREOR e.V.  
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**Art work and printing:**  
VISUELL, Werbung und Kommunikation, Aachen

As at: December 2011





## Executive Summary

► Biochar, or fine-grained charcoal added to soils, is being promoted as a way of sequestering carbon in and reducing greenhouse gas emissions from soils whilst, at the same time, making soils more fertile. This briefing first introduces the different methods for producing biochar and looks at the (very limited) uses of biochar and traditional uses of charcoal in agriculture. It then explores who are the interest groups behind biochar and its main advocacy group, the International Biochar Initiative, before discussing what the science shows about the impacts of biochar on climate and especially soil carbon. It then discusses the likely impacts on poor communities should biochar be commercialised on a wider scale, by looking at biochar impacts on crop yields, the potential health impacts of biochar, the claims made about ‘biochar cook stoves’, and the possibility of a future larger biochar demand resulting in land-grabbing. Finally, proposals to include biochar in particular and soil carbon in general into carbon markets are explored.

As the briefing shows, optimistic claims about biochar offering a reliable way of mitigating climate change, mainly by sequestering carbon in soils, and of raising crop yields are not backed by the science. The limited number of peer-reviewed field studies shows that adding biochar to soils cannot be relied on to result in higher overall soil carbon compared to plots where only mineral fertilisers are used or ones where different organic amendments, such as

sawdust or green manure, are applied. The reasons are complex and not fully understood and are likely to include a combination of biochar carbon turning into CO<sub>2</sub>, biochar causing microbes to turn pre-existing soil organic carbon to turn into CO<sub>2</sub>, and biochar carbon eroding. Furthermore, if fine biochar particles become airborne they can cause additional warming in the same way as soot does. Similarly, field studies show that the impact of biochar on crop yields is highly variable, negative in some cases, and cannot be predicted based on current knowledge. This means that small farmers using biochar would carry a significant risk, which would be even greater if they had to bear even part of the cost of producing or procuring biochar. Biochar-making cook stoves have been promoted as being particularly suitable for rural families, however there is a lack of independent data about how well they work, with strong indications that they require more biomass fuel to provide the same heat for cooking as similar stoves that do not produce biochar. Furthermore, the amount of biochar produced by such stoves is very small compared to amounts used in field trials. Those most likely to benefit from any future inclusion of biochar into carbon markets are likely to be agribusiness and plantation companies and other larger organisations and companies who can offer economies of scale and afford the transaction costs, not small farmers. ◀



*Biochar, the product of pyrolysed biomass*

# What is biochar?

1

► Biochar is essentially fine-grained charcoal applied to soils, which is being promoted primarily for climate change mitigation and for raising soil fertility. Like all charcoal, it is made by exposing wood, grasses, crops, plant residues or other biomass to high temperatures but with limited oxygen, a process called ‘pyrolysis’. The term biochar was invented in 2005, by one of the most outspoken advocates of its large-scale use, the late Peter Read, who defined it as ‘finely divided pyrolysed biomass prepared for soil improvement’.<sup>1</sup>

Wood or other biomass charred and blackened after an open air fire will have been at least partly pyrolysed and any type of charcoal is, in chemical terms, the result of *pyrolysis*. The carbon in all types of charred biomass, or in coal for that matter, is called **black carbon**. However different types of charred biomass have very different properties and chemical structures, depending on the temperature and the length of time for which they were charred and the type of biomass used. During traditional charcoal production, neither the energy which is released nor any of the air pollutants are captured, causing significant pollution. Biochar advocates generally eschew traditional charcoal production and instead support modern pyrolysis methods.

In modern pyrolysis, energy produced from the combustion of biomass is captured in gaseous (“syngas”) and/or liquid (“bio-oil”) form, leaving behind char as a byproduct. Generally around 10-40% of the original volume of biomass is left behind as char depending on what is used and how it is burned<sup>2</sup>. Syngas can be used like natural gas, although the energy content per unit of volume is considerably lower, which means that far more of it has to be used to produce the same heat or electricity<sup>3</sup>. Pyrolysis oil can be used for heat and electricity or in shipping engines. Efforts are underway to find ways of refining both syngas and pyrolysis oil into biofuels for road transport or aviation.

Pyrolysis is by far the most common method for producing biochar, however, two other methods exist: One is **gasification**, in which biomass is also exposed to high temperatures but together with oxygen. Gasification leaves behind at most 10% of the biomass carbon as charcoal and there are no studies which look at the properties of biochar made that way and how it impacts on soils. Another technique is called **hydro-thermal carbonisation or HTC** and it involves steaming biomass together with different types of acid which act as a catalyst. HTC is being developed primarily in Germany

and is still the early research and development stages. It appears to be most significant in the nanotechnology context. This report therefore focuses on biochar made through pyrolysis.

Modern pyrolysis facilities range from large industrial pyrolysis plants to cooking stoves. Modern pyrolysis plants are still largely in the development stages, most of them confined to research institutions and commercial pilot plants.

This is why the vast majority of the research so far has not looked at biochar produced with modern pyrolysis. Instead, most studies have used crushed traditional charcoal, or charcoal produced through wildfires and swidden cultivation, some of it decades or centuries old. This is problematic because, as the UK Biochar Research Centre explains: “The function of biochar in soil is strongly influenced by formation conditions, and [traditional] charcoal may only provide an insight into some general principles of biochar function in soil.”

## 1.1 Terra preta

Highly fertile and carbon-rich soils in Central Amazonia, called *terra preta*, meaning ‘black earth’ are widely cited as evidence that biochar works, i.e. that charcoal addition to soils sequesters carbon and makes soils more fertile over long periods. *Terra preta* soils are found in patches of 1-80, usually 20, square metres mostly along the Amazon and its tributaries and are surrounded by relatively infertile soils which contain little carbon.<sup>4</sup> According to the Food and Agriculture Organisation (FAO), many terra preta soils are 500-1,500 years old but some are probably older than 2,500 years. FAO states: “The knowledge systems and culture linked to the Terra Preta management are unique but have unfortunately been lost. [Terra preta soils] are, however, still an important, yet threatened, resource, as well as an agricultural heritage that needs better scientific understanding.”<sup>5</sup> Archaeologists, anthropologists and soil scientists have discovered features of the farming practices which created *terra preta* soils. A study along the Berbice river in the Guyanan Amazon forest found evidence of pre-colonial ‘garden cities’ that left behind *terra preta* soils, large settlements where a variety of trees, shrubs and perennial crops were grown in long crop cycles, with intercropping, and where the fields or gardens were seasonally flooded by the river.<sup>6</sup> Remnants of turtle shells, fish and mammal bones and

river sediments have been found in *terra preta*, as well as remains of manure, human waste and variety of kitchen-waste, together with charcoal and a large volume of pottery shards. The late Wim Sombroek, described as the “founding father of the carbon-negative biochar initiative”<sup>7</sup> formulated a research programme aimed at supporting small farmers in the Amazon basin “through the replication/emulation of the anthropogenic black earths of the pre-Columbian Indian tribal communities”.<sup>8</sup>

***The prevalent idea behind biochar, however, is not to try and replicate pre-colonial Amazonian farming practices but to isolate one single element of those practices – charcoal – in the hope that this will help to create soils***

***which will become as fertile and carbon rich in the long-term as terra preta.*** Of the limited number of biochar field trials, most look at the use of fine-grained charcoal within industrial agriculture, i.e. in combination with synthetic fertilisers or manure or both and with crops grown in monocultures, usually with the aid of pesticides and other agro-chemicals. Not surprisingly, there are major differences between the properties of terra preta and those of soils with modern biochar, which is discussed below. Nonetheless, references to terra preta are being widely used to promote biochar. What is more, various patent applications and trademarks for biochar, some of them using the term ‘terra preta’ have been submitted by companies.<sup>9</sup> ◀

## 2

## Biochar use today

▶ All biochar projects today are small-scale and generally classed as ‘trials’, often in partnership between companies and researchers. Many of them have been set up with the explicit aim of promoting biochar use amongst farmers and/or demonstrating the viability of biochar for carbon offsets. At the end of 2010, Biofuelwatch, together with the African Biodiversity Network and Gaia Foundation, helped to conduct web searches about biochar projects in Africa and found references to 28 projects or plans in at least 13 African countries.<sup>10</sup> The largest ones were two projects by the Biochar Fund in Cameroon and DR Congo, involving 1,500 farmers and 10 villages respectively, and a 2,500 hectare trial including for biochar by the Centre for Rural Innovations in Cote d’Ivoire.

In Latin America and the Caribbean, biochar projects appear to be smaller in numbers and include:

- a small-scale feasibility study with a pyrolysis pilot plant to run on residues from timber and oil palm plantations in Costa Rica, supported by the International Biochar Initiative (IBI), one of the aims being a business plan “including the possibility of eventual carbon crediting for biochar”;<sup>11</sup>
- a biochar feasibility project by UK biochar company Carbon Gold in partnership with the Toledo Cacao Growers Association in Belize, supported by the Cadbury Foundation. Carbon Gold have been advocating strongly for the inclusion of biochar into carbon markets;
- a project by WorldStove to introduce biochar in Haiti in the wake of the 2010 earthquake.



*Biochar carbon sink – implementation in South Sumatra, Indonesia*

Unfortunately, no independent accounts or evaluations have been published in relation to any of those biochar projects. In many cases, there is no information to show whether or not different projects are ongoing or have been abandoned. In the case of one high-profile biochar company, WorldStove, Biofuelwatch established that their public claims about at least one of their ‘projects’ were fabricated. The company had publicly claimed to be

pursuing a biochar-related project under the Clean Development Mechanism (CDM) in Burkina Faso, yet our enquiries showed that no application for such a project had ever been made under the CDM. Furthermore, an NGO announced as WorldStove's partner in the Haiti stoves project, International Lifeline Fund, appears to have removed all references to the company from their website and has recently published progress with a 'clean stoves' Haiti project which does not involve biochar stoves.<sup>12</sup> In other cases, convincing information is provided about a project having been established but updates are either missing or cease after some time. In one case, a Swiss NGO reported that their first biochar trial in Ghana had failed but that they had set up a successful second one elsewhere in the country. No details of either of those trials have been published, thus no lessons can be learned from them.<sup>13</sup> All this points to a strong need for a genuinely independent evaluation of different biochar projects, particularly in Southern countries.

## 2.1 Traditional charcoal use in agriculture today

Literature describing communities directly adding charcoal to soils is scarce. Fertile soils rich in black carbon have been found in various regions, but little is known about their origin and many may well be the result of swidden cultivation in the past. British researchers have begun studying ancient dark, carbon-rich soils in different West African countries, the African Dark Earths Project.<sup>14</sup> The project aims to combine studying "indigenous knowledge and practices" with looking at "the value now attributed to biochar for soil enhancement, carbon sequestration and clean energy production". As with *terra preta*, this raises the concern of indigenous knowledge being appropriated and used to help attract subsidies and carbon offsets for biochar entrepreneurs and companies in the North.

There is no literature that describes traditional *terra preta* methods being practised in South America today. A Brazilian agronomist with 35 years experience of working with small farmers across different states in her country reported in personal communications that she had never come across charcoal being deliberately used in soils and that she first became aware of the concept in the context of the carbon offset debate. There are anecdotal reports about farmers in the Batibo region of Cameroon amending their soil with charcoal made by burning mounds of grass covered by earth<sup>15</sup>, and of indigenous Munda communities in Northern India adding charcoal from cooking stoves to their soil, together with burnt grass and

farmyard manure.<sup>16</sup> It seems likely that similar practices exist elsewhere and that ash and charcoal from cooking fires would be put on fields more widely, but there is no evidence that traditional farming methods that are thought to have led to the formation of *terra preta* are widespread.

Charred trees and other vegetation undoubtedly play a major role in farming in many regions and has done so for millennia – through swidden cultivation, often called slash-and-burn farming. Biochar advocates strongly distance themselves from such farming methods which they tend to blame for deforestation. A 2006 article by soil scientist Johannes Lehmann, Chair of the International Biochar Initiative as a lead author, claims: "Existing slash-and-burn systems cause significant degradation of soil and release of greenhouse gases...Our global analysis revealed that up to 12% of the total anthropogenic C emissions by land use change (0.21 Pg C) can be off-set annually in soil, if slash-and-burn is replaced by slash-and-char."<sup>17</sup> 'Slash-and-char' would involve clearing forests and other vegetation and using modern pyrolysis methods to capture bioenergy and maximise charcoal production, in the hope that the charcoal will help to make the soil arable over long periods, although there are no medium- or long-term trials to compare it with swidden cultivation. According to the same study, slash-and-burn farming converts only 3% of the original biomass to charcoal.<sup>18</sup> There is a lot of variation and uncertainty, however, and different studies suggest that anything between 3 and 40% of biomass carbon is turned into black carbon during swidden cultivation.<sup>19</sup>

## 2.2 Who is behind the biochar lobby?

The International Biochar Initiative (IBI) is the main international advocacy group for biochar support, including biochar inclusion into carbon markets. The IBI has officially advocated for biochar carbon offsets and/or subsidies for example in relation to proposed US legislation and the UN climate negotiations. They have formally partnered with the Carbon War Room, set up by Richard Branson, with the aim of rapidly scaling up biochar production through its inclusion into different carbon markets.

Various regional and national biochar initiatives have been set up, for example in Europe, India, Mongolia and Canada, which liaise closely with the IBI.

The membership of the IBI's Advisory Board and Board of Directors, and the list of their conference sponsors illustrates the different interest groups represented: Commercial, independent and public sector research institutes,

start-up biochar and pyrolysis (including stoves) companies, carbon offset firms and bioenergy companies with an interest in pyrolysis and gasification. A small number of NGOs is involved in biochar promotion, above all the French NGO Pro Natura and the US-based Clean Air Task Force. Interest has also been expressed by plantation companies and some of their representatives. Amongst them are the former executive director of the Indonesian Palm Oil Association (GAPKI), Didiék Goenadi, Indonesian-Japanese pulp and paper company PT Musi Hutan Persada, PT Tanujngem Lestari Pulp and Paper in Indonesia, Malaysian researchers looking at biochar production from oil palm plantation residues and the Norwegian company

Green Resources, which is investing in monoculture tree plantations for ‘carbon offsets’ in East Africa.

ConocoPhillips are the only multinational company that has been actively supporting biochar developments. Most of their support comes from ConocoPhillips Canada who are sponsoring the development of biochar carbon offsetting especially for the Alberta Offset System. This is a state-wide carbon offset scheme primarily aimed at and supported by the tar sands industry. There are other close links between the IBI and the Canadian tar sands industry, for example one of the chief architects of the Alberta Offset System<sup>20</sup> was appointed by the IBI to draft their first ‘biochar standards’. ◀

## 3

## Is biochar really climate friendly?

► According to the International Biochar Initiative, biochar can sequester up to 2.2 billion tonnes of carbon every year by 2050 and this carbon will remain in soil for hundreds or thousands of years. Furthermore, the use of syngas and pyrolysis oils from biochar production can be used to replace fossil fuels. As well, they claim that soil fertility will be dramatically improved, fertilizer demand lessened and that nitrous oxide emissions from soils will be reduced.<sup>21</sup>

Burning wood and other biomass for energy is, controversially, presumed to be ‘carbon neutral’ because new trees and other plants are expected to re-sequester the carbon as they grow. By not releasing all the carbon during pyrolysis but storing a significant percentage in soils for long periods, advocates claim that biochar production is ‘carbon negative’. If done on a large scale, they claim, then biochar can at least slow down global warming.

The evidence for these claims is largely based on short-term laboratory studies or on observations of terra preta or charcoal from wildfires in soils, and on modelling that extrapolates from such studies. The main basis for the belief that biochar can help reduce climate change is the apparent high stability of black carbon, i.e. the carbon it contains.

***How stable an individual carbon particle is does not determine whether a practice such as biochar is climate friendly. Natural ecosystems, including soils, constantly ‘recycle’ carbon, i.e. most of their carbon tends not to be very stable.*** According to a 2006 study, the Amazon forest, for example stores most of the carbon dioxide taken from the atmosphere for no more than five years and then releases it back as carbon dioxide.<sup>22</sup> Other carbon will be

returned to the atmosphere when trees die and decompose. Yet, despite the fact that carbon in forests is not very stable, the Amazon forest has played a major role in storing carbon and otherwise regulating the climate system for up to ten million years, holding up to 120 billion tonnes of carbon at present.

Here are the most important questions that need to be answered to determine whether or not biochar is climate friendly:

### 3.1 How does biochar affect soil carbon?

If biochar is added to soils, does that, in the longer term, result in those soils being richer in carbon than they would otherwise have been? How long biochar remains in soil is important in this context, but so is the impact of biochar addition on existing soil organic carbon and on plants.

This can only be answered by a combination of laboratory, field and comparative studies (including studies of charcoal from wildfires and other sources). Field studies, using a variety of non-sterile soils under natural conditions, are especially important. In medicine, no drugs would be approved without clinical trials on humans, because the effectiveness and safety of a drug in real people cannot be known simply from laboratory studies. Similarly, in soil science, effects of different practices cannot be predicted unless they have been tested in a wide range of ‘real life’ field conditions. After all, soils are highly complex, diverse and still rather poorly understood ecosystems. As one soil science study explains: “One gram of



soil may harbour up to 10 billion microorganisms from possibly thousands of different species. As less than 1% of the microorganisms observed under the microscope are cultivated and characterized, soil ecosystems are, to a large extent, uncharted... Soil diversity exceeds that of aquatic environments.”<sup>23</sup>

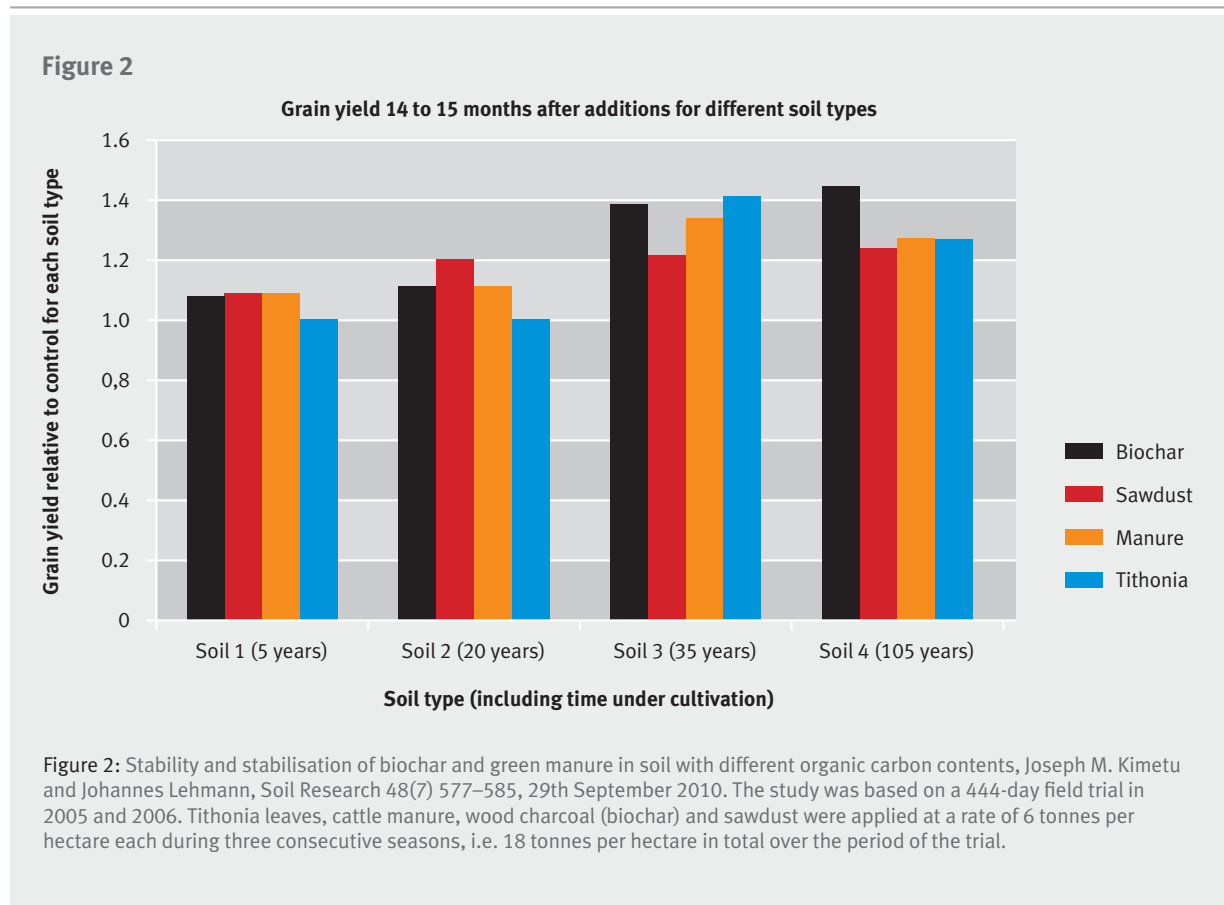
A further contribution to the complexity is that different types of biochar and charcoal vary greatly depending on the original biomass and the conditions under which it was charred. Of course, field studies cannot demonstrate what will happen to carbon in soils over centuries or even millennia. However, studies lasting at least a few years would seem to be a high priority. Since the first biochar company, Eprida, was founded in 2002, one might expect a range of biochar field trials going back nine to ten years by now. Unfortunately, this is not the case.

A 2010 science review by the UK Biochar Research Centre evaluated 75 peer-reviewed studies related to the properties of biochar. Based on their literature review as well as more recent publications, Biofuelwatch has identified just 11 biochar field trials about which peer-reviewed studies have been published. All of them look at biochar use in industrial agriculture with monocropping.

Out of those eleven one, based in Ghana, looked at soils underneath traditional charcoal kilns<sup>24</sup>, which is very different from what is being promoted as biochar since, in that case, the soil itself had been pyrolysed. At least one other, based in Sumatra<sup>25</sup> used a questionable study design which ran counter to the ‘best practice’ advised in the International Biochar Initiative’s own Guide to Conducting Biochar Trials.<sup>26</sup> Of the remaining nine field studies, four do not look at what happens to soil carbon when biochar is used. This means **that evidence from no more than five field trials has been published which look at what biochar does to soil carbon**, two in Colombia, one in Western Kenya, one near Manaus in Brazil and one in the Philippines. The two longest of them, based in Colombia and in the Philippines, lasted for four years each. The results of four of these trials are summarised here the study from the Philippines<sup>27</sup> was only published at the time this briefing was written and could not be evaluated in time.

### 3.1.1 Western Kenya trial

In this trial,<sup>28</sup> biochar, manure, sawdust and Tithonia leaves (also promoted for soil fertility) were applied to different



plots, together with mineral fertilisers. Control plots were treated with mineral fertilisers only. Maize was grown on all plots. The soils were all of the same type but differed according to how long they had been under cultivation – ranging from 5 to 105 years of continuous farming. Those that had been farmed the longest were most degraded and had the least initial carbon. Soils were tested after 14-15 months and three crop rotations. As can be seen from figure 1 above, soil carbon was significantly improved when biochar, rather than nothing at all was added to soil. However, only in one of the soil samples – the one which had been farmed the longest and thus had the least carbon to start off with – was the biochar carbon associated with a greater increase in soil carbon than all other organic amendments. In the soil which had been farmed the next longest, for 35 years, there was no statistically significant differences between amounts of soil carbon after Tithonia, manure or biochar had been used. In soil farmed for 20 years, soil carbon was the highest after sawdust had been used and in the soil farmed for just five years, there

were no statistically significant differences in soil carbon from any type of soil amendment.

### 3.1.2 Colombia Study

A biochar crop trial growing wheat and soya in rotation was set up on Colombian savannah soil, where the native vegetation had been removed immediately beforehand.<sup>29</sup> All of the plots were fertilised with mineral fertiliser and biochar was added at two different rates, with some plots being left as ‘controls’ without biochar. Soil carbon was reported at three time intervals for control plots and for plots with 20 tonnes per hectare biochar addition and at one time interval for plots with 8 tonnes per hectare biochar addition. No significant difference in soil carbon was found between any of the biochar or the control plots, except after two years, when there was significantly *less* carbon in the soil amended with 20 tonnes of biochar per hectare.

Findings from the other two case studies published before April 2011 are no more positive with regards to biochar and soil carbon. In one, from Central Amazonia, biochar on its own and in most combinations with other fertilisers did not significantly improve soil carbon at five months after application.<sup>30</sup> In the other, also from Colombia, biochar made no significant difference to soil carbon after two years except when a very high amount, 116 tonnes per hectare was used.

Each of the field studies thus points to a very different picture than that suggested by the International Biochar Initiative regarding the climate impacts of biochar and each of them raises questions to which the answers are not known. Perhaps, at least in some cases, the black carbon in biochar is not as stable as thought, or rather, less of it is stable than commonly assumed. ***Evidence suggests that black carbon can be stable in soils for thousands or even tens of thousands of years but that it can also be lost far sooner and be turned into carbon dioxide.*** For example, after wildfires a much greater percentage of the charcoal that would have been produced is still found in soils decades later in some regions than in others. The stability of black carbon appears to be affected by many different factors: The soil depth where it ends up, the species composition of microbes in a particular soil, how and from what type of biomass the black carbon/charcoal was made, etc.<sup>31</sup> Another possibility is that adding biochar could cause soil microbes to turn other carbon in the soil into CO<sub>2</sub>. There is growing evidence that this can happen, but that these effects vary greatly and, again, are impossible to predict with any meaningful level of certainty.<sup>32</sup> Finally, the measured loss of carbon may have been through wind

Figure 3

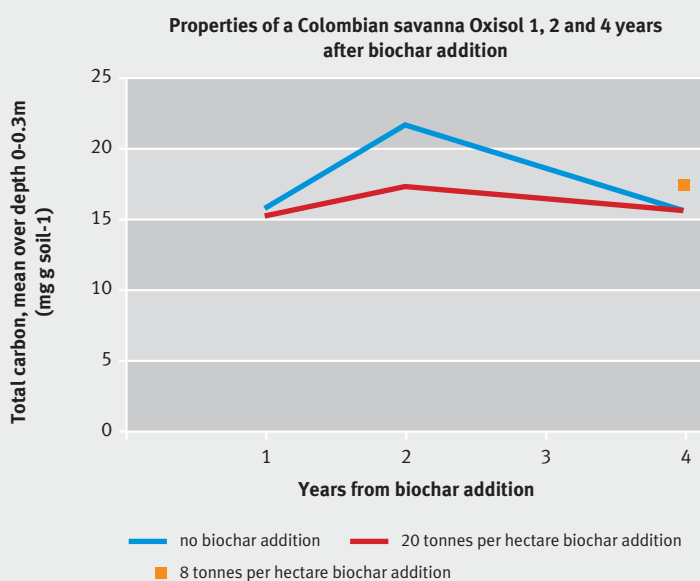


Figure 3: Maize yield and nutrition during 4 years after biochar application to a Colombian savannah oxisol, Julie Major & Marco Rondon & Diego Molina & Susan J. Riha & Johannes Lehmann, Plant Soil (2010) 333:117–128. This was a four year trial conducted between 2003 and 2006. Soil carbon measurements for plots with no biochar and for those amended with biochar at a rate of 20 tonnes per hectare were taken after one, two and four year only. For plots amended with biochar at a lower rate of 8 tonnes per hectare soil carbon was measured only once, at the end of the four-year trial. Biochar was applied only once, at the start of the trial.

or water erosion. There is evidence that biochar is more prone to water-erosion than other carbon in soils<sup>33</sup>. If biochar erodes, the carbon itself may remain stable for a long time, depending on where it ends up, but what will happen to it cannot be measured or predicted. As discussed below, if some of it became airborne due to wind erosion, it would cause further warming.

### 3.2 Likely climate impacts of a large biomass demand for biochar

How will a large new demand for biomass to produce biochar impact climate? Biochar is not yet used anywhere on a large scale, and so the answer to this question has to come from an assessment of the impacts of existing demands for wood and other biomass, and of the size of the new demand that large-scale biochar production would dictate. Bioenergy, including agrofuels, though often classed as ‘carbon neutral’, has been shown to have an overall climate impact which can be worse than that of the fossil fuels they replace for several centuries. Much of this is due to the direct and often indirect destruction of natural ecosystems as the demand for wood and crops increases.<sup>36</sup> If trees are cut down for bioenergy, new trees will take decades to sequester the carbon released instantly by burning that wood, thus worsening climate change during the crucial period when climate scientists warn that greenhouse gas levels in the atmosphere must be reduced to have any hope of avoiding the worst impacts of climate change.<sup>37</sup>

### 3.3 Biochar effects on other greenhouse gas emissions from soil

How does biochar affect the emission of other greenhouse gases, specifically methane and nitrous oxide from soils? Biochar supporters suggest that biochar can also help to reduce emissions from soils of nitrous oxide and methane, both powerful greenhouse gases. This could happen if biochar helps plants to grow well with less chemical fertilisers or if it affects soil microbes in such a way that they cause less nitrous oxide and methane to be emitted from soils. Only one field-study looks at biochar impacts on nitrous oxide and we could find no study at all that looks at biochar and methane. The field study in question looks solely at whether adding biochar to cow urine on pasture land in Australia will reduce nitrous oxide emissions – it does not consider the impacts of biochar used on crops rather than pasture.<sup>38</sup> Its answer is “yes” when



*Eucalyptus plantation in Brazil*

➤ Ahead of the 2010 UN Climate Summit in Cancun, La Via Campesina called for ‘thousands of people’s solutions to climate change’ and highlighted the role which the diverse sustainable practices developed by peasants and Indigenous Peoples around the world can play in countering change, including through ‘recuperating soil organic matter’ and ‘halting deforestation and practicing integrated forest management’.<sup>34</sup> Their statements are backed up by evidence, some of which was summed up in a 2009 publication by the international NGO Grain<sup>35</sup>, who in particular highlighted the importance of rebuilding and constantly replenishing organic matter in soils, which has been progressively depleted and eroded by industrial agriculture. This includes common traditional practices such as using crop residues, compost, manure, leaving land fallow and allowing natural vegetation to recover periodically, terracing, mulching, and keeping forest cover largely intact or sufficient trees standing to protect crops and soils from erosion. They cite results of a 10-year study by the Rodale Institute comparing compost, manures and artificial fertilisers. According to that study, combining manure and compost and rotating crops in organic agriculture resulted in significant soil carbon increases (2,000 lb/acre/year), whereas fields which were conventionally tilled and on which only artificial fertilisers were used lost significant amounts of carbon (300 lb/acre/year). ◀

a high amount, 30 tonnes per hectare of biochar, is used but “no” when half that amount is used.

### 3.4 Small airborne biochar particles

Small airborne black carbon particles have a global warming potential that is 500-800 times greater than that of carbon dioxide over the course of a century, according to NASA scientists. Could black carbon from biochar production or small particles of biochar become airborne and thereby contribute to warming? Airborne black carbon has a very strong, if short-lived impact on global warming because it directly absorbs energy from the sun rather than reflecting it back into space. Furthermore, small black carbon particles are deposited over snow and ice, they cause or speed up melting and thus cause further warming. According to NASA scientists<sup>39</sup>, black carbon causes 500-800 times more warming than

the equivalent amount of carbon dioxide when averaged over a century.<sup>40</sup> Particles need to be very small, the size of soot particles, to become and stay airborne for long enough to have this effect. Biofuelwatch has not been able to find a single study which looks at whether biochar particles can become airborne like soot. However, there are strong indications to suggest that they can. For example, an interim report about a biochar trial in Quebec suggests that 30% of biochar was blown away during application.<sup>41</sup> An agricultural research institute has analysed biochar produced by the company that supplied this trial and found a significant proportion of the particles to be as small as soot particles. Moreover, there is evidence that larger biochar particles can quickly degrade to such a size. Given the strength of the warming impact of airborne black carbon, the airborne loss of even a small percentage of biochar would be enough to cause biochar to have a negative impact on the climate – even if carbon benefits were proven, which they are not. ◀



*Man and woman working in the fields in Angola*

## Biochar – benefiting the poor?

► According to the French NGO Pro Natura, biochar could lead the way towards a ‘Third Green Revolution’: “A single [biochar] application can provide benefits over many years, biochar has the potential for increasing the self-reliance and resilience of small-scale subsistence producers”.<sup>42</sup> The allusion to the Green Revolution seems unfortunate, given the very negative impact this has had on small farmers, food sovereignty and the environment in South-east Asia. However, their key message – that biochar helps to improve crop yields and thus rural incomes and resilience – is backed by most biochar advocates.

There are different ways in which biochar could, at least in theory, raise yields. Some of them are short-term effects which will disappear after one or a few crop cycles.

- Fresh biochar contains varying amounts of ash and nutrients, but these become depleted.
- Most, though not all, types of biochar are alkaline. Many soils in the tropics and also elsewhere are acidic. Crops generally find it harder to absorb key nutrients if the soil is acidic. Adding an alkaline biochar can thus work much like liming soils and make it easier for crops to take up nutrients and grow better. This effect, too, will disappear over time.
- Biochar always contains some carbon that is unstable and easily degraded by microbes. This can stimulate microbes that benefit crops, but again, this is not a long-lasting effect.
- A short-term negative effect is also possible: The high proportion of carbon in biochar can make it harder for plants to access the nitrogen they need, but studies suggest that this effect is not a lasting one. Still, it could translate into farmers having a smaller harvest for a year after they used biochar.<sup>43</sup>

Other effects could be long-lasting:

Biochar might make soils less compacted and more able to hold water. Both nutrients and beneficial micro-organisms, fungi and plant roots could attach (adsorb) to the pores in biochar. It could cause changes that allow nutrients to be transferred more easily to plants and to micro-organisms in the long term. Its structure could also support earthworms and other soil fauna. Nutrients would still need to be added through organic or synthetic fertilisers, for example, but biochar might allow plants to grow better with less of these.

Each of these claims is credible, based on laboratory studies and models, although one would expect impacts to differ depending on the type of biochar, soil type and

crops grown. For example, one could expect less positive results from adding an alkaline biochar to an alkaline soil. If a biochar only has very small pores, nutrients might still attach to them but microbes, fungi and plant roots might not be able to reach them. Producing biochar at a higher temperature and from the right feedstock could overcome this particular problem – but the higher the temperature, the less biomass is turned into biochar. A biochar with a lot of carbon that can be easily digested by microbes might help plants grow better – but that would defeat the ‘carbon sequestration’ arguments. So ***even in theory, one would expect the impacts of biochar on plants to vary greatly.*** This is why researchers increasingly focus on producing ‘designer biochars’ for different soils that have been tested. Yet basic pyrolysis plants are at the pilot stage and ‘designer’ ones are a long way off. If they become viable, it is difficult to imagine soil testing and ‘designer biochars’ ever becoming affordable to small farmers.

### 4.1 Potential health impacts of biochar

Health risks from biochar relate to possible soil and thus food contamination, and to the effects of breathing in small biochar particles. Contamination can come either from contaminated biomass or from the pyrolysis process. For example, trees absorb heavy metals and other air pollutants and when wood is burnt or pyrolysed, those become concentrated in the ash, which forms part of the biochar. Norwegian researchers found that ash retained after burning wood from forests well away from any sources of pollution contained so many heavy metals that some of it should have qualified as toxic waste.<sup>44</sup> Depending on the pyrolysis temperature and the original biomass, there is a risk of particles called Polycyclic Aromatic Hydrocarbons (PAHs) forming, some of which are known to cause cancer and birth defects.<sup>45</sup> All of this can be avoided by testing different batches of biochar before they are used. It is of concern, however, because small farmers amongst whom biochar is being or might in future be promoted may well not be able to afford or arrange for such testing, even if they are informed about its importance. Biofuelwatch could find no indication in the description of biochar projects that precautions are always being advised and taken.

Breathing in small charcoal particles can cause ‘black lung disease’ or pneumoconiosis.<sup>46</sup> Furthermore, breathing in ash residues from charred rice husks is linked to

a risk of the lung disease silicosis.<sup>47</sup> Both are potentially fatal lung diseases. These risks can be significantly reduced if people who handle and apply biochar wear adequate masks. However, pictures from biochar trials, for example in Sumatra, show that such precautions are not always been taken.<sup>48</sup>

## 4.2 Can biochar be relied upon to raise crop yields?

Of the eleven peer-reviewed field trials which Biofuelwatch found, one, as discussed above, is not very relevant to biochar and another is based on methods which do not comply with the IBI’s guidance on field trials. Seven of the remaining studies look at how well crops grow with

biochar. The results are extremely varied. They show that biochar can result in higher or in lower yields or make little difference, depending on how much biochar is used and whether it is applied with fertilisers and, if so, with what type of fertiliser. **There are no universal, consistent trends.** For example, in one study in Laos, two varieties of rice were tested with and without biochar and with and without nitrogen fertilisers on two types of soils. On the same soil, using biochar had nearly the opposite effect on two different varieties of rice. One variety saw its yields suppressed by biochar on its own, raised when biochar was added to fertilisers, but not if too much of it was used. Another variety did not respond to biochar on its own but saw its yields depressed if biochar was added to fertilisers.<sup>49</sup> Here are graphs that illustrate findings from two other studies:

Figure 4 and 5

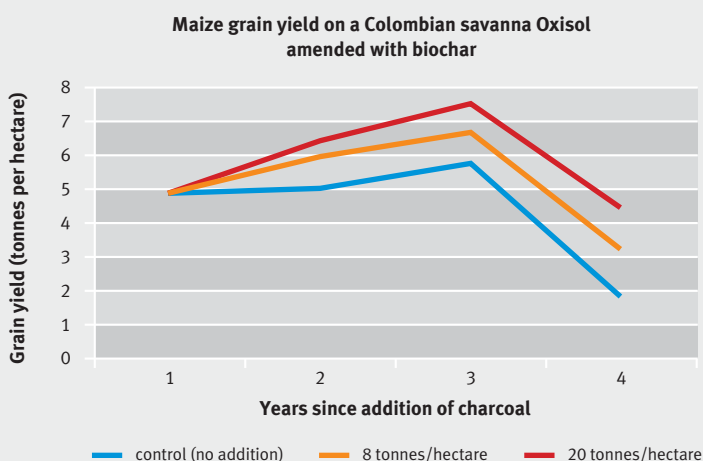


Figure 4, based on Figure 3 (p.10) in the same Colombian study by Julie Major et al discussed above in relation to soil carbon

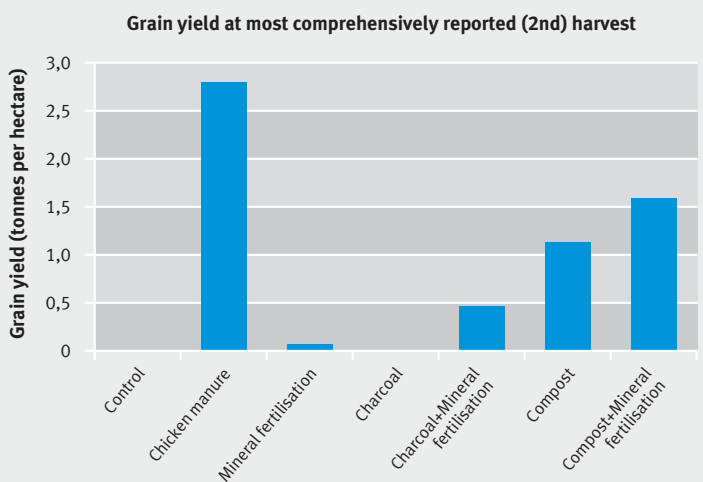


Figure 5, Data taken from Figure 3 in Long term effects of manure, charcoal and mineral fertilization on crop production and fertility on a highly weathered Central Amazonian upland soil, Christoph Steiner et al, 2007, Plant Soil DOI 10.1007/s11104-007-9193-9. This was based on a 600 day field trial in 2001 and 2002. The second, most comprehensively reported harvest took place in April 2002. The field trial may have continued beyond the 600 days, however no subsequent information has been published. Charcoal was applied once, at the start of the trial, at a rate of 11 tonnes per hectare. The amounts of compost, chicken manure and leaf litter were adjusted to match the amount of carbon contained in the charcoal and those organic amendments were also applied only once, at the beginning of the trial.

The second graph is based on the trial in Central Amazonia, on the same type of soil from which *terra preta* would have been created in the past. The harvest represented above took place around one year after the start of the trial. Chicken manure continued to result in the highest yields throughout the trial.

Unfortunately, all but two studies lasted for two years or less, too short to say whether biochar would have any long-term effects of plants. Even in the four year study from Colombia, the authors could find no indication of long-term effects – instead they suggested that yields were improved because alkaline biochar was added to acidic soil, and the effect known not to last.

***Biochar appears to be a high-risk strategy for small-farmers. Indeed, a leading biochar researcher in Australia has warned against farmers trying out biochar in the absence of further research and knowledge.<sup>50</sup> This makes it all the more worrying that biochar is already being promoted to farmers in a growing number of projects in Southern countries, as discussed in Section 2, particularly since there is no evidence to suggest that farmers are being informed of the experimental nature of biochar trials in each of the projects.***

### 4.3 How much biomass is required to make biochar?

If, in the right circumstances, biochar can help to improve harvests, why does it matter if those effects might disappear after a year or a few years? After all, farmers would expect to apply manure, mineral fertilisers, compost, etc. regularly.

The problem with biochar, however, is that making it requires very large amounts of wood or other biomass. In the field trial in Central Amazonia for example, researchers applied 11 tonnes of biochar per hectare – a fairly low rate compared to what is used in many other trials. They explained that they chose this amount because this was how much they could produce by cutting down and charring one hectare of secondary forest. So the 22 tonnes/hectare of biochar which helped plants grow better in the trial in Colombia discussed above would have required the felling of the equivalent of two hectares of secondary tropical forest to make one hectare of soil more fertile for four years. Producing even 10 tonnes – an amount which is at the lower end of what has been used in field trials per hectare of land requires around 50 tonnes more of biomass. That is a lot more than the residues which may be found on any hectare of land, let alone residues which can be removed without harming soils or competing with other needs, such as animal feed.



A small farmer from Haiti

If farmers wanted to apply as much biochar to their land as is used in most field trials, unless they were to cut down forests, they would need to either set aside part of their land to grow crops and trees solely to make biochar – hardly be an option for small farmers – or they would need to purchase biomass (and a kiln or pyrolysis plant to char it) or ready-made biochar. Either way, it would require a significant investment and cost and this would be especially unattractive if they only expect to see positive effects for a few years.

### 4.4 Land-grabbing for biochar?

Biochar is being advocated on an extremely large scale. The Chair of the IBI has spoken of a potential for sequestering more carbon in biochar than all the carbon released by burning fossil fuels every year.<sup>51</sup> More recently, an article by leading biochar advocates published in Nature Communications claimed that ‘sustainable biochar’ could offset 12% of annual greenhouse gas emissions, which would require large-scale extraction and charring of residues (including 90% of pig and poultry manure and 25% of cattle manure worldwide), as well as the conversion of 556 million hectares of grasslands and so-called ‘abandoned croplands’ to produce crops and trees for biochar production. The land figures are largely based on a different study which classes vast areas of pastoral lands as being ‘abandoned’ lands.<sup>52</sup> ***556 million hectares would be more than twenty times the area of land used to produce biofuels at present, raising the spectre of even larger-scale and faster land-grabbing and ecosystem destruction/conversion that is happening for biofuels today.*** In reality, it seems unlikely that such a large-scale biochar vision would ever be real-

ised, or that it would ever receive much greater policy support and finance than biofuels do today. This is particularly the case since none of its claimed benefits can actually be demonstrated. Nonetheless, even at a much smaller scale, and provided larger-scale carbon credits or subsidies for biochar become available, there is a high chance of future land-grabs by those hoping to cash in on them.

#### 4.5 What do biochar cook stoves offer to rural households?

Biochar stoves are biomass stoves of a type often called ‘micro-gasifiers’ or ‘wood-gas stoves’, although they can use a variety of biomass, not just wood. They are amongst a range of modern ‘clean biomass stoves’ advocated for use households, mostly in rural areas, who currently rely on open biomass fires for cooking. The basic concept of a biochar stove is this: The biomass is exposed to high temperatures, this releases flammable gases and those gases are then burnt in a separate part of the stove, which significantly reduces (indoor) air pollution. Compared to open cooking fires, such stoves are undoubtedly far cleaner and more efficient. Unfortunately, it appears that there is not one compara-

tive study of the many different ‘clean biomass stoves’ being promoted and produced. Not only is there a lack of independent data to see how efficient different stoves are, but it cannot be verified how well each type of stove works and how practical it is for those using it. For example, many appear to require biomass pellets, which could be difficult and expensive to obtain for rural families. A recent report, sponsored by the German government, lists a large range of ‘micro-gasifiers’ and sums up most of the information available, but that is largely limited to the developers’ own claims.<sup>53</sup> Although the report was produced in collaboration with the IBI and is very supportive of biochar stoves, the information collated shows that the micro-gasifier stoves that have been most widely produced and used are ones that do not retain charcoal. They are ones which also gasify the charcoal leaving nothing but ash behind. Looking at the limited information in the report, it appears that the stoves that gasify the charcoal provide more cooking time for the same amount of biomass compared to ones where charcoal is retained. This is hardly surprising: The more carbon that is left behind and not burned, the less energy will be produced. Clearly, it would make sense to compare biochar stoves with the most efficient biomass stoves not just with open fires.



*A typical open fireplace*



**Independent data, including information about people's experiences with using different types of stoves is needed before any credible recommendations about different types of stoves can be made.**

**What is clear even from the figures provided by the developers of biochar stoves is that people would need to use a stove over many decades before they had, say,**

**10 tonnes of biochar, the rate at which some field trials show at least temporary improvements in crop yields.**

For example, WorldStove state that a family cooking with one of their biochar stoves three times a day will have obtained 438 kg of biochar by the end of one year. **That family would thus have to use their stove continuously for 23 years before they had 10 tonnes of biochar.** ◀

## Biochar for carbon markets?

▶ When the Kyoto Protocol and its following accords were negotiated, it was agreed that under the Clean Development Mechanism (CDM), a limited amount of carbon offsets – no more than 1% of the total – could come from 'carbon sink' projects, but only from ones relating to 'afforestation and reforestation'.

The measurement of Soil carbon sequestration, it was decided, was too uncertain to be included into carbon markets. Given that the UN Climate Change Framework Convention (UNFCCC) continues to define monoculture tree and shrub plantations – even oil palm and jatropa plantations – as forests, this opened the door to carbon credits for such plantations, albeit only to a limited amount of credits. No offsets from any plantations or other so-called 'carbon sinks' have been allowed under the EU Emissions Trading Scheme, which is by far the largest carbon market worldwide.

Since then, calls for unlimited CDM and other carbon credits for oil palms and all types of plantations have become stronger and have found their way into various UNFCCC negotiating texts, although so far no decision to increase the scope and amount of CDM credits for so-called 'carbon sinks' has been made. Soil carbon offsets are backed, amongst others, by the Food and Agriculture Organisation, the UN Convention to Combat Deforestation, the World Bank and a large number of governments. They are proposed not just for the CDM but for a range of new regional and voluntary carbon markets. If, at a future climate conference it was decided to include soils into carbon markets, then all the decisions over methodologies, i.e. over which practices would be eligible for soil carbon CDM credits would be made by the CDM Board alone. Governments of non-Annex 1 countries can, however, decide what type of CDM projects and what individual project they do and don't want to see in their own countries. The CDM Board has already approved a range of very dubious methodologies and offsets projects

▶ CDM credits for Plantar's eucalyptus plantations were approved despite protests from local, national and international groups. The impacts of this supposedly 'sustainable' charcoal plantation include the pollution and depletion of rivers, the forced displacement of local communities, land disputes, destruction of highly biodiverse native forests, repression and human rights abuses, high rates of accidents and disease and a threat to food security.<sup>54</sup> Plantar's CDM credits for charcoal plantation are particularly pertinent for the biochar debate. New CDM methodologies generally refer to existing ones and if charcoal/biochar use in agriculture was included in the CDM then the Plantar decision is likely to be used as the basis for what type of charcoal production will be rewarded. Indeed an article by the IBI's chair, Johannes Lehmann and two other IBI members describes Plantar's plantations as an example for 'sustainable charcoal production'.<sup>55</sup> ◀

which benefit plantation companies. There is thus a high chance that biochar would benefit from a decision to include soil carbon offsets into carbon markets and, furthermore, that this would cover biochar produced from monoculture plantations, thus fuelling plantation expansion. This is illustrated by a recently approved CDM project and methodology benefiting a eucalyptus plantation belonging to Plantar in Brazil, which produces charcoal for pig-iron production (see box).

Biochar carbon offsets have already been proposed for other carbon trading schemes, all of which are laxer and even more developer-friendly than the CDM: Those are:

- Legislative proposals for a Carbon Farming Initiative in Australia, which would create 'land-based' carbon off-

sets, including for biochar, without being linked to any emissions cap. Under the proposals, projects would be approved without any consultation; ‘sustainability’ is not even mentioned as a requirement for projects;

- The Panda Standard, which is the first (voluntary) carbon market being set up in China;
- The Verified Carbon Standard Agency which certifies voluntary offsets and works closely with the World Bank. A biochar proposal, submitted in 2009, has not yet been approved, however;
- The Alberta Offset System: A biochar proposal has reportedly been submitted but has not yet been published.

Carbon markets are growing worldwide in size and number and soil carbon is expected to play an important role in many of them.

➤ In the case of one high-profile biochar company, WorldStove, Biofuelwatch established that their public claims about at least one of their ‘projects’ were fabricated. The company had publicly claimed to be pursuing a biochar-related project under the Clean Development Mechanism (CDM) in Burkina Faso, yet our enquiries showed that no application for such a project had ever been made under the CDM. Furthermore, an NGO announced as WorldStove’s partner in the Haiti stoves project, International Lifeline Fund, appears to have removed all references to the company from their website and has recently published progress with a ‘clean stoves’ Haiti project which does not involve biochar stoves.<sup>56</sup> ◀

A project by the Belgium-based Biochar Fund and the Congolese NGO ADAPEL in DR Congo was the first biochar project to attract funding linked to Reducing Emissions from Deforestation and Degradation (REDD), through the Congo Basin Forest Fund. That funding was granted in the context of ‘forest conservation’ by avoiding slash-and-burn farming. Swidden cultivation is being widely targeted as a presumed cause for deforestation under REDD proposals, with at least eight national REDD plans submitted to the World Bank proposing to effectively ban it.<sup>57</sup> This is highly problematic: There is strong evidence that the main drivers of deforestation are the growing international demand for and trade in agricultural products, wood as well as urbanisation, not practices by small farmers.<sup>58</sup> Furthermore, in many cases indigenous swidden cultivation meth-

ods continue to be sustainable agro-ecological farming methods and help conserve rather than destroy forests and their biodiversity – quite the opposite of industrial-scale logging and burning to clear forests for plantations. **REDD and various emerging forest and agricultural carbon markets are viewed by International Biochar Initiative (IBI) – the main lobbying and promotional body for biochar – as opportunities to advocate and get funding for biochar practices, including replacement of swidden agriculture.**

## 5.1 Who would benefit from biochar carbon credits?

In project-based carbon trading mechanisms, such as the CDM, companies in industrial countries, instead of reducing their own greenhouse gas emissions can instead pay for projects in poorer countries which are classed as saving greenhouse gases and aiding sustainable development there. Critics have pointed out that this approach is at best a ‘zero sum game’ because for any emissions saved in the South, more emissions will happen in the North. Furthermore, researchers have shown that a large proportion of CDM projects is not even additional – i.e. they already existed or would have happened anyway<sup>60</sup>. Furthermore, the great majority of CDM credits so far have gone to polluting industries in the South, such as ones using outdated technologies to produce refrigerators, thus producing and then capturing very powerful greenhouse gases.<sup>61</sup>

A particularly relevant question in the context of biochar is who will benefit from possible future biochar CDM or similar carbon offset projects. Under the CDM and any regulated carbon offset mechanism, project development and certification cycle are lengthy, complex and costly. This is why those most likely to obtain carbon credits are those who can afford to pay for specialist ‘carbon consultants’ and who can offer offset projects large enough to cover the CDM related transaction costs. The Biochar Protocol, set up with support from the IBI and ConocoPhillips to develop biochar carbon offsets, stresses the importance of ‘economies of scale’.

They suggest that small-scale biochar projects “may need to be aggregated together”.<sup>62</sup> Yet such a system of aggregation, or ‘bundling’ in the CDM has been proven to be particularly difficult and expensive. In theory, one would expect this to be particularly difficult for any soil carbon, including biochar projects since their impacts on soil carbon will be extremely difficult to predict and vary greatly, as discussed above. In practice, however,

methodologies could be adopted which simply ignore all those uncertainties and variations and simply assume that biochar will always sequester a certain proportion of carbon. According to research by the Institute for Agriculture and Trade Policy, the World Bank's first soil carbon offset project ever, in West Kenya, does not involve measuring soil carbon at all – they simply rely on estimates from 'proxies' (such as crop yields) and acknowledge that accurate measurements are not possible. In other words, soil carbon sequestration will be rewarded without checking whether any carbon has actually been sequestered in soils. Nonetheless, the transaction cost associated with this one project, exceeded \$1 million.<sup>63</sup> This is a good indicator that rural communities will never be able to apply for their own biochar or other soil carbon CDM projects but that they would depend on large NGOs or companies to do so. This means that the money would go not to small farmers but to an NGO or company. If sustained higher crop yields from biochar projects were guaranteed then small farmers could still benefit from a biochar carbon offset project. In reality, as discussed above, small farmers would carry the risk of unpredictable effects on their crops, with no promise of any longer term benefits and possible with detrimental impacts.

At the same time, agribusiness and plantation companies are in a particularly advantageous position because they can afford high upfront costs, they have economies of scale to offer, and many already have experience with CDM projects.

## 5.2 Who has profited from biochar so far?

Biochar is not so far commercially viable and is unlikely to become so without subsidies or inclusion in carbon trading schemes. Biofuelwatch has found no evidence of any company having profited from commercial biochar production or use although various companies have sustained themselves through biochar-related research and development and consultancy.

A small number of biofuel/bioenergy companies appear to have used 'carbon-negative' claims about biochar to attract investments. Amongst them is the Californian company CoolPlanet Biofuels who are working on developing biofuels for transport from wood and other solid biomass. Their process is still in the early development stages and would only produce a small amount of biochar as a byproduct. Nonetheless they base the following claim on biochar: "Imagine driving high performance



*Biochar – the new black gold?*

cars and large family safe SUV's while actually reversing global warming".<sup>64</sup> Claims about 'carbon negative fuel' have helped them to attract significant investments from General Electric, NRG Energy, ConocoPhillips and Google Ventures. Another biofuel company, Best Energies promote itself on a web-page relating, partly, to biochar by claiming: "We are well-placed to win the current land grab in next generation fuels."<sup>65</sup>

Biochar-related research has attracted substantial and growing subsidies and foundation support and nearly all of this is linked explicitly to the aim of biochar 'deployment', i.e. the development of commercial biochar use in future, and aim which appears not to be compatible with critical scientific findings about biochar impacts. For example, the government of New Zealand has made various grants available to biochar research and development, the largest being a grant for NZ\$3.13 million (1.72 million Euros) for the New Zealand Biochar Research Centre. The UK Biochar Research Centre has attracted several government grants, the largest for £2 million (2.23 million Euros). The Australian Government is funding biochar research through several grants, the largest being a AUS\$1.4 million (1.03 million Euros) grant to the Com-

monwealth Scientific and Industrial Research Organisation (CSIRO). In the US, biochar-related funding comes from the Department of Energy and the Department of Agriculture amongst others and the European Commission also funds several biochar-related research projects. Other biochar-related funding comes from foundations, including the Gates Foundation. While most of the funding is going to research institutions based in Europe, Australia, New Zealand and North America, biochar de-

ployment in Southern countries is an important aim of much of this research. For example, the Gates Foundation has given US\$1.6 million (1.09 million Euros) to Cornell University for biochar work, including for developing biochar-making stoves to be used in Africa and developing biochar use by farmers in Kenya<sup>66</sup> – illustrating the close links between biochar research and promotion. Some of the UK government’s biochar research funding also relates to biochar developments in Africa.<sup>67</sup> ◀

## 6

## Conclusion

► Lobbyists claim that biochar has a high potential for mitigating climate change and helping to raise soil fertility. In reality, there is paucity of evidence and especially of field studies. Field studies which have been published point to very inconsistent and unpredictable impacts which different types of biochar have on different soils. Far from reliably increasing soil carbon, biochar has been shown in several studies either to not increase it at all, even over a short time-span, or not to increase it as much as is attained by more common organic fertilisers. The reasons for those findings are not understood and furthermore, the possibility of small airborne biochar particles worsening warming has not been studied at all. Short-term impacts on crops are so varied as to make biochar a high-risk strategy for farmers and long-term ones have not been studied in trials. Nonetheless, there is a strong and growing policy momentum for including biochar into existing and emerging carbon markets. If successful, this could create new incentives for land-grabbing by those hoping to cash in on such carbon credits.

► In 2008, around 130 organisations worldwide signed a declaration urging caution over biochar and opposing the inclusion of soils into carbon markets.<sup>68</sup> According to the declaration: “Small-scale agro-ecological farming and protection of natural ecosystems are effective ways to mitigate the impacts of climate change. These proven alternatives should be fully supported (...). Indigenous and peasant communities have developed many diverse means of caring for soils and biodiversity, and living sustainably”. ◀

We recommend:

1. Soils must be kept out of carbon markets. If they were included then biochar as well as other dubious and potentially dangerous practices would inevitably be rewarded.
2. There should be no subsidies for the commercialization and use of biochar based on current scientific knowledge about the variable and unpredictable impacts on soil fertility. This includes grants for biochar research that are tied to facilitating biochar deployment. Until now, substantial scientific evidence and understanding is lacking and biochar has not proved positive long term effects on soil fertility, poverty reduction or sustainable land use.
3. Independent monitoring and evaluation of existing biochar projects, including biochar stoves, is needed. The study of soil science should focus on understanding the diversity and functioning of soils and their responses to climate change, not on advancing deployment of biochar. Farmers, Indigenous Peoples and civil society groups should play an important role in determining what soil practices work for them and are supported and advanced by agriculture policies.
4. The patenting of knowledge based on ‘terra preta’ and on other knowledge and practices which belong to existing and past indigenous and farming communities must be prevented. ◀

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## The author

Almuth Ernsting helped to found Biofuelwatch in 2006 and has been researching and campaigning on issues relating to industrial bio-energy, including biofuels since then and has been researching and writing about biochar since 2008. Biofuelwatch is a UK- and US-based organisation which works to raise awareness of the negative impacts of industrial biofuels and bio-energy on biodiversity, human rights, food sovereignty and climate change.

More information at: [www.biofuelwatch.org.uk](http://www.biofuelwatch.org.uk)

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