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Commentary

Biochar—One way forward for soil carbon in offset mechanisms in Africa?

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ABSTRACT

The Kyoto Protocol's Clean Development Mechanism (CDM) has had relatively little success in Africa due to a number of factors. Increases in agricultural soil carbon have strong benefits for soil health as well as potential for carbon sequestration, but such projects are currently excluded from the CDM and other offset mechanisms. Small-scale biochar systems with net emission reductions may hold a key for Africa to engage with the international offset mechanisms and open the door to soil carbon sequestration projects.

1. Introduction

The benefits promised for Africa by the Kyoto Protocol's Clean Development Mechanism (CDM) have not materialized, in large part due to its failure to include projects suitable to the region. Soil carbon sequestration through biochar projects may offer a way forward for Africa's participation in offset mechanisms under the next international agreement, through a modified CDM or an agricultural parallel to Reducing Emissions from Deforestation and Degradation (REDD) projects, as well as voluntary emissions offset markets.

Offset mechanisms allow parties with emissions reduction targets to meet a portion of their targets by purchasing emission credits that are generated through the implementation of greenhouse gas (GHG)-reducing projects, rather than making the reductions themselves. The Clean Development Mechanism is an offset mechanism under the Kyoto Protocol where projects in developing countries may generate Certified Emissions Reductions (CERs) which can be sold to countries with emissions reduction targets. It was designed to stimulate sustainable development in developing countries by providing finance for technologies and opening an otherwise unaffordable path to clean development, while developed countries gain access to lower-cost emissions reductions, increasing the efficiency of global GHG reductions (UNFCCC, 1997). Unfortunately, to date, the CDM has failed to help many of the countries that are most in need: a meagre 2% of all registered projects have been in Africa (Fig. 1), home to many of the least developed countries (LDCs) (UNFCCC, 2009a).

Although likely modified from their current forms, offset mechanisms will probably be included in the post-Kyoto international climate change agreement. Negotiations leading to the new post-2012 agreement have had a significant focus on REDD. Whether incorporated as a new type of offset mechanism or as a separate project, forest projects are likely to constitute an important piece of this agreement. However, for a number of reasons, REDD may be no more promising for African nations than the CDM was, particularly in the near

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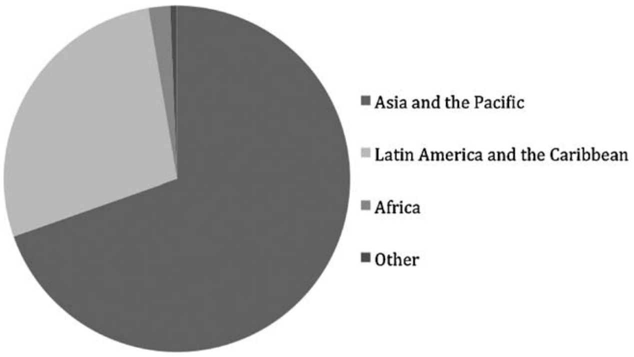

Fig. 1 – CDM Project Distribution by Region (March, 2009) (UNFCCC, 2009a).

term. Recent attention to biochar under the UNFCCC raises the issue of how it might fit into the framework through offset projects and whether it could provide real benefits in Africa.

2. Barriers to Africa's involvement in offset mechanisms

Part of the difficulty many of the African LDCs have had in engaging with offset projects has been related to the bureaucracy that surrounds the authorization of projects and the eventual issuing of credits. Within the CDM, an elaborate system of checks and balances under the CDM Executive Board means that the overall rate of project authorization and implementation has been slow.

A second reason that African nations have had low success rates of engaging with the CDM and forest offset projects is that neither energy-based projects nor afforestation/reforestation projects, the two mainstays of these mechanisms, have attracted many foreign investors (Sieghart, 2009). Even though there may be high technical potential for projects, barriers persist (de Gouvello et al., 2008). As remote-sensing capabilities have improved our ability to accurately monitor forest stocks (Gibbs et al., 2007), the post-Kyoto agreement may consider country-wide forest stocks under REDD, making individual projects less important in the future (Minang et al., 2008). However, some of the same challenges that affected CDM afforestation or reforestation projects in Africa may apply to REDD. These issues include tree-plantation projects that are essentially designed to serve as ''carbon farms'', without offering significant local benefits (Ringius, 2002), land rights barriers (Unruh, 2008), and the issues of ongoing deforestation pressures or loss of carbon through fires, which may deter investors (Murdiyarso et al., 2008).

3. Soil carbon and offsets

Interest around the potential for integrating soil carbon sequestration into the CDM has existed since its inception, but soil carbon enhancement projects under the CDM and other offset mechanisms are currently limited. Although there is an established methodology for assessing soil organic carbon (UNFCCC, 2008) under afforestation/reforestation projects, current regulations allow for soil carbon pools to be neglected in many cases (UNFCCC, 2006), and there are currently no CDM projects that focus primarily on soil carbon. This is lamentable, because the agricultural co-benefits of increasing soil carbon are manifold and such projects have strong potential to provide true sustainable development. Mechanisms such as conservation tillage, slowing land conversion, reducing erosion, or management of organic residues can all contribute to the reduction of GHG emissions while promoting soil health and thereby supporting local communities (Lal, 2004). However, delivering inexpensive and credible proof of soil carbon increases is not without challenges (Paustian et al., 2009). A second issue is that, similar to tree-planting projects, some gains could be reversed upon a shift back to old cultivation practices, undoing the carbon storage that had occurred and been credited. Recently, an opportunity has emerged that has the potential to overcome some of these roadblocks for soil carbon: biochar.

Biochar is a highly stable carbon compound created when biomass is heated to temperatures between 350 and 600 °C in the absence of oxygen. Biochar was most notably identified in ancient soils of the Amazon, known as *Terra preta*, where these dark, carbon-rich soils have remarkably high agricultural productivity in an area of generally nutrient-poor soils (Lehmann, 2007). Thought to be created by pre-Columbian populations, these soils are notable today not only for their high fertility, but also for the stability of their carbon,–carbon in these soils has been identified to be over 3000 years old (Glaser et al., 2001). Modern-day interests in enhancing soil health, organic agriculture, and sequestering carbon have led to a resurgence of interest in biochar (Lehmann and Joseph, 2009).

Today, biochar may be produced by a variety of methods, from small cook stove systems to larger bioenergy systems. In Africa, one of the most likely options for biochar offset projects may be the introduction of biochar-producing stoves. Traditional biomass would be used to produce energy for cooking, with biochar remaining as a co-product, which could then be applied to soils (Fig. 2). Farmers could benefit from increased crop yields (Kimetu et al., 2008). If these stoves are more efficient and cleaner burning than conventional stoves, as shown for improved combustion stoves (Johnson et al., 2009), they could significantly reduce fuel gathering pressure and respiratory diseases (Bruce et al., 2002). Such biochar has been found to have mean residence times in excess of 1000 years (Lehmann and Joseph, 2009), which means that there is a greater net GHG reduction benefit when biochar is sequestered in soil, rather than being burnt (Gaunt and Lehmann, 2008).

With biochar mentioned as a mitigation strategy in the current UNFCCC (2009b) negotiating text for the pending international climate agreement, it is crucial to begin to critically assess biochar as a piece of the international emissions reduction system. Biochar could have real potential to be Africa's key to initiate an engagement with international offset projects and to support soil carbon management as a valuable mechanism for carbon sequestration and soil health improvement. Many of the serious pitfalls discussed earlier are avoided in a biochar system: its application to soil could

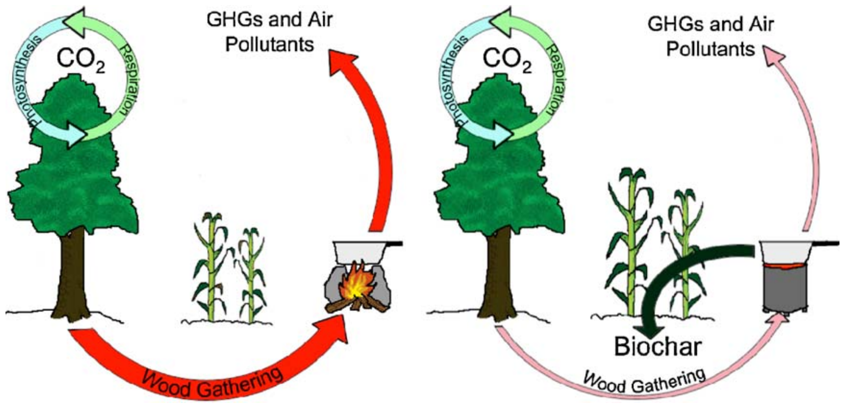

Fig. 2 – Greenhouse Gas Flows in a Traditional Cook Stove System (Left) as compared to a Biochar Cook Stove System (Right).

directly contribute to local sustainable development, by enhancing soil organic carbon, improving nutrient retention, and increasing crop yields (Lehmann et al., 2006). Furthermore, its production in a bioenergy system could use alternative feedstocks, such as crop residues, forest leaf litter or grasses (Yaman, 2004), potentially reducing deforestation pressures. Under this bioenergy system, carbon credits could be earned both from the provision of cleaner energy or fuels to local people as shown for combustion stoves (Johnson et al., 2009) and also from the sequestration of carbon from the addition of the resulting biochar to soil (Lehmann et al., 2006). This sequestration would be secure. The amount of biochar applied to soil can be quantified on a mass basis, and it is identifiable or traceable (Lehmann and Joseph, 2009). Even years later, it would be possible to determine how much of the applied biochar remains in the soil and the biochar would not be at risk of loss due to fire or changed management regimes (Lehmann, 2007). The important issue of additionality is relatively easily addressed: biochar production and application is not currently practiced in agricultural systems, so such a shift in practice would clearly be a deviation from ''business as usual''.

Although it has significant soil health benefits beyond carbon sequestration, initial development and a start to widespread implementation of biochar technologies would require financing through a mechanism such as the CDM. The technical potential for such an approach is high. If biochar-producing cook stove projects were applied to 50% of current household fuel wood burning in Africa (Yevich and Logan, 2003), this could potentially sequester over 100 Mt of CO_2 annually as biochar, creating over 100M CERs from the biochar C sequestration alone.[1] At a price of $13.6 per CER (mean for 2008: Capoor and Ambrosi, 2008), this would be worth around $1.5Bn per year. While, being realistic, it is unfortunately likely that this money would never reach those African communities where projects are being implemented, local communities would still benefit. Biochar-producing stoves have strong sustainability linkages to enhanced soil fertility (Lehmann, 2007) and to improved respiratory health due to reduced emissions of particulates, if they are developed as successfully as improved combustion stoves (Johnson et al., 2009).

Initially, it seems that the potential for such projects could be large, but rapid and extensive field research must be done in advance of significant implementation of biochar as an offset. Rigorous inquiry is also required into those questions behind any offset strategy – is it really appropriate to justify financing emissions reductions in the global south in order to continue to emit GHGs in the global north when the stakes are as high as those we currently face with global climate change? Although improved stoves in general may provide efficiency increases, resulting in decreases in fuel use, attempts to justify credits for reductions in deforestation may be spurious, if the wood left ungathered as a result of stove introduction is simply made available for another use (resulting in ''leakage''). This is one reason the production of biochar and its application to soils is particularly appealing – because of the certainty of its sequestration, regardless of the effects of reduced fuel wood use. The land-use change issues associated with any significant biofuel use (e.g., Fargione et al., 2008) would be somewhat bypassed in a stove system, as long as biomass use is limited by the amount of food that is needed for cooking, and not by the amount of biomass that can be accessed.

4. Conclusions and recommendations

Interest is growing regarding a full evaluation of biochar's potential for mitigation of climate change—a group of eleven African nations and the UN Convention to Combat Desertification (UNCCD) have both submitted papers proposing biochar as an item to be considered during the next rounds of UN climate negotiations (African Governments, 2009; UNCCD, 2009). Our global food system depends on the sustainable management of agricultural soils and biochar could very well be Africa's key to the doors that the CDM was supposed to open toward sustainable development and climate change mitigation. Significant field-level research is

[1] Assuming a wood carbon content of 50% by mass, conversion factor for carbon in fuelwood converted into stable biochar carbon of 40%, and at least equivalent fuel use (as proven for non-pyrolysis improved cookstoves by Johnson et al., 2008), thereby not requiring an increase in fuel use. Note that if the reduction in fuel use were great, then total reduction potential might be lower depending on the fate of the now non-harvested wood.

needed first, but biochar could lead the way for other soil carbon management strategies to improve soil health and provide tangible local benefits while addressing global warming, making it a strong candidate for future incarnations of the CDM and other offset mechanisms in Africa.

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