



The Terrestrial Carbon Group

**Terrestrial Carbon Policy Development:
Innovative Approaches to Land in the
Climate Change Solution**

The 'plus' in REDD+

Agriculture as a driver of deforestation

Increasing soil carbon in forestry and agriculture

Linking agriculture and forestry

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Acronyms

AFOLU	Agriculture, Forestry and Other Land Uses
CDKN	Climate Development and Knowledge Network
CDM	Clean Development Mechanism
COMESA	Common Market for Eastern and Southern Africa
COP	Conference of the Parties
FAO	Food and Agriculture Organization of the United Nations
GtC	Gigatonne of carbon
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
LEDS	Low Emission Development Strategy
LULUCF	Land use, land-use change and forestry
MRV	Monitoring, Measurement, Reporting and Verification
NAMAs	Nationally Appropriate Mitigation Activities
NAPAs	National Adaptation Programmes of Action
OECD	Organisation for Economic Co-operation and Development
REDD	Reducing emissions from deforestation and forest degradation in developing countries
REDD+	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
SBSTA	UNFCCC Subsidiary Body on Scientific and Technical Advice
SFM	Sustainable Forest Management
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations Collaborative Programme between FAO, UNDP and UNEP on REDD

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In a Nutshell: Potential innovative approaches to land in the climate change solution

The 'plus' in REDD+

- Reverse forest degradation
- Encourage sustainable forest management
- Meet demand through off-site substitution
- Provide opportunities for alternative livelihoods

Addressing agriculture as a driver of deforestation

- Recognise that agriculture itself has changing drivers
- Understand when intensive or extensive agriculture is appropriate
- Take practical action
- Reform trade rules
- Use innovative financing options

Increasing soil carbon in forestry and agriculture

- Recognise the different impacts of different land uses
- Address permanence and leakage
- Go beyond incentive payments
- Promote sustainable agriculture
- Recognise the potential of rangelands
- Roll-out and scale-up demonstration projects

Linking agriculture and forestry

- Recognise food security is different at different scales
- Involve the whole value chain in food security
- Create mechanisms to allow decision makers to compare future scenarios
- Make spatial data publicly available for land use planning

1 Introduction

1.1 The importance of land in avoiding dangerous climate change

Land is a crucial component of the climate solution. Human-induced climate change is caused by the build-up of greenhouse gases in the atmosphere. Greenhouse gases have only two other places to go: the oceans and the terrestrial system (including land and vegetation). This means that if the world is serious about avoiding dangerous climate change, terrestrial carbon emissions and sequestration must be part of the solution. Improved management of the world's land (including terrestrial carbon) represents one third of the overall global abatement potential in 2030 (and a half in 2020)¹. It represents 7Gt CO₂e of mitigation in developing countries in 2020, roughly 40% of the 17Gt CO₂e of mitigation required globally². Realising this abatement potential will require the creation of new incentives in the developing world for maintaining existing terrestrial carbon (eg. avoiding deforestation and forest degradation) and creating new terrestrial carbon (eg. afforestation, reforestation, and better soil management).

1.2 The response so far

Many countries are currently working to implement national strategies and action plans that result in land based climate change mitigation and adaptation outcomes. These actions are being driven by the many national, multilateral and bilateral commitments that have been made, particularly in regard to forests and deforestation, and of course the ongoing international climate change negotiations, where land is addressed in a variety of ways. Under the banner of the United Nations climate change talks, discussions are ongoing under two subsidiary bodies. The first is the Ad Hoc Working Group on Further Commitments for Annex I Parties³ under the Kyoto Protocol (AWG-KP). Under the AWG-KP, land in *developed* countries is addressed through discussions on LULUCF, in particular articles 3.3 and 3.4 of the KP and decision 16/CMP.1. Note that under the KP, direct reductions in the business as usual emissions of terrestrial carbon in *developing* nations are excluded (Terrestrial Carbon Group, 2011a). However, the Clean Development Mechanism (CDM), defined in Article 12, does allow for emissions-reduction or removal projects in developing countries to earn certified emission reduction credits. These saleable credits can be used by industrialized countries to meet a part of their emission reduction targets. The CDM is one of three market-based mechanisms under the Kyoto Protocol– the other two being emissions trading and Joint Implementation. While a number of afforestation and reforestation projects have been registered, activities that enhance agricultural (soil and aboveground biomass) carbon sequestration are not yet eligible (UNFCCC, 2011).

The second body, established when the Bali Action Plan (BAP) was agreed in 2007, is the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA). This subsidiary body considers long term cooperation and the means to deliver a strengthened international deal on climate change. 'Enhanced national/international action on mitigation of climate change' makes up section b of the BAP. Components particularly relevant to terrestrial carbon and land based mitigation efforts include:

¹ McKinsey & Company, 2009. Pathways to a Low Carbon Economy: Version 2 of the Greenhouse Gas Abatement Cost Curve, McKinsey & Company. Based on calculation of abatement potential at a cost of less than 60€/tCO₂e.

² McKinsey & Company analysis for Project Catalyst in "Towards the inclusion of forest-based mitigation in a global climate agreement" (Working Draft May 2009). Based on calculation of abatement potential at a cost of less than 60€/tCO₂e. McKinsey & Company analysis for Project Catalyst in "Scaling up Climate Finance: Finance briefing paper" (September 2009). Required mitigation is calculated as the difference between business as usual greenhouse gas emissions and the level of emissions required to stay on a pathway to stabilising greenhouse gas concentrations at 450ppm.

³ Annex I Parties are industrialised countries listed in Annex I to the UNFCCC, and who accepted country-specific emissions targets for the period 2008-2012 in the Kyoto Protocol.

- QELROs: Measurable, reportable and verifiable nationally appropriate mitigation commitments or actions, including quantified emission limitation and reduction objectives (QELROs), by all developed country Parties, while ensuring the comparability of efforts among them, taking into account differences in their national circumstances;
- NAMAs: Nationally appropriate mitigation actions (NAMAs) by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building, in a measurable, reportable and verifiable manner;
- REDD+: 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 (REDD+);
- Agriculture: Cooperative sectoral approaches and sector-specific actions, in order to enhance implementation of Article 4, paragraph 1(c), of the Convention, including agriculture.

The most recent United Nations Climate Change Conference was held in Cancun, Mexico from 29 November to 11 December 2010. Under the resulting 'Cancun Agreements' it was agreed that developing country Parties would be:

- Encouraged (as deemed appropriate given respective capabilities and national circumstances) to implement 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 (REDD+).
- Invited to voluntarily inform the COP of their intention to implement nationally appropriate mitigation actions (NAMAs) and to enhance action on adaptation under the Cancun Adaptation Framework. These actions all have bearing on broader land use issues.
- Requested, when developing and implementing their national strategies or action plans, to address drivers of deforestation and forest degradation, land tenure issues, forest governance issues, gender considerations and safeguards (in this context, SBSTA was requested to develop a work programme that identifies LULUCF activities in developing countries, in particular those that are linked to the drivers of deforestation and forest degradation).
- Invited to enhance action on adaptation through planning, prioritizing and implementing adaptation actions - including areas such as water resources; agriculture and food security; terrestrial, freshwater and marine ecosystems (UNFCCC, 2010c).

1.3 Policy issues requiring further guidance

Given the tasks listed above, it is not surprising that conversations with stakeholders and experts in late 2010 and early 2011 have revealed four key areas where further guidance would be welcomed:

- How can the 'plus' in REDD+ (enhancement of forest carbon stocks, including sustainable forest management) be best achieved?
- How can agriculture be addressed as a driver of deforestation?
- How can soil carbon stocks be enhanced in forestry and agriculture?
- How can agriculture and forestry be linked

This is significant because it shows the importance of considering action beyond forest conservation. For countries to be able to fulfil commitments to protect existing forest, they must be able to address key drivers of land use change and deforestation beyond the forest. While guidance on how to design avoided deforestation schemes under REDD+ have been forthcoming, less attention has been paid hitherto to the broader context of REDD+. In undertaking this project, it became apparent that the linkages between agriculture and forestry, particularly in terms of food security and land use planning, were

another important part of this broader context. Therefore this fourth issue is included as well. Successful management of these four issues will greatly enhance the effectiveness of national approaches to land based mitigation and adaptation.

This report builds upon:

- Interviews with representatives from 8 countries and 10 intergovernmental organisations and research institutes from late 2010 to mid 2011.
- Discussions amongst representatives from 11 countries and 8 intergovernmental and research institutes at the 'Innovative Approaches to Land in the Climate Change Solution: Terrestrial Carbon Policy Workshop', held from 29 to 31 March 2011 in Lusaka, Zambia and co-hosted by the Terrestrial Carbon Group and the Common Market for Eastern and Southern Africa (COMESA).
- Two documents funded by the Climate and Development Knowledge Network (CDKN): A 'State of Play' Assessment of Land Use in the International Policy Response to Climate Change (Terrestrial Carbon Group, 2011a); and A Compendium on Capacity for Implementing Land Based Mitigation: An overview of policy, institutional, economic, and scientific developments in twenty countries (Terrestrial Carbon Group, 2011b).

It is the purpose of this report to consider these issues and outline the challenges, opportunities and possible policy solutions: given current progress nationally and internationally. This report is intended as a starting point for discussion. It is not intended to preclude alternative views or suggestions. In fact, it is hoped that it triggers many alternative ideas.

2 The 'plus' in REDD+: Enhancement of forest carbon stocks, including sustainable forest management

In this report, the 'plus' in REDD+ is taken to mean policy approaches and positive incentives on issues relating to sustainable management of forests and enhancement of forest carbon stocks in developing countries. This 'plus' is crucial. It will not be possible to achieve reduced emissions from deforestation and forest degradation, or forest conservation, without it. Global demand for timber is increasing. And timber remains an important alternative to more emission intensive materials such as steel (Profft et al., 2009).

Finding ways to enhance forest carbon stocks in existing forests means either reversing forest degradation, implementing sustainable forest management and/or reducing pressure through off-site substitution of wood products. The IPCC (Nabuurs et al., 2007) proposed a series of options to reduce emissions and increase sequestration in the forest sector. These include afforestation/reforestation, as well as increasing:

- Carbon density through the reduction of forest degradation;
- Carbon density through planting, site preparation, tree improvement, fertilization, uneven-aged stand management, or other appropriate silviculture techniques; and maintaining or increasing the landscape-level carbon density using forest conservation, longer forest rotations, fire management, and protection against insects; and
- Off-site carbon stocks in wood products and enhancing product and fuel substitution using forest-derived biomass to substitute products with high fossil fuel requirements, and increasing the use of biomass-derived energy to substitute fossil fuels.

2.1 Reverse forest degradation

As pressure from human activities such as agriculture need to be reduced to avoid deforestation, so too do human activities that lead to degradation. Forest degradation can be caused by a range of factors,

including high impact logging fragmentation. Definitions of forest degradation usually relate to canopy cover, ecological function, carbon stocks or other forest attributes (DeFries et al., 2007). In general terms, it is caused when the rate of biomass removal is greater than the rate of regrowth, leading to a gradual decline in overall biomass (DeFries et al., 2007). This is why a major objective of most sustainable management programmes in production forests is to achieve a long-term balance between harvesting and regrowth (Miner, 2010).

Currently, biomass supplies 10.6% of global energy demand. In some developing countries, biomass for energy is used to meet 50-90% of demand, mostly for cooking and space heating (IEA, 2007). Wood removal for woodfuels can also lead to degradation - with fuelwood being the main source of household energy for an estimated 2.6 billion people globally (Sampson et al., 2005). Bioenergy policies can significantly impact on commodity markets, land-use patterns and the environment (Lankoski and Ollikainen, 2011).

In a review of community forest management in West Africa, it was found that many areas of dry forest and savanna woodlands were degraded, meaning that they had 'room to grow' (Skutsch and Ba, 2010). In other words, dry forests represent a major opportunity for carbon sequestration if degradation can be reversed. It has also been found that local communities are able to effectively manage the forests and undertake standard forestry inventory work. While communities may not earn money directly from carbon credits, particularly where funding is directed to a central government body, incentives could still be created through alternative and possibly more manageable approaches. For example, the local community could be paid for the measurement and monitoring of a forest area (Skutsch and Ba, 2010).

Strategies for reversing forest degradation will vary depending on the level of degradation itself. For minor degradation, allowing natural regeneration may be all that is required. For more severe degradation, the use of silvicultural techniques to accelerate tree regeneration or the active planting of new seedlings may be required (Sasaki et al., 2011). The most appropriate course of action will depend on the local context and the level of local participation.

Egypt

Afforestation in Egypt is considered from a multi-functional approach, where it can be an effective tool to prevent erosion, increase food security, protect and reclaim arable lands, combat desertification, decrease pollution and improve the amenity of arid regions for local inhabitants as well as tourists.

In order to protect Greater Cairo from further sand encroachment, and to reduce wind erosion, protect topsoil and combat desertification, the Egyptian Environmental Affairs Agency has distributed 3 million trees for all the Egyptian governorates. The Ministry of State for Environmental Affairs has also constructed 290 nurseries in different governorates, as part of an afforestation effort that involves cultivating a green belt around the city. This effort also includes cultivating green parks and green belts for the main cross-roads (junctions). The Green Belt is an intensive 100km tree belt surrounding Greater Cairo with 600,000 trees, at a depth of 50km. Second and third phases of the green belt are planned, for the ring road at a depth of 25 km and for the new cities emerging in Greater Cairo.

This effort has also resulted in the establishment of new wood industries and new income sources from secondary products like the silk worm and bio-fuel diesel from *Jatropha*. The green belt plantations are irrigated by treated wastewater.

2.2 Encourage sustainable forest management

Global trends indicate that pressure on forest carbon stocks is only going to continue. The global forest products industry is increasingly reliant on planted forests for raw material. In 2005, total planted forest area covered 271 million hectares, or 6.9% of global forested area and supplied about one third of global roundwood (Miner, 2010). So long as the world needs wood, better forest management will continue to

be needed in order to enhance carbon stocks in existing forests. In the long term, sustainable forest management (SFM) strategies aimed at maintaining or increasing forest carbon stocks, while producing an annual yield of timber, fibre, or energy from the forest, are thought to generate the largest sustained mitigation benefit (Nabuurs et al., 2007).

An assessment of China's capacity to sequester additional carbon through forestry found that, even with the goal of adding 40 million hectares of forests by 2020, there are additional gains to be had (Yin et al., 2010). Yin et al (2010) found that if there was a greater focus on improved silvicultural practices and forest governance, efficiency and productivity, significant forest carbon gains could be made in existing forest areas. To combat low growth rates, stand yield and vigour and the failure of the canopy to close, they recommended silvicultural practices such as improvements in:

- Site and species selection;
- Planting density, quality and timing; and,
- Competition, control and thinning.

Another alternative is to concentrate harvests on a smaller forest area and meet timber needs through intensive management. This reduces carbon stocks in one area, but can alleviate pressure on other areas (Nabuurs et al., 2007). In theory, there is great potential to increase forest carbon stocks in production forests because they have marketable value. These revenues can in turn contribute to the protection of other types of forests. When using plantation forests as a tool, there is the need to ensure that the regional / political context is taken into account. There are also important trade-offs to consider. One example is the relationship between water use and tree growth. Young growing forest plantations can have high water usage and there is limited research on the effects of restoration of degraded land on hydrological functioning. However, it is thought that the benefits can outweigh the negatives as trees can deliver improved soil condition and groundwater infiltration (Malmer et al., 2010). It is also worth thinking beyond fast growing forest plantations of exotic species and to consider more diverse options for forest use and forest landscapes (Malmer et al., 2010).

Specific examples of actions:

- Legalising the charcoal making business in order to enable regulation and more sustainable production and management;
- Rehabilitation of degraded sites in arid and semi-arid lands by reducing overgrazing, improving household incomes and integrating forestry into overall land use management; and,

Forest certification is one way to encourage more sustainable forest management. It is also a way to manage the international demand for timber, soy, beef and the impacts that this has on deforestation. Yet, while almost 8% of the world's forests have been certified by independent third parties, forest certification is not extensive in developing countries, with less than 2% of forest in Asia, Africa and Latin America being certified (Miner, 2010). In addition, the maintenance of carbon stocks is not addressed directly in the main programmes for certifying sustainable forest management, though it may be inherent in their requirements (Miner, 2010).

Most forest management activities aimed at enhancing sinks require up-front investments. The duration and magnitude of their carbon benefits differ by region, type of action and initial condition of the forest. At present there is a mismatch between incentives and outcomes, particularly in terms of upfront costs.

Uruguay and Chile

Chile has been a pioneer in the use of market mechanisms to achieve environmental outcomes (World Bank, 2008a). The government of Chile has introduced new measures aimed at improving forest management through a new law which allows for a one time tax credit for the following activities:

- Reforestation of fragile soils, marshes or areas threatened by desertification;
- Recovery and forestation activities for eroded non-arable dry soils; and
- Sand dune stabilization and forestation.

The government of Uruguay is launching codes to support investment in the forestry industry. Forest subsidies of between 20% and 50% of the afforestation cost are available, depending on the species planted, afforestation density, and type of establishment (WFI, 1999; FWPA, 2011). Plantation owners must meet the following requirements to be eligible for these subsidies:

- Afforest in designated priority forest areas
- Afforest with the species indicated by law
- Plant a minimum forest area of 10 hectares
- Prepare a forestry plan for the project that has been evaluated and signed by a professional forest engineer or agronomist
- Ensure that 75% of the original planted density survives after one year of establishment

The General Assembly of the United Nations adopted UN Resolution 62/98 in 2007, establishing the *Non-legally Binding Instrument on All Types of Forests*. This instrument describes sustainable forest management “as a dynamic and evolving concept, aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations” (UN General Assembly, 2007). Under section IV, four global objectives can be found. Under section V, a range of national policies and measures are recommended for member states, including:

- Create enabling environments to encourage private-sector investment, as well as investment by and involvement of local and indigenous communities, other forest users and forest owners and other relevant stakeholders, in sustainable forest management, through a framework of policies, incentives and regulations;
- Develop financing strategies that outline the short-, medium- and long-term financial planning for achieving sustainable forest management, taking into account domestic, private-sector and foreign funding sources;
- Encourage recognition of the range of values derived from goods and services provided by all types of forests and trees outside forests, as well as ways to reflect such values in the marketplace;
- Identify and implement measures to enhance cooperation and cross sectoral policy and programme coordination among sectors affecting and affected by forest policies and management;
- Integrate national forest programmes, or other strategies for sustainable forest management, into national strategies for sustainable development, relevant national action plans and poverty reduction strategies;
- Enhance access by households, small-scale forest owners, forest dependent local and indigenous communities, living in and outside forest areas, to forest resources and relevant markets in order to support livelihoods and income diversification from forest management, consistent with sustainable forest management.

Sustainable forest management can be an important tool for increasing carbon stocks. This is particularly so where countries first map standing forests and establish spatial and zoning for different forest types and different uses. Yet it should be emphasized that forests provide more than timber or climate change mitigation. Carbon is one ecosystem service that forests provide.

2.3 Meet demand through off-site substitution

Another way to reduce pressure on forests is to meet fuelwood, timber and other demands elsewhere. An example includes tree-based land-use systems such as agroforestry.

Agroforestry

Examples of major agroforestry practices in tropical and temperate regions include (from Nair et al., 2009):

- Alley cropping (with fast growing woody species)
- Home gardens (with multistory combinations)
- Multipurpose trees (such as fruit, fuelwood, fodder etc)
- Shaded perennial- crop systems (eg. with cacao or coffee)
- Shelterbelts and windbreaks (to protect from wind damage etc)
- Silvopasture (trees integrated into livestock systems)
- Riparian buffer strips (perennial vegetation)

In particular, outcome based initiatives driven by farmers can form an attractive alternative to project-based interventions that rely upon detailed prescriptions and planning (van Noordwijk et al., 2008). This is because outcome based approaches can be more effective, particularly if they result in self-organizing and adaptive local initiatives rather than projects designed based on previously determined and simplistic cause-and-effect paradigms (van Noordwijk et al., 2008). In Kenya, the Agriculture (Farm Forestry) Rules 2009 aim to promote and maintain farm forest cover of at least 10% per cent of every agricultural land holding. The proposed new constitution, also refers to a target of achieving and maintaining tree cover of at least 10% of the land area of Kenya (Article 69(1)(b)).

2.4 Provide opportunities for alternative livelihoods

Reducing the pressure on existing forest stocks, and reversing forest degradation requires providing alternatives for communities – alternative wood sources and alternative livelihoods. There are different types of forest: production, conservation, and protection. The distinction between different types of forest is important as the drivers will also vary, as will the way to empower local people and provide opportunities for alternative livelihoods. Communities in forests have diverse needs. They should be involved in determining what is best for their community. This may include non-monetary options, such as training in how to use forest products without removing trees, or creative economic measures such as the establishment of community trust funds with requirements for appropriate uses. Women especially need to be involved in this, as they can be overlooked as decision- makers. Payments for Ecosystem Services (PES) are one option - where a certain percentage of payments go directly back to local communities. Another is ecotourism, where communities can again receive the benefits from conservation. As described above, UN Resolution 62/98 calls for enhanced access to forest resources and relevant markets in order to support smallholder livelihoods and income diversification from sustainable forest management (UN General Assembly, 2007). Such diversification can mean that forests still provide livelihoods, but in a more sustainable way. For example, in Cameroon, there is a forestry project where rural enterprises plant trees and when grown, they use the tree products without removing the actual trees (such as seeds, fruit, timber and honey).

3 Addressing agriculture as a driver of deforestation

Looking to the future, analysis by the Terrestrial Carbon Group has found that, although REDD+ remains a very promising mitigation tool, its effectiveness will be limited without complementary measures to address agriculture as a driver of land use change, both within and beyond the forest. This is not least due to the resulting displacement that would occur of agricultural expansion from forest land to areas of other natural land cover (including cerrado, grasslands etc), in effect cancelling out 50% of the avoided deforestation emissions from REDD+ (Terrestrial Carbon Group, 2010).

3.1 Recognise that agriculture itself has changing drivers

Addressing agriculture as a driver of deforestation is complicated by the projected increases in global demands on land for food, fuel and fibre in coming decades. Without serious interventions, it is likely that the world will experience a period of rapid global agricultural expansion and land-use change over the next 40 years. World trade in all agricultural commodities will keep growing. Growth in production will come in part from increasing yields, but will also depend on increased area of production (Miles et al., 2008). In the past 40 years, agricultural land area grew by 500 million hectares (Mha) through the conversion of other land uses, often forest lands (Smith et al., 2007).

When trying to understand or anticipate drivers of land use change, it is too easy to come up with simplistic explanations of population growth, poverty or infrastructure. Change is also driven by individual and social responses to changing economic conditions and opportunities, markets and policies, mediated by institutional and global factors (Lambin et al., 2001). Between 1980 and 2000, more than 55% of new agricultural land resulted from the conversion of intact forests while another 28% came from disturbed forests (Gibbs et al., 2010). In terms of drivers of land use change, the biggest growth in land area devoted to crops was for rice, maize, soybeans and oil palm (Gibbs et al., 2010).

Between 2000 and 2005, the drivers of expansion shifted. DeFries et al. (2010) found that urban rather than rural population growth was associated with forest loss for this time. This is in contrast to the 1980s and 1990s when rural growth rates were found to be more important than urban rates. These results point to the importance of distant urban-based drivers and international demand for agricultural products and energy. It also suggests that small-scale production to support subsistence needs or local markets is no longer the dominant driver of deforestation in many places. Rather, it is urbanization that is leading to increased consumption levels and increased demand for agricultural products (DeFries et al., 2010).

The shift to more large-scale and mechanised agriculture has also played a role. For example, in Mato Grosso, Brazil, deforestation for large-scale cropland and intensive mechanised agriculture accounted for 17% of forest loss in large clearings during 2001-2004. This signalled a significant shift from the more historical uses of cattle ranching and small holder agriculture (Morton et al, 2006). This link between urban population growth and forest loss is stronger in Latin America and Asia than Africa. Likewise, agricultural trade seems to be most strongly associated in Asian countries as a driver of deforestation (DeFries et al., 2010).

At the same time as land has been converted from forest cover, the average amount of arable land per person has also been falling. It fell from 0.39 hectares in 1960 to 0.21 hectares in 2007 (Evans, 2010). Many regions of the world now face a shortage of arable land for additional cropland expansion (Morton et al. 2006). In some areas, cropland itself is being lost due to other uses due to increasing urbanization, industrialization, energy demand and population growth (UNEP, 2009). Widespread land degradation, soil erosion, yield losses due to climate change and changes in the proportion of non-food crops to food crops all have impacts on the available cropland for food production (Foley, 2005; von Braun, 2007; Bai et al., 2008; Kiers et al., 2008). Current projections suggest that an additional 120 Mha – an area twice the size of France or one-third that of India – will be needed to support the traditional growth in food production by 2030, mainly in developing countries, without considering the compensation required for certain losses

(FAO, 2005; UNEP, 2009). These shortages are leading some countries and companies to look elsewhere for their land.

Water scarcity is another factor. 60-70% of the world's current crop production is rainfed (Rost et al., 2009). Losses in yield can result due to unproductive soil evaporation, interception losses, surface runoff and deep percolation below the root zone (Rost et al., 2009). While such water losses can in part be avoided through integrated soil and water management strategies that optimise the use of rainwater, these are not always easily adopted or widespread (WBCSD and IUCN, 2008). In most African regions the major challenge is not the lack of water, but unpredictable and highly variable rainfall patterns with occurrences of dry spells every two years causing crop failure (UNEP, 2009). The demand for irrigated land is projected to increase by 56% in Sub-Saharan Africa (from 4.5 to 7 million ha), and rainfed land by 40% (from 150 to 210 million ha), without considering future ecosystem services losses and setbacks in yields and available cropland (Tweeton and Thompson, 2009; UNEP, 2009).

It is also important to realise that there are links between drivers of energy, food and water scarcity – and hence drivers of agricultural development. Energy and food are converging in a world where energy becomes food and food can become energy. More intensive farming practices usually mean more intensive energy use. Longer supply chains, transport and distribution infrastructure, biofuels and increased water use all drive these feedback loops. Improving producers' access to markets is an important area of investment, but it is also another factor that impacts on these converging sectors (Evans, 2010).

Land tenure insecurity is often cited as a potential driver of smallholder deforestation. It is also proposed as a means of improving agricultural productivity. Yet these relationships are not always clear. For example, in a conservation area in Belize, Wyman and Stein (2010) found that land tenure was not correlated with deforestation. Instead, the leading driver was cattle ranching. This was because the majority of residents were long term occupiers of the land, with a strong perceived land security, irrespective of the actual legal nature of their tenure.

In this case, avoiding deforestation by involving the residents in conservation and tourism activities was only successful where the benefits and incentives were greater than those provided by alternatives such as cattle ranching. In fact, some studies have shown that if conservation benefits are too small, the revenue received can actually be reinvested into better machinery and technology and agricultural expansion (Wyman and Stein, 2010). Muriuki et al., (2010) also found that where tenure insecurity has been prevalent for a long period of time, the provision of tenure security on its own may not address trends in land cover change, with other factors influencing its degree of importance (Muriuki et al., 2010).

There is a difference between actual and perceived tenure security. Land users can have a high perceived tenure security even if in fact the opposite is true. In a study of tenure security in north-east Ghana, poor agricultural production and environmental degradation was caused by factors not related to tenure such as lack of finance, poor soil fertility, inadequate and unreliable rainfall, pests and diseases, inadequate farmlands, bush burning and excessive tree cutting (Bugri, 2008). However, it should be noted that in Ghana the state owns all naturally growing trees while planted trees belong to the person who planted them (Bignoni, 2010). In summary, it appears that tenure security can be a necessary condition, but alone is not likely to result in improved agricultural production and environmental management (Bugri, 2008).

The drivers of agriculture are complex and not always well known. These drivers will also vary for different agricultural systems and economies where the nature of subsistence, smallholder, industrial and commercial enterprises will all vary. There are also a significant number of landholders who are not part of the monetary economy. Each type of agriculture will have different drivers, with different economics and will be influenced differently by trade rules, changing diets and supply and demand. What all this points to the need for policy responses to be flexible and responsive to changing causes of land conversion over space and time (DeFries, 2010).

3.2 Understand when intensive or extensive agriculture is appropriate

In its report on land acquisitions, the World Bank (2010) suggested that the rediscovery of investment in the agricultural sector could be an opportunity for land abundant countries to gain better technology and create rural jobs. However, if managed improperly, it could result in “conflict, environmental damage, and a resource curse”.

Some suggest that the best way to minimise the expansion of new cropland is by increasing the productivity of existing cropland. This concept is referred to as the Borlaug (land sparing) hypothesis. Unfortunately, intensification in itself does not seem to result in land sparing, at least if not accompanied by specific policies and measures to deliver this outcome (Pirard and Treyer, 2010). For example, conservation payments may be necessary to offset lost income that would have been gained through cropland expansion.

Debates over intensive versus extensive agriculture will no doubt continue. Both past intensification and extensification have brought different environmental problems of their own (World Bank, 2008b). Advocates of intensification claim that the climate impacts of intensive agriculture are preferable to the emissions that could result from a global expansion in cropland area (Burney et al., 2010). Yet, there is evidence that the productivity of many intensive systems cannot be maintained with current management (World Bank, 2008b). Another problem is that yield gains and intensification do not necessarily preclude expansion, and might lead to even further expansion because of increased profitability.

Tensions between proponents of industrialized agriculture and smallholder agriculture are not only distracting but also constrain the development of any shared vision for agriculture globally (Negra and Wollenberg, 2011). Nationally, many agricultural policies are disjointed and lack linkages with relevant non-agricultural policies. For example, biofuels account for only about 1.5 percent of transport fuel use worldwide today but their use is likely to increase (IEA, 2007). Shifts to conservation farming, increased water protection and more efficient biofuel processing are likely to improve the social acceptability of biofuels. To achieve this, closer coordination is needed between biofuel policies, forestry and agri-environmental policies (Lankoski and Ollikainen, 2011).

Where agricultural expansion is to be prevented, then rural economies will need to be diversified and alternative livelihoods created. If not alternatives are available, then business as usual will continue. In this context, rural poverty is an overarching issue with many connections to other factors, including sustainable forest management.

3.3 Take practical action

Small wins are just as important, if not more so, than grand plans. Tangible, practical and decisive actions can be important not just for their immediacy, but because they create a pattern of success. A “strategy of small wins” can build a solid foundation for further action, which can be adapted in response to feedback and to changing conditions and opportunities as they arise (Weick, 1984, p. 40).

Policies and incentives are needed to encourage sustainable land management but not create dependency. It is proposed that greater integration of sustainable land management considerations into mainstream agricultural development planning will help achieve a more holistic approach to agricultural development and climate change adaptation and mitigation (FAO, 2010).

A shift to more sustainable agricultural systems will require changes in production systems in order to increase resilience and regenerative capacity. Such changes could include:

- Reducing post-harvest losses (UNCTAD, 2010)
- Using locally sourced inputs (UNCTAD, 2010)
- Renewable bio-energy systems (UNCTAD, 2010)
- Knowledge- and labour- intensive rather than agro-chemical and energy-input intensive systems (UNCTAD, 2010)
- Conservation farming
- Precision agriculture
- Integrated water management and integrated crop management (WBCSD and IUCN, 2008)
- Specific practices such as composting, cover crops, mulching, crop rotation, stubble retention, green manure and intercropping.
- Tree-based agricultural systems, such as agroforestry, for increasing productivity and sustaining smallholder livelihoods (ICRAF, 2009).

Collective resource management activities could include:

- Restoration of degraded areas to improve soil quality (FAO, 2010a)
- Improved management of communal water resources (FAO, 2010a)
- Informal seed systems to facilitate the exchange of plant genetic resources (FAO, 2010a)
- Greater roles for small-scale farmers and farmer organisations (UNCTAD, 2010)

Tensions still exist between technology driven conservation agriculture and traditional approaches such as slash and burn agriculture. Yet, technology plays a role, not least in terms of access to equipment access, the role of local entrepreneurs, and the need for nutrients such as lime applications reducing the need to burn stubble, green manure to replace artificial inputs, the importance of nitrogen, phosphorus, and potassium. Alternatives to maize are needed. Improved food storage, weed management, and integrated pest management are also important actions. Gradual change is as important as sudden change. Time is needed for the development, testing and evolution of new technologies.

Many proponents highlight the importance of finding alternative high-yielding farming practices that are less detrimental to ecosystems and the societies that rely on them (Licker et al., 2010). For example, given that Africa imports 90% of its agrochemicals, UNCTAD (2009) suggest that “Africa should build on its strengths – its land, local resources, indigenous plant varieties, indigenous knowledge, biologically diverse smallholder farms and limited use (to date) of agrochemicals” (UNCTAD, 2009).

Prominent options for reducing emission in agriculture include improved crop and grazing land management, restoration of organic soils that have been drained for crop production and restoration of degraded lands. Additional actions include agro-forestry, set-asides, cropland conversion and improved livestock and manure management. Implementation of such measures will only be possible with appropriate policy programmes and economic incentives (Smith et al., 2007).

In essence, practices which increase the input of carbon through photosynthesis or decrease the loss of carbon through respiration, fire or erosion will sequester carbon through the increase in carbon reserves. Increasing carbon reserves is not the only consideration. Other gases can also be affected (Smith et al., 2007). There is no point adding more nutrients to promote soil carbon gains if these additions result in higher N₂O emissions instead. More research is needed on the tradeoffs and cross-sector interactions of reducing emissions and building carbon stocks in agricultural landscapes (ICRAF, 2009). Likewise, a focus

on improving the emissions efficiency per unit of production shouldn't cloud a focus on total cumulative emissions as well.

There are innovative approaches to demonstrations, extension and education that can be learnt from. Field plots need to be of an adequate size, and field demonstrations need to be designed appropriately. There are valuable lessons in the experiences of farmer field schools. Indigenous knowledge of farmers is also important to success.

3.4 Reform trade rules

Many argue that the global trading system itself needs to be redesigned to maintain the economic viability of agriculture as well as environmental sustainability (Kissinger and Rees, 2009). Yet suggestions on exactly how to realistically achieve this are not easy to find. In recent years, negotiations over market access and domestic support have not gone well and it is not likely that issues of free trade in relation to environmental and social sustainability will be addressed in the near future (Dibden et al., 2009).

The 'traffic light' scheme originated under the Uruguay Round of trade negotiations from 1986-1994. During this time, the World Trade Organisation was established, as was the Agreement on Agriculture (AoA). The AoA ranks subsidies based on their link to production decisions and ability to distort trade (Dibden et al., 2009). Subsidies are placed in amber, blue and green boxes.

- Amber box: all subsidies related to production quantities
- Blue box: payments designed to limit production and area based payments
- Green box: agri-environmental payments under rural development schemes

In terms of rewarding beneficial climate change mitigation by agriculture through the use of subsidies and conservation payments, there can be constraints imposed by trade rules. Under the WTO Agreement on Agriculture (AoA), subsidies will qualify for the environmental component of the "green box" if they are limited to the extra costs incurred by farmers (Blandford and Josling, 2009). Part of the problem is that the WTO was essentially created to resolve disputes over market access and issues of demand. It is less well equipped to deal with concerns over security of supply and the trade risks that arise with scarcity – issues that have become more relevant in recent years (Evans, 2010).

In order to create an enabling environment and change the incentive structure as part of targeted agricultural and fiscal policies that strengthen sustainable agriculture practices, UNCTAD (2010) suggests that policy measures at the international level could include:

- More diversified international supply chains with reduced reliance on a small number of agro-companies;
- Reformed international trade policies that are supportive of ecological agriculture; and,
- Improved market access for developing country producers.

The important thing is to ensure that any trade arrangements that open national agricultural markets to international competition must not come before basic national institutions and infrastructure are in place. Otherwise local agricultural sectors can be undermined (Kiers et al., 2008).

3.5 Use innovative financing options

There are innovative financing and insurance options that could be learnt from, more widely adopted and scaled up. Examples include insurance programmes (including insurance for inputs), marketing systems, access to credit and finance to build assets, and diversified rural economies and markets. Diversified farm systems are also important; along with other mechanisms for reducing risk. The private sector has a role, not least because the 'demand side' needs to be integrated into any action on supply.

There are challenges to using a regulatory approach in agriculture, meaning that there tends to be a greater focus on providing direct or indirect incentives to farmers to adopt changes in production practices that result in improved environmental outcomes (Blandford and Josling, 2009). For example, regulatory action such as imposing performance standards for the agricultural and food sector would require sanctions for producers who do not conform. The problem is that it can be difficult to administer, with an adequate monitoring and inspection program required to identify non-compliance and put in place sanctions.

Due to the specific nature of many land based activities, there is the risk that they will be again left out of financing mechanisms if ways can not be found to adequately take in to account these sector specific needs (FAO, 2010a). In order to incentivise alternative approaches to agriculture, national policy measures could include promoting:

- Non-traditional sources of finance, improved financial services and credit access (FAO, 2010a; UNCTAD, 2010);
- Greater focus on marketing and commercial services (FAO, 2010a);
- Insurance programmes and safety net programmes;
- Modified tax and pricing structures (UNCTAD, 2010); and,
- Incentives to improve the management of previously cleared land (Gibbs et al., 2010).

Small farmers have a limited asset base to absorb carbon project risk (Shames and Scherr, 2010). For this reason, the FAO (2010a) suggests public financing for mitigation at the sub-sectoral or regional level, rather than smallholder scale (FAO, 2010a). Another solution could be a hybrid model, where the carbon payment is distributed between the farmer, the community, broader conservation initiatives and project monitoring and management (Shames and Scherr, 2010). Alternative sectoral approaches are possible too. Agribusiness and the food industry also both have the potential to reduce transaction costs by implementing mitigation projects within their existing supply chains and corporate infrastructure (Shames and Scherr, 2010; Negra and Wollenberg, 2011).

Kenya

M-PESA was developed by mobile phone operator Vodafone and launched commercially by its Kenyan affiliate Safaricom in March 2007. M-PESA is an electronic payment and store of value system that is accessible through mobile phones. It has been adopted or trialed by 9 million customers (equivalent to 40% of Kenya's adult population). M-PESA was originally conceived as a way for customers to repay microloans (Mas and Radcliffe, 2010). However, as it was market-tested, the focus shifted from loan repayments to money transfers. After registering, customers are assigned an individual electronic money account that is linked to their phone number and accessible through a SIM card on the mobile phone. The significant of M-PESA is that it has demonstrated the promise of leveraging mobile technology to extend financial services to even the poorest who do not have bank accounts (Mas and Radcliffe, 2010). The applications of M-Pesa go beyond banking. A new farm insurance program, Kilimo Salama ("Safe Agriculture"), uses M-PESA to distribute insurance payments to farmers. It was launched under the Agricultural Index Insurance Initiative, a partnership between UAP Insurance and the Syngenta Foundation for Sustainable Agriculture (SFSa). The product is implemented in partnership with the agribusinesses MEA Limited and Syngenta East Africa Limited, the telecommunications company Safaricom, the Kenya Meteorological Department, and the NGO CNFA/AGMARK (Syngenta Foundation, 2010).

In many countries, non-climate policies related to macroeconomics, agriculture and the environment can have a large impact on agricultural mitigation, sometimes more so than climate policies alone (UNFCCC, 2008). Examples of policies that may have cross sectoral impacts include land and tenure reform, improved governance and decentralization (Angelsen, 2010). Positive results can also come from policies that

support micro-enterprise development which reduces reliance on land and provides alternative livelihoods that require less space (Muriuki et al., 2010). At present, there is a growing gap between the number of new rural workers and the number of new jobs in sub-Saharan Africa, South Asia, the Middle East and North Africa (World Bank, 2008b). This means attention also needs to be paid to the rural non-farm economy as a provider of employment.

In the context of agriculture, financing mechanisms may need to overcome conceptual divisions between adaptation and mitigation and between climate change and development activities (FAO, 2010a). The adoption of improved agricultural practices can potentially result in both mitigation and adaptation (FAO, 2010b). The FAO is recommending an international work programme on agriculture that identifies guidelines for identifying where potential synergies and trade-offs exist across mitigation, adaptation and development objectives, including food security and poverty (FAO, 2010b). Indeed, when it comes to agriculture, mitigation may be more of a co-benefit facilitated by additional incentives that build on other actions such as adaptation (Negra and Wollenberg, 2011).

4 Increasing soil carbon in forestry and agriculture

4.1 Recognise the different impacts of different land uses

Soils are a major provider of ecosystem services (Sanchez et al., 2009). Meanwhile, soil carbon sequestration (enhanced sinks) holds 89% of the technical mitigation potential of agriculture (Smith et al., 2007). Soil carbon refers to the total carbon in soils and includes both organic and inorganic carbon (Walcott, 2008). The global soil carbon pool is about three times the size of the atmospheric pool and almost 4 times the size of the vegetation pool. This means that any proportional change in the soil carbon pool will have a significant effect on the global carbon budget (Nair et al., 2009). In terms of sequestration, most focus is on organic carbon, which has shorter timescales for cycling with the atmosphere than inorganic carbon (decades compared to thousands of years).

The organic carbon content of the soil is the balance between the rate of carbon deposition and the rate of carbon loss (Wang and Dalal, 2004). The major inputs are dead plants, animals and microbes, which decay through different processes and at different rates depending on their composition. The components of soil organic matter are defined by the stage of decay, which in turn influences soil function (Walcott, 2008). Rates of soil organic carbon (SOC) sequestration in agricultural and restored ecosystems will depend on soil texture and profile characteristics. These rates can also vary significantly depending on climate (Lal, 2004).

Of particular importance is how SOC changes with land use change. When land use change occurs, the equilibrium between carbon inflows and outflows in soil is disturbed. Eventually a new equilibrium is reached in the ecosystem. Even so, there are considerable uncertainties regarding the degree of change in soil carbon stocks following the transition from one vegetation type to another (Murty et al., 2002).

According to meta-analysis by Guo and Gifford (2002), soil carbon stocks *decrease* after land use changes from:

- Pasture to plantation;
- Native forest to plantation (in some instances, a broadleaf plantation placed on to prior naturally regenerated secondary forest or pasture did not affect soil carbon stocks, whereas pine plantations reduced soil carbon stocks); and,
- Native forest to crop (soil c stocks are halved in the topsoil but not affected at depth).

Soil carbon stock *increase* after land use changes from:

- Native forest to pasture (when forest is cleared to establish pasture, consideration aboveground carbon in vegetation is lost, while there may not necessarily be declines in soil carbon);
- Crop to pasture;
- Crop to plantation; and,
- Crop to secondary forest.

Soil organic carbon (SOC) is an extremely valuable resource. High SOC levels are essential for improvements in water and nutrient holding capacity, soil structure and biotic activity – all responsible for maintaining consistent yields and potentially improving productivity and reducing agricultural pressures on forests (Lal, 2004). Murty et al. (2002) found that the conversion of forest to cultivated land led to an average loss of approximately 30% of soil carbon. Meanwhile, a transition from forest to pasture led to no significant changes in soil carbon or nitrogen. Their study also found a relationship between changes in soil carbon and system nitrogen, which has implications for carbon to nitrogen (C: N) ratios and in turn microbial activity and decomposition. This is important because carbon is only one of the key elements of humus (Lal, 2004). Lal (2004) estimated that 1 Gt of carbon sequestration would require 80 million tonnes of nitrogen (N), 20Mt of phosphorus (P) and 15 Mt of potassium (K). This compares to the aggregate global consumption of fertilizer in 2008/09 of approximately 156 Mt for N,P,K (IFA, 2009). Sources for such elements could include biological nitrogen fixation, recycling from the subsoil, aerial deposition and the use of biosolids and crop residues (Lal, 2004). In addition, enhancing SOC stock increases the soils capacity to oxidize methane (CH₄), especially under no-till farming, but can also exacerbate emissions of nitrous oxide (N₂O) (Lal, 2004). This is why it is important that fluxes of CH₄ and N₂O are also considered along with SOC sequestration (Lal, 2004).

4.2 Address permanence and leakage

It is important to realize that there are non-permanence and leakage risks in agriculture just as there are in other sectors. While agriculture accounts for approximately 10-12% of total global anthropogenic emissions of greenhouse gases, proportionally, CO₂ emissions account for only 9% of the total, while N₂O accounts for 46% and CH₄ accounts for 45% (Smith et al., 2007; UNCTAD, 2010). So, while carbon sequestration is important, so too is full accounting for all greenhouse gases. That said, it should be possible to design approaches that deal with leakage. Examples of modalities/procedures could include national/sectoral/sub-sectoral approaches, conservative approaches, buffers and insurance (FAO, 2010b).

The limit to carbon sequestration, after which soil carbon can no longer increase, is referred to as carbon saturation. This limit can vary depending on soil condition (Walcott, 2008). Soil sink capacity and permanence are related to clay content, mineralogy, structural stability, landscape position, moisture and temperature regimes and ability to form and retain stable micro-aggregates (Lal, 2004). The implication is that soil carbon sequestration payments would not be made in perpetuity, whether the saturation point is reached in 20 or 100 years. However, short-term payments may be feasible and deliver permanence where they result in the transition to more productive and resilient agricultural systems (FAO, 2010a).

4.3 Look beyond incentive payments

It is often assumed that incentive payments will lead to carbon sequestration taking place on marginal lands, due to lower opportunity costs. Yet, land with favourable soil and climatic properties may have a higher carbon sequestration potential than marginal land. In addition, more productive lands may have more crop residue and biomass to work with, potentially outcompeting marginal lands in terms of effectiveness at sequestering carbon, from both a biophysical and economic point of view (Antle and Stoorvogel, 2008).

This challenges the assumption that carbon sequestration activities will be focused on marginal lands, at least where only economic forces are at play. In such circumstances, where poor farmers are located in marginal semi-arid areas with sandy soils and higher rates of land degradation, impacts on poverty are also likely to be relatively small (Antle and Stoorvogel, 2008). In other words, it won't necessarily remediate the reality that Lal (2004) described as "marginal soils with marginal inputs produce marginal yields and perpetuate marginal living".

Carbon payments alone are not likely to transform unsustainable systems into sustainable ones. Like most payment for ecosystem services, they are more likely to have a positive impact in an enabling economic and institutional context (Antle and Stoorvogel, 2008). It is also inevitable that some forms mitigation at the scale of smallholder agriculture will not be cost effective, meaning alternative approaches will be required (FAO, 2010a).

The challenge is that, for now, the buyer market for agricultural carbon remains quite small (FAO, 2010a; Shames and Scherr, 2010). At the UN Climate Change Conference in Cancun in December 2010, agreement could not be reached on a key area of the Bali Action Plan - sectoral approaches and sector-specific actions, including agriculture. In effect, this means that there is unlikely to be an international framework for incentivising soil carbon sequestration in the near future. At present, the Clean Development Mechanism (CDM) largely excludes agriculture. The World Bank's BioCarbon Fund and some voluntary carbon markets do include soil carbon.

There is a widespread lack of understanding of what soil carbon is, and how it fits within a bigger picture of soil health and productivity. At the national level, soil carbon should be couched within a broader policy framework of sustainable land management, agricultural productivity and food security. In other words, soil carbon should be conceptualised as one component of an integrated system that reflects the nature of the agricultural sector and systems for food, fuel and fibre production. At present there is a lack of policy vision and strategy from the agricultural sector in countries in which soil carbon could have a place. A more diversified response is needed at the international level, beyond carbon markets. There is scope to encourage enhanced soil carbon through NAMAs, NAPAs and also non-UNFCCC mechanisms and green growth strategies. It may also be possible to develop policies that deliver an incentive for a related activity, rather than the actual production of soil carbon. In other words, carbon is the co-benefit, not the other way around.

Mexico

Payments for carbon in Mexico began in 2004 as part of a wider programme: Payments for Carbon, Biodiversity and Agroforestry Services (PSA-CABSA). This programme complemented the Payments for Watershed Services (PSA-H) which was established in 2003. By 2008, there were over 2600 communities and individuals receiving payments under the two schemes, covering an area of more than 1.75 million hectares. Administered by the National Forestry Commission (CONAFOR), payments are usually for a period of five years. The challenge for these projects will be to secure long-term funding, potentially through international channels such as the Clean Development Mechanism and voluntary carbon markets. The experiences gained in implementation provide important lessons for the implementation of market based mechanisms for climate change mitigation in both agriculture and forestry (Corbera, 2011).

4.4 Promote sustainable agricultural practices

SOC can be enhanced through sustainable agricultural technologies such as no-till farming, composts and mulching, leguminous cover crops, water harvesting, agroforestry, integrated farming systems and the careful use of chemicals (Lal, 2004). Though improved agronomic yields in rain-fed agriculture, low SOC stock can be also enhanced. These improvements can come from improved water conservation, water harvesting and water-efficient farming systems (Lal, 2004). Despite this, it is important to note that there are no guarantees for the sequestration potential of no-till. The benefits can be overemphasised and there have been different results reported for no-till versus conventional-till farming, not all resulting in an increase in SOC pool in NT (see for example Christopher and Lal, 2009). There is also evidence that it is the combination of conservation farming practices, rather than isolated treatments, which can lead to improved CO₂ mitigation potential - such as no-till, stubble retention and N fertilization combined. See for example Wang and Dalal (2004). In more recent work on vertisols in a semiarid subtropical region, Dalal et al. (2011), found that tillage effects on SOC and soil total N were small. While crop residue retention and N fertilisation did have benefits/ particularly in the early years, it does not seem that these benefits keep accruing over time.

Zambia

The Conservation Farming Unit (CFU) was established in 1995 to develop and promote the adoption of Conservation Farming (CF) and Conservation Agriculture (CA) practices by Zambia's small-scale farming community. The CFU was established in response to the realization that, even in good seasons, the majority of small-scale farmers in Zambia are unable to produce adequate quantities of food to feed their families until the next harvest. It was also acknowledged that conventional cultivation practices, including deforestation and burning, were unsustainable and were leading to significant environmental degradation in some areas of the country (Conservation Farming Unit, 2011). It was around this time that the Government of Zambia endorsed the promotion of CF as national extension policy. The government says at least 180,000 small holder farmers are now using CA principles, covering 325,000 hectares, with a focus on minimising soil disturbance, maintaining a permanent soil cover and promoting crop rotation (Bafana, 2010).

4.5 Recognise the potential of rangelands

From a carbon point of view, grassland ecosystems, including rangelands, are very important. Grasslands occupy two-thirds of global agricultural area and represent a major terrestrial carbon stock which has the potential to be increased with appropriate management (FAO, 2009; Neely et al., 2009). Globally, there are approximately 120 million pastoralists who are responsible for more than 5000 million hectares of rangelands, which store up to 30% of the world's soil carbon (Tennigkeit and Wilkes, 2008). Estimates suggest that improved rangeland management has the biophysical sequestration potential of 1300-2000 MtCO₂e up to 2030 (Tennigkeit and Wilkes, 2008). This technical mitigation potential of grasslands is greater than that for methane emissions from ruminant animals or manure management emissions (FAO, 2009).

Reversing land degradation in extensive dryland areas through improved pasture and rangeland management has the potential to significantly improve the global soil carbon sink and have both mitigation and adaptation benefits (Neely et al., 2009). Improved management of grasslands is also critical to food production and sustainable development in many countries as well as to the one billion people who depend on them (FAO, 2009). Grassland management interventions that can increase carbon inputs to the soil, increase above ground woody vegetation and reduce losses in vegetation include (FAO, 2009):

- The introduction of new species and varieties;
- Fire management;
- Restoration of organic soils and degraded lands;

- Extending the use of perennial crops;
- Increasing tree cover in silvopastoral systems;
- Managing grazing intensity and duration/periodicity; and,
- Improving pasture quality.

As with smallholder cropland based carbon finance projects, the need for aggregating carbon assets and the potential role of organisations as ‘aggregators’ should to be considered (Tennigkeit and Wilkes, 2008).

Here, it is also worthwhile highlighting the potential role of livestock in extensive rangeland systems. The challenge for policy makers, researchers and practitioners will be to envisage new ways to integrate animals into ecosystems in order to foster regeneration, rather than reduce resilience. This is particularly the case in complex ecosystems that need “gentle continual disturbance” in order to flourish (Janzen, 2011, in press).

4.6 Roll-out and scale-up demonstration projects

A key barrier to action on enhancing soil carbon is the lack of evidence on what actually needs to be done. In turn, it is unclear what value soil carbon actually has in terms of productivity and sustainability. At present, carbon research is commonly organised around major land classes – forests, croplands, grasslands and drylands, and wetlands and peatlands (Terrestrial Carbon Group, 2009a). While much is already known and considerable capacity and expertise is available, research and information synthesis for carbon management techniques have not been equally distributed across carbon pools, land use types, and regions of the world (Terrestrial Carbon Group, 2009a). The development of cost-effective, easy to use tools and methodologies and spatially-resolved, accurate data-gathering is needed to expand focus to all land classes (including complex landscapes), regions, and carbon pools.

Today, it is technically possible to measure and monitor all major carbon pools using existing methods and systems (Terrestrial Carbon Group, 2009b). However, there is considerable variety among countries in their ability to measure and monitor all types of terrestrial carbon. While some have sophisticated measurement and monitoring capacity, in general, non-Annex I countries have limited data-gathering capacity and access to reliable existing datasets and conversion equations. Existing reports and international guidance provide a solid foundation for current and future work. However, there are significant differences in guidance for reporting emissions and sequestration across scales and sectors and streamlined processes are needed for approving consistent definitions, standards, and methodologies. Efforts to improve convergence and consistency can produce synthesized scientific knowledge, harmonized reporting guidelines and methodologies, compatible terminology, definitions, and classifications, and integrative modelling. Likewise, expanding and building regional and global networks can provide needed linkages across field research and technological advancements and facilitate access to tools, databases, technical support, infrastructure, and extension services.

GlobalSoilMap.net

A global effort to produce the world’s first freely-available, fine-resolution (~100m), 3-dimensional digital map of the world’s soils began in 2006, and was officially launched in 2009 (Sanchez et al., 2009). The collaboration between scientists and organisations around the world is an initiative of the Digital Soil Mapping Working Group of the International Union of Soil Sciences. The aim is to fill an information gap by providing accessible quantitative, up-to-date and spatially referenced data on soil properties for the whole world. There are currently 8 nodes: South Asia, East Asia, EurAsia, Latin America and Caribbean, North America, Sub-Sahara Africa, Central and West Africa – North Africa, and Oceania. The official launch of the Oceania Node (Australia, New Zealand, Indonesia and the Pacific Islands) took place in February 2011. See www.globalsoilmap.net for more information on this project.

Diverse local, national, and regional circumstances can be accommodated by developing a regionally-relevant mix of management practices, measurement approaches, conversion equations, and models as well as planning for changing regional climatic conditions. Even so, there is a lack of clarity around how much it will actually cost, what capacities are needed and who should be responsible. Demonstration projects would be valuable where they contribute to the evidence of the benefits of soil carbon for factors such as productivity and soil fertility and a greater understanding of permanence. Comprehensive soil inventories are needed to facilitate both this understanding and MRV. National soil inventories are a good first step, followed by adequate MRV systems. Greater capacity will be needed to implement these actions, including institutional capacity. The high cost of MRV also needs to be addressed. Greater evaluation is needed of both the costs and benefits of the range of options (and incentives) available to increase soil carbon. NAMAs are a possible way to get started. Lessons can also be learnt from a range of existing responses including the CDM and A/R, Voluntary Carbon Standard, MRV in the forestry sector, the process of creating inventories of land use and emissions in individual countries, including projects to quantify soil carbon.

5 Linking agriculture and forestry

As described in section 1, it is clear that linkages between agriculture and forestry add another important dynamic affecting the broader context and responses to it by both policy makers and individual decision makers on the ground. Here two issues at the nexus of multiple land uses are considered: food security, land use planning.

Common solutions for managing these linkages include better land use planning, scenario modelling, cross sectoral cooperation in the public and private sector and inter-district, inter-state and international cooperation across borders. There must also be a mandated national organisation with the responsibility and power to ensure this cooperation takes place.

5.1 Food Security

In using the term food security, we mean the definition as accepted by the FAO that: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". Every year, even in good years, households can still have days when they have no access to food. Food security at the household and local level is different to food security at the national level. There are misconceptions about food security based on the fact that these differences are not recognised. Food security is an issue for the whole value chain. It is not just about one crop or one portfolio - food security extends beyond the agricultural ministries, and needs to involve ministries of health, employment, finance, planning.

As for agriculture, practical actions are required, from addressing food storage problems to making appropriate technology available, including seeds and fertilizers. Policy development and implementation needs to involve participatory action, cross-ministry involvement and targeted communications.

Malawi

Gliricidia, *Tephrosia*, *Faidherbia* and other leguminous cover crops are potential tools for farmers seeking to adapt their agricultural systems to better cope with adverse climate change (Garrity et al., 2010). In addition, the use of 'fertiliser trees' such as *Faidherbia* can be effective in reducing reliance on inorganic fertilisers, especially in areas of low soil fertility. In Malawi, crops have been cultivated under *Faidherbia albida* for generations. Given the associated improvements in maize yields, the Government of Malawi launched an Agroforestry Food Security Programme in 2007. This programme provides tree seeds, nursery materials, and training for a range of agroforestry species, including fertilizer trees (Garrity et al., 2010).

5.2 Land Use Planning

Land-use planning involves determining which area of land will be used for what purpose so as to optimise sustainable development outcomes. Land use planning is inherently political. There will always be winners and losers, so decisions (and tradeoffs) must be made. This means that process is important – involving all stakeholders is key. This may extend beyond national borders. There is also the need for agencies that go across borders. Lessons can be learnt from the management of RAMSAR sites, International Heritage Sites, the Kavango-Zambezi TFCA and the Nile Treaty and watershed management in the Mekong. There needs to be political support at the highest level for land use planning to be possible and effective. This will require the streamlining of conflicting policies across sectors, and true collaboration between government departments. There are lessons to be learnt from previous experience, with many examples around the world showing the need to reconcile the objectives of different ministries.

Mechanisms are needed to allow decision makers to compare various pathways and directions. A key issue is the need for publicly available spatial data to allow for spatial planning and for stakeholder input into the process. Not all spatial planning is equal - there is good and bad - depending on how economic and ecological factors are reconciled. A publicly available online tool to allow for hypothetical 'scenarios' to be tested could be useful to simulate the consequences of decisions, raise awareness and envisage alternative futures.

There is a need for both top down and bottom up planning that goes beyond the short term needs of high-value industries such as mining, towards a direction based on national interest. At the international level, there is a need for a high level organisation(s) or forum(s) to mandate, develop and enforce specific agreements in relation to certain land use resources and conservation. Lessons could be learnt from the WTO process.

At the national level, an effective approach would include:

- Integrated land use planning, policy and regulations
- A recognized authority to categorize protected versus open land, top-down to bottom up, with regulatory mechanisms
- Inter-institutional coordination mechanisms
- Involvement of stakeholders at various levels and from competing interests
- Spatial databases

Eururalis

The ambition of the EURURALIS project is to develop a discussion oriented tool to support policy makers in discussions about the future of rural areas in the European Union with scientifically sound data and methodologies. Eururalis 1.0 and 2.0 were initially developed with help of the former Dutch Ministry of Agriculture and it is now supported by several EU countries. An important feature of the EURURALIS toolbox is the consistent linkage between economic and biophysical domains and the linkage between global and local scales. The Eururalis modelling framework links three models: LEITAP, IMAGE, and CLUE-s(Prins et al, 2011). Maps and graphs indicating a variety of possible futures for Europe, with four plausible main scenarios as starting points. Version 1.0 was released in 2004 and Version 2.0 followed in 2007. The focus was especially on Europe. Eururalis 3.0, released in 2010 and funded by the Dutch Ministry of Economic Affairs, Agriculture and Innovation, includes innovative methodologies for policy assessment (e.g. a new agro-biodiversity indicator) and the assessment of the impact of the agricultural policies on people, planet and profit indicators and land use. The EURURALIS is looking to broaden its scope and application globally through the development of sustainability impact assessment tools for all countries in the world. In particular, this scenario modelling and spatial analysis tool could have broad application across developing countries. For more information go to: <http://www.eururalis.eu>

A related process to land use planning is low emission development strategies. At least 30 Annex I countries and 16 non-Annex I countries that have produced a national climate change strategy or LEDS to date (OECD, 2010). Non-Annex I countries included Bangladesh, Brazil, Chile, China, Costa Rica, Guyana, Honduras, India, Indonesia, Korea, Mexico, Peru, South Africa, Tajikistan. Almost all included the agriculture and forestry sectors. In an overview of these LEDS, the OECD (2010) found that there is no single common formula for a LEDS and the scope and content will depend on national circumstances. However, common critical factors for success included: identifying priorities, maintaining a flexible approach in line with national economic development priorities, and providing transparent and objective analysis through a collaborative process (OECD, 2010).

6 Where to from here?

6.1 Allow time for transition

Full implementation of all the essential functions and organisations required for a comprehensive system to deliver terrestrial carbon mitigation will require an evolutionary process, planning for which means taking a long-term view. It means considering not only the systems to be established today, but how these systems will be compatible with the later inclusion of other land uses (Terrestrial Carbon Group, 2009c). For example:

- The functions and institutions (including reserves, registers and exchanges) originally established for REDD+ will need to be “upwardly compatible” with the later inclusion of agriculture and other land uses;
- Common data requirements of different land uses should be determined to allow the coordination of data gathering and interpretation in these areas, even if one land use will not be phased into the accounting until after another. This will avoid duplication and maximise effectiveness of the resources available; and,
- Credible Quality Assurance / Quality Control procedures will be required to ensure that we can form a global picture of emissions and sequestrations from land use sectors covered by international and national responses.

Generating the economic impetus for such action will inevitably require a mix of sources of funding including international funds, and international trading – under bilateral, multilateral and/or global arrangements - where the unit of product is based upon emissions reduced or carbon sequestered. To be scalable and sustainable over the long run, long-term effective participation of both the public and private sectors in both developing and developed countries will be required. In practical terms, to achieve scale and sustainability, the system must be flexible and take into account evolving capabilities and resources over time. It must be capable of delivering the necessary mitigation potential from the AFOLU sectors, starting with REDD+.

Time needs to be allowed for new policies and frameworks to work. Too often reforms are abandoned before they’ve had a chance to evolve. As has been highlighted in this report, local context is important. Just as it is important not to generalise too much from context specific successes, so too is it important not to generalise too much from context specific failures.

6.2 Get the institutional framework right

In their report on “Growing within Limits” (van Vuuren and Faber, 2009), the Netherlands Environmental Assessment Agency called for “appropriate institutional conditions” to drive the innovation and fundamental transitions needed to bring about a green economy. It seems that this is the key challenge - figuring out what such institutional conditions might be and how effective policies might be designed.

Perhaps most importantly, what we still need are more concrete examples of low carbon, climate resilient growth (Evans, 2010). Now more than ever, we need innovation policy approaches for land.

REDD+ may be new but there are lessons to be learnt from other initiatives such as forest certification, community-based natural resource management and integrated conservation and development projects (ICDPs). In an assessment of past experience with ICDPs, Blom et al. (2010) found that the following were important lessons for REDD and tropical conservation at the project scale:

- Have measurable and clearly defined goals, with a mechanism for monitoring and evaluation;
- Project duration should reflect the time commitment needed to achieve goals;
- Markets must be available for participant's products and services;
- National policies should support project activities;
- Locally-based conservation should be applied where threats and solutions are local;
- Recognise and acknowledge tradeoffs between conservation and development;
- Develop an understanding of community heterogeneity, complexity and livelihood needs;
- Design projects to be adaptive and flexible;
- Involve the community in all phases and provide clear and sustainable community benefits; and.
- Collaborate with other projects - engage in activities you know, collaborate with others for activities that you do not.

At the national scale, institutions are needed to establish clear governance frameworks between national and regional governments and to create credible and transparent systems and institutions to certify and audit the production of carbon mitigation as well as to coordinate with international institutions. This does not necessarily mean new institutions are required. Circumstances will vary from country to country depending on current capacity, financial resources and whether responsibility for functions can be taken on by existing organisations without conflicts of interest. In an assessment of policy, institutional, economic, and scientific developments in twenty countries (Terrestrial Carbon Group, 2011b) it became clear that there were some common elements of successful national approaches. For example, characteristics of success include:

1. A national climate change plan or other overarching policy is used to signal the government's intent and ensure coordination between government policies, regulations and departments. Such coordination is made a priority and includes links between national and sub-national approaches;
2. A multi-sectoral approach is taken to addressing the drivers of deforestation and forest degradation. For example, agroforestry is promoted to enhance farm forest cover and secure future timber supplies;
3. Incentive systems are built upon the recognition that both voluntary fund-based approaches and market-based system approaches have different merits and will be appropriate in different circumstances;
4. Investments are fit-for-purpose and build upon existing equipment available, technical capacity and expertise, with human capacity being harnessed where possible; and,
5. Regional cooperation and coordination is undertaken to maximize policy effectiveness. Such cooperation is in conjunction with capacity development at the national level.

In addition to an effective overarching policy framework, a coherent regulatory platform is necessary to (i) implement national and sub-national policies and measures, and (ii) stimulate changes in the use of land resources that achieve avoided emissions and increased sequestration (Terrestrial Carbon Group, 2009d).

Creating this platform involves reviewing existing laws and drafting new regulations to establish terrestrial carbon registers, exchanges, dispute resolution and enforcement mechanisms, and regulatory oversight. This includes addressing the question of what types of powers will the responsible institution governing the national system have in terms of monitoring and enforcement.

6.3 Work together

In addition to precedents for many of the types of institutions required at the international and national level, it is also possible to learn from early experience. Implementation of effective land based mitigation requires a high level of technical, scientific and inter-stakeholder cooperation, capacity building and support. At all scales, work is already being done to lay down this foundation through the efforts of forest countries with support from developed countries. The next step is to ensure greater coordination between and across these scales of implementation.

The international community will need to work together. There will be many different solutions relevant and appropriate for different local social, economic, environmental and institutional contexts. Greater transparency and public reporting of the successes or failures of implementation would be of benefit not just to policy makers in the future, but to other countries as well.

Cooperation between governments can help to overcome shortfalls in capacity. While some countries have strong policies and institutions, they may be weaker on finance and economics or science and technical capacity. The reverse may also be true, where a country may be strong on the science but have weaker institutions. Cumulatively, there is much capacity that could be better shared, particularly across Africa, Asia and Latin America.

Brazil

A recently signed a Memorandum of Understanding between Brazil's National Institute for Space Research (INPE) and UN-REDD will make Brazilian satellite monitoring systems available to other UN-REDD Programme countries. INPE has committed to sharing its experience in large scale monitoring of deforestation that can help provide accurate and transparent data to the public. These data and monitoring systems (TERRA-AMAZON, PRODES, DETER, DEGRAD) will be made available to other countries to help them advance their own forest monitoring where current system are not sufficiently accurate or do not exist. To develop technical and institutional capacity, INPE will be responsible for training in a new center in Belem, Brazil, while FAO will be responsible for the in-country training and implementation. In two years time, the goals are to train technical people from 30-40 countries (FAO, 2010).

Tanzania

Tanzania's REDD strategy emphasises capacity building and infrastructure development at the national and sub national levels (Tanzania, 2010). The UN-REDD Programme in Tanzania is collaborating closely with the Finish-funded National Forest Resources Monitoring and Assessment of Tanzania (NAFORMA) Programme to train national experts in remote sensing and forest mapping. The NAFORMA project is currently undertaking a National Forest Inventory of Tanzania (UNREDD, 2010a). In addition to in-country training, the global UN-REDD Programme, in collaboration with the Brazilian Institute for Space Research (INPE), has organized intensive training on the satellite forest monitoring system based on the INPE model, with experts being trained in Brazil (UNREDD, 2010a). Google has also announced it will provide NAFORMA with data collector handheld sets, to test new technologies that can improve data collection and data integrity from the National Forest Inventory (UNREDD, 2010b). Meanwhile, Tanzania participates in the Southern African Fire Network (SAFNet) as well as in the Miombo Network.

7 Conclusions

This report has shown that there are many ways in which innovative approaches can be taken to land in the climate solution. What is clear is that no one mechanism will deliver a one-size-fits-all solution. The messy international policy framework is not necessarily a problem, so long as nations seek to reconcile and coordinate their commitments at the national level.

While terrestrial carbon has crucial mitigation potential, not all policy approaches have to directly target carbon itself. In some instances, it may indeed be more effective to view carbon as a co-benefit to other ecosystem services and sustainable land management and adaptation and mitigation efforts should be coalesced. This is because policy responses will be more successful if they are framed with the broader context of land use and land management systems in mind.

Potential innovative approaches to land in the climate change solution include:

The 'plus' in REDD+

- Reverse forest degradation
- Encourage sustainable forest management
- Meet demand through off-site substitution
- Provide opportunities for alternative livelihoods

Addressing agriculture as a driver of deforestation

- Recognise that agriculture itself has changing drivers
- Understand when intensive or extensive agriculture is appropriate
- Take practical action
- Reform trade rules
- Use innovative financing options

Increasing soil carbon in forestry and agriculture

- Recognise the different impacts of different land uses
- Address permanence and leakage
- Go beyond incentive payments
- Promote sustainable agriculture
- Recognise the potential of rangelands
- Roll-out and scale-up demonstration projects

Linking agriculture and forestry

- Recognise food security is different at different scales
- Involve the whole value chain in food security
- Create mechanisms to allow decision makers to compare future scenarios
- Make spatial data publicly available for land use planning

It is apparent that much good work is being done. This work is threatened by duplication and constant reinvention. Cooperation at all levels, between ministries, countries, and regions is critical to prevent

unravelling of work that has already been done and creating resilient solutions that build on existing efforts. In this, artificial divisions between mitigation and adaptation approaches are counter-productive and again diminish the potential returns on existing efforts.

Governments need to be serious about allocating responsibility to a central organisation so that it can ensure that integrative approaches to land and climate change take place. They can also watch for 'orphan' issues that not necessarily profitable to the private sector and overlooked by the public sector. At the same time, governments also need to be serious about devolving responsibility to communities where appropriate, and allowing for true local participation and solutions.

There is also no single driver of deforestation, nor even a single driver of agricultural expansion. There are different types of agriculture (subsistence, smallholder and industrial) and different forces at work at different scales. There are different types of forest degradation and differences in how different soils respond to land use change. Again, this complexity is not necessarily a problem. Simplicity is not the opposite of complexity. Practical actions can be effective and 'cut-through' while still appropriate in a complicated context. We rely on land every day to survive. It is an intricate part of our lives. Changing the way we manage land not only requires changing the way we live, but changing the way we think.

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