Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies

Food and Agriculture
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Executive summary

Two key challenges facing humanity today stem from changes within global food and climate systems. The 2008 food price crisis and global warming have brought food security and climate change to the top of the international agenda. Agriculture plays a significant role in both and these two challenges must be addressed together, rather than in isolation from each other.

Farmers will need to feed a projected population of 9.1 billion in 2050. Meeting this demand together with challenges from climate change, bioenergy and land degradation puts enormous pressure on the agricultural sector to provide food, feed and fibre as well as income, employment and other essential ecosystem services. Making changes to agricultural production systems, particularly amongst smallholders, is a key means of meeting this objective. Such changes also have implications for adaptation and mitigation in the agricultural sector.

The paper explores potential synergies between food security, adaptation and climate change mitigation from land-based agricultural practices in developing countries, which could help to generate the multiple benefits needed to address the multiple demands placed on agriculture. It indicates promising mitigation options with synergies, options that involve trade-offs, possible options for required financing, and possible elements in designing country implementation processes.

Key conclusions of the paper include:

- A more holistic vision of food security, agricultural mitigation, adaptation and development is needed if synergies are to be maximized and trade-offs minimized. This needs to be mainstreamed into global agendas and national strategies for addressing climate change and food security.
- Realizing the synergies and minimizing trade-offs between agricultural mitigation and food security will require financing for up-front investments, opportunity costs and capacity building. Current levels of agricultural investment are inadequate to meet these and other costs.
- The magnitude of potential financing for terrestrial-based mitigation, relative to overall investment requirements for agriculture, indicate that leveraging mitigation finance to support climate smart agricultural development strategies and investments will be necessary to capture synergies between mitigation, adaptation and food security.
- There is currently no consensus on measuring, reporting and verification (MRV) for financing mechanisms, but decisions in this regard would affect the costs and viability of different agricultural mitigation activities.

The main recommendations of the paper are:

(1) Capturing synergies and managing trade-offs between food security and agricultural mitigation can be part of the solution to these two challenges and governments may wish to reflect this is the outcomes of the World Summit on Food Security in Rome and United Nations Climate Change Convention (UNFCCC) Conference of the Parties (COP15) in Copenhagen.

(2) The formulation and implementation of climate change and food security strategies, should benefit from greater awareness of the potential synergies and trade-offs between these two policy areas within the agriculture sector, and how they might be best managed to generate multiple benefits rather than perverse outcomes.

(3) Capturing the potential of agricultural mitigation and its co-benefits will require new and additional resources, multiple funding streams, innovative and flexible forms of financing, and the unequivocal eligibility of agriculture, including soil carbon sequestration, in existing and any new financing mechanisms.

(4) Beyond Copenhagen, possible next steps that Parties may wish to consider, include:
   (i) A work programme on agriculture could be initiated within the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA), with technical support provided, inter alia, through already ongoing Intergovernmental Panel on Climate Change (IPCC) - FAO cooperation. Such a work programme could address methodological issues, including those related to reference levels, financing, and MRV. A decision in this regard could be taken by the UNFCCC COP, at its fifteenth session in Copenhagen.
   (ii) A suite of country-led pilots could be launched to build readiness, confidence and capacity for implementation of nationally appropriate agricultural mitigation action. The modality of implementation could be a phased approach, linked to country-specific capacities, circumstances and sustainable development processes.

List of acronyms

AAUs	assigned amount units
AFOLU	agriculture, forestry and other land use
BAP	Bali Action Plan
BAU	business as usual
C	Carbon
CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
COP	Conference of the Parties
CSO	civil society organization
ERs	emission reductions
EU	European Union
FAO	Food and Ariculture Organization of the United Nations
GEF	Global Environment Facility
GHG	green-house gas
kcal	kilocalories
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
LCA	life cycle analysis
LDCs	least developed countries
LULUCF	land use, land-use change and forestry
MDGs	Millennium Development Goals
MRV	measurement, reporting and verification
N	Nitrogen
N_2O	Nitrous Oxide
NAMA	nationally appropriate mitigation action
NGO	non-governmental organization
OECD-DAC	Development Assistance Committee of the Organisation for Economic Co-operation and Development
ODA	official development assistance
PAMs	Policies and Measures
PoA	programme of activities
REDD	Reduction of Emissions from Deforestation and forest Degradation
R&D	research and development
SALM	sustainable agricultural land management
SBSTA	Subsidiary Body on Scientific, Technical and Technological Advice
SDPAMs	sustainable development policies and measures
SNLT	sector no-lose target
tCERs	temporary certified emission reductions
UNFCCC	UN Framework Convention on Climate Change
VCS	Voluntary Carbon Standard

1

Introduction

1.1 The context

Two key challenges currently facing humanity stem from changes occurring within global food and climate systems. The food price crisis of 2008 and already discernable signs of global warming, which are thought to be symptomatic of deeper and longer term changes, have brought food security and climate change to the apex of the international agenda. Agriculture has significant roles in both, underlining the need to address the two challenges together, rather than in isolation from each other.

Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) states that the ultimate objective of the Convention is:

> "..stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

It is widely held that achievement of this objective will entail: 1) more ambitious commitments by developed countries to reduce emissions; and 2) internationally supported nationally appropriate mitigation action by developing countries. In line with the Convention, both should be done in ways that 1) do not negatively affect development processes; 2) adhere to the parameters outlined in Article 2 above and 3) respect common but differentiated responsibilities and capabilities. Decisions to be taken by Parties, currently negotiating a Copenhagen outcome, are to shape how such commitments might be pursued and such action implemented and supported.

The objectives of this paper are to provide information on the potential of land-based agricultural systems to contribute to meeting the ultimate objective of the Convention and to identify options for actions for enabling this contribution.

Agriculture is the major economic sector of many developing countries and most Least Developed Countries (LDCs). It is the main livelihood of 75 percent of the poor in developing countries. Farmers constitute the largest group of natural resource managers on earth (land, water, domesticated genetic resources). Agriculture is expected to feed a population that will number 9.1 billion in 2050, while providing income, employment and environmental services. Responding to more rapid and intense climate changes is additional to these other demands on the sector and follows decades of declining investment in the sector and a global financial crisis.

At the same time, agriculture is an important source of greenhouse gas (GHG) emissions, representing 14 percent of the global total. Developing countries are the source of 74 percent of these emissions (Smith et al. 2008). If related land-use change, including deforestation (for which agriculture is a key driver) and emissions beyond the farmgate are considered, the sector's share would be higher. The technical mitigation potential of agriculture is high and 70 percent of this potential could be realized in developing countries. From 1990 to 2005, emissions from agriculture in developing countries increased 32 percent and are expected to continue to rise, driven by population increases and changes in diet.

Agricultural systems can contribute significantly to overall mitigation that will help to reduce the extent of adaptation required and catastrophic impacts on systems and sectors, on which lives and livelihoods depend. Agricultural systems will also need to adapt to unavoidable climate change impacts in order to ensure food security and sustainable development. Most developing countries will need to do both and will need to involve smallholders.

Many agricultural mitigation options, particularly those that involve soil carbon (C) sequestration (which is 89 percent of the technical mitigation potential of agriculture), also benefit adaptation, food security and development, referred to as co-benefits. These options involve increasing the levels of soil organic matter, of which carbon is the main component. This would translate into better plant nutrient content, increased water retention capacity and better structure, eventually leading to higher yields and greater resilience. These agricultural mitigation options can be pursued in the context of, and without adverse affects to, national sustainable development processes. They can also contribute to implementation of Article 2 of the Convention.

However, some of these options involve difficult trade-offs, with benefits for mitigation but negative consequences for food security and/or development. For example, biofuel production provides a clean alternative to fossil fuel but can displace or compete for land and water resources needed for food production. Restoration of organic soils enables greater sequestration of carbon in soil, but may reduce the amount of land available for food production. Restoration of rangelands may improve carbon sequestration but involves short-term reductions in herder incomes by limiting the number of livestock. Some trade-offs can be managed through measures to increase efficiency or through payment of incentives/compensation. Other options may benefit food security or agricultural development but not mitigation.

The imperative to increase sustainably the productivity and resilience of agricultural production systems, while contributing to emission reductions, follows decades of declining investment in the sector and a global financial crisis. New and additional resources will be needed to cover additional requirements, such as: formulation/implementation of national agricultural mitigation strategies, incentives for adoption of mitigation options by rural producers, and readiness/confidence/capacity building, including the use of technologies and methodologies for MRV of both action and support. More innovative financing will also be required, drawing on multiple funding streams, integrating new mitigation financing with existing official development assistance (ODA) and utilizing a range of financing mechanisms from public sector funds to market-based mechanisms. Above all, financing mechanisms, will need to be inclusive of, and appropriate to, the specificities of agriculture, including the multiple benefits of synergies offered through soil carbon sequestration in particular. This applies to both newly created financial mechanisms or reformed existing, and the two are not mutually exclusive.

While the profile of agriculture within the climate change negotiations has improved slightly, although currently not mentioned under adaptation, it is still considered to be a difficult sector.

Two steps could help to bring agriculture into the mainstream of mitigation action. First, a work programme on agriculture could be placed within the UNFCCC SBSTA. Such a work programme could address methodological issues related to reference levels, financing, and MRV. Second, a suite of country-led pilots could be considered to build readiness for implementation through a phased approach linked to country capacities and circumstances.

1.2 The paper

This paper is situated between two important international gatherings on the twin challenges of food security and climate change: the World Summit on Food Security (Rome, November 2009) and the UNFCCC COP 15 (Copenhagen, December 2009). It underlines the need for more interrelated solutions to these interrelated challenges. The paper addresses possibilities for maximizing synergies (mitigation and co-benefits) and minimizing trade-offs, as well as relevant financing options and their MRV requirements. Finally, it suggests possible steps at the international and national levels to enable country-led implementation processes. The paper should be seen as the beginning of a process of exploring issues related to the development of synergistic nationally appropriate mitigation action in the agriculture sectors of developing countries.

Synergies and trade-offs between agriculture mitigation and food security

2

Meeting the food demands of a global population expected to increase to 9.1 billion by 2050, and improving incomes and livelihoods to enable access to food, will require major improvements in agricultural production systems. At the same time, agricultural mitigation has the potential to enhance removals and reduce emissions. The questions addressed in this chapter are 1) the extent to which there are potential synergies or trade-offs in the changes in production needed to meet global food security objectives and those needed to increase mitigation from the agricultural sector; and 2) identifying means of enabling actions that contribute to both objectives.

2.1 Current state of food security

The World Food Summit in 1996 adopted the following definition of food security: "Food security exists when all people at all times have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996). FAO's State of Food Insecurity report (2002) refers to four elements of food security: food availability, food accessibility, food utilization and food system stability. Availability focuses on food production whereas accessibility focuses on the ability of people to obtain food, either through production, purchase or transfers. Food utilization focuses on the nutritional value of food, the interaction with physiological condition and food safety. Food system stability focuses on stability of supply and access, as well as the ability to respond to food emergencies.

As captured in the 2008 State of Food Insecurity report, there are nearly one billion people who are undernourished. As shown in figure 2.1, the overall proportion of the population suffering from undernourishment in sub-Saharan Africa remains persistently high at 30 percent, and is over 50 percent in some countries. Undernourishment also affects more than a fifth of the population of South Asia (21%), and many Caribbean countries (23%) (FAO 2008b).

Food accessibility for many people in the developing countries remains closely tied to local food production (FAO 2008a,b; Bruinsma 2009). The World Development Report 2008 stresses the importance of agriculture-led growth to increase incomes and reduce poverty and food insecurity in the least developed and developing countries. Countries with large food insecure populations are often also those whose agricultural systems are highly vulnerable to climate shocks now, particularly in sub-Saharan Africa and South and Southeast Asia (Gregory et al. 2005).[1] Given the close link between local production and food insecurity, investments in the agricultural sector that increase food availability and strengthen the resilience of the food production system will have immediate positive impacts on all elements of food security in food insecure regions.

1 As noted by many authors, global food production is sufficient, at the moment, to cover global consumption needs (c.f. FAO, 2008b). However, trade in agricultural products is still quite low, at approximately 16% (FAO, 2008a), so that national consumption remains closely – though not perfectly – linked to national production. It is important to note that accessibility by the poor at the local level largely depends on income, and incomes are affected by more than simply agricultural output.

Figure 2.1: FAO World Hunger Map

2.2 Global food needs to 2050

Although the rate of global population growth is declining, the UN projects that total population will increase by more than 30 percent by 2050 (UN 2009), i.e. from the current 6 billion to approximately 9.1 billion in 2050. Most of the increase is projected to occur in South Asia and sub-Saharan Africa. Both regions have a large share of the world's food insecure population, dependent on agriculture for their livelihoods.

FAO projects that global agricultural production will need to grow by 70 percent overall by 2050 (Bruinsma 2009). These projections are based on assumptions about population and income growth as well as dietary patterns. Under the baseline scenario[2], per capita calorie availability is projected to increase 11 percent by 2050, to an average of 3130 kcal/per capita. Under this scenario, 4 percent of the developing world population would still be food insecure.[3]

There are three main means of increasing agricultural production to meet projected increases in demands: 1) bringing new land into agricultural production; 2) increasing the cropping intensity on existing agricultural lands; and 3) increasing yields on existing agricultural lands. Adoption of any one of these strategies will depend upon local availability of land and water resources, agro-ecological conditions and technologies used for crop production, as well as infrastructural and institutional development.

Using the FAO 2006 baseline demand projections, Bruinsma (2009) calculates the potential sources of agricultural supply response by region and for the main categories of production increase. The analysis, however, excludes any explicit impacts of climate change on agricultural production and assumes that land for biofuels produced domestically remains at 2008 levels[4]. The study assumes that the bulk of foods consumed will be produced locally,

2 Described in FAO 2006.

3 This result is based upon an assumption of shifts in dietary patterns involving an increase in the share of high value foods and meat consumed as incomes rise. Lower calorie content and inefficiency associated with conversion of feed grains to meat calories translates into reduced increases in caloric availability per increase of agricultural production. Actual experience with income growth and dietary transformation could vary from this projection, which would in turn affect the needed supply response from agriculture – however in this report we will use this as the base case.

based on the observation that only 16 percent of world production enters international trade at present. Given these assumptions, a detailed investigation was conducted of present and future land/yield combinations for 34 crops under rainfed and irrigated conditions in 108 countries and country groups. This analysis yields a baseline projection of potential sources of agricultural production growth by region for the three main categories of supply response as shown in table 2.1 below.

Seventy-five percent of the projected growth in crop production in developing countries comes from yield growth and 16 percent from increases in cropping intensity. Arable land expansion is found to be an important source of growth in sub-Saharan African and Latin America. These results highlight the potential tensions that may be created between the need to increase food production and possible transitioning towards sustainable, low emission agriculture strategies if viable opportunities are not developed to enable meeting both goals.

Despite several caveats associated with these assessments, the analysis is a useful point of departure for understanding the scope and magnitude of changes needed in agricultural production systems[5]. It can be expanded to include information from other studies on factors that could change the nature of the agricultural supply response. While there are many factors, three are particularly important: potential impacts of climate change on agricultural production, the effects of environmental degradation, and the potential effects of future biofuel development.

Climate change can impact agricultural production and supply response via changes in temperature and precipitation that in turn affects which crops can be grown and when, as well as potential yields. Several studies conclude that in the near term (e.g. to 2050) relatively limited changes in temperatures and precipitation are expected to limit negative impacts on global agricultural production (Fischer et al. 2007; Schmidhuber and Tubiello 2007; Cline 2007). Over this period climate change could even have a positive impact in some areas due to carbon dioxide (CO_2) fertilization effects. However, Lobell et al. (2008) predicted that productivity of many important staple crops may decline by 2030 in high food insecure regions, particularly in Southern Africa and South Asia. After 2050, large

Table 2.1: Projected sources of growth in crop production to 2050 (Percent)

	Arable land expansion	Increases in cropping intensity	Yield increase
All developing countries	21	10	69
sub-Saharan Africa	25	7	68
Near East/North Africa	-7	17	89
Latin America and Caribbean	30	17	53
South Asia	6	9	85
East Asia	2	16	81
World	9	16	75

Source: Bruinsma 2009, Baseline Scenario

4 80-85 million tonnes of cereals for ethanol production (mostly maize in the US) and 10 million tonnes of vegetable oil for biodiesel production in the EU.

5 Missing or poor data required expert judgment to fill gaps on productivity and cropping intensities and problems in assessing the suitability of land use change for agriculture including lack of consideration of alternative uses such as forests, protected areas and human settlements. In addition, biophysical and socio-economic constraints to development may not be well reflected in suitability estimates, which may result in overestimates of the potential for arable land expansion. Bruinsma (2009) notes that land suitability for specific crops is more realistic than developing an overall suitability index due to these problems. In addition, potential changes in land quality (e.g. either rehabilitation of degraded lands or increases in degradation on existing lands), water scarcity, climate change impacts and biofuel expansion, which could affect yield growth and cropping intensity, are not explicitly included.

decreases in agricultural production are projected. For instance, building on assessments of six climate models and two crop modelling approaches, Cline (2007) concludes that global agricultural output could decrease between 6-16 percent by 2080, assuming a 4.4 degree increase in temperature and 2.9 percent decrease in precipitation, depending on the effects of CO_2 fertilization. UNEP (2009) identified increasing water scarcity arising from increased glacier melt as another potential source of agricultural production decline, leading to potential agricultural yield reductions of 1.7-12 percent by 2050 globally. Changes in pest and disease patterns could also significantly impact agricultural production (Lobell et al. 2008). South Asia and parts of sub-Saharan Africa are expected to be hardest hit in both the near and longer term, with decreases in agricultural productivity between 15-35 percent (Stern 2006; Cline 2007; Fisher et al. 2002; IPCC 2007).

Continued land degradation and water scarcity – even in the absence of climate change – could also have major impacts on future agricultural supply response. Salinization of soils, nutrient depletion and soil erosion all reduce the productivity of lands for agricultural production. In cases of advanced degradation, lands become unsuitable for agricultural production. Overall, UNEP estimates a loss of 0.2 percent in cropland productivity per year globally due to unsustainable agricultural practices (UNEP 2009).

Bio-energy constitutes a further challenge to the agricultural sector, representing the largest source of new demand for agricultural commodities in recent years. Production of biofuels, particularly ethanol and bio-diesel for use in the transport sector, has tripled since 2000 and is projected to double again within the next decade. Fischer et al. (2007) find that expansion of first generation biofuels is likely to continue to compete with food production for land and water resources, with potentially significant negative impacts on food insecurity. However, second generation biofuel development could decrease competition for arable land use from biofuels, indicating the importance of research and development in this area (Fischer et al. 2007; Kahn & Zaks 2009).

While impacts on mean agricultural production by 2050 are expected to be limited outside of Southern Africa and South Asia, nearly all researchers conclude that increased climate variability and extreme weather events are projected to increase even in the near term, affecting all regions (c.f. Lobell et al. 2008, IPCC 2001 & 2007, Rosenzweig and Tubiello 2006). For instance, Antle et al. (1999) simulated changes in dryland grain production in Montana due to projected climate changes; model results show that impact on mean returns by 2030 were ambiguous (-11% to +6%), but that variability increased under all scenarios – both with and without adaptation. Many developing countries are already vulnerable to weather shocks, and without significant investments in agriculture, future climate changes will increase this vulnerability (Parry et al. 2007). Thus, increasing the resilience of agricultural systems is a key means of adapting to climate change as well as increasing food security.

2.3 Changes in agricultural practices and their impacts on adaptation/food security

The next three sections of this chapter focus on a set of changes in agricultural land uses and their implications for food security, adaptation and mitigation. A consistent set of land use changes has been used, based on the main categories for terrestrial mitigation options from agriculture, identified by IPCC 2007, to assess their impacts on food security, adaptation and mitigation. It is striking that, to a very large extent, the land use changes needed to improve food security and adaptation are the same as those that generate mitigation.

This section starts by assessing the impact of land use changes on the level and stability of food production, the two components of food security directly linked to land use and management[6]. Table 2.2 below provides a list of potential changes in agricultural systems that have been proposed to increase agricultural production, as well as to decrease output variability due to climate variability and extreme climate events. Many of these options overlap with those proposed for adaptation to climate change, notably options that increase system resilience and reduce impacts of climate events on food production. A more detailed version of the table is provided in annex 7.1

An important point captured in the table is that impacts on food production can vary in the short versus long-run. For several options, short term impacts may be negative depending on underlying agro-ecological conditions, previous land use patterns, and current land use and management practices. Long-term impacts are expected to be positive for increasing both the average and stability of production levels. For instance, crop and grassland restoration projects often take land out of production for a significant period of time, reducing cultivated or grazing land available in the short run, but leading to overall increases in productivity and stability in the long run. A different type of trade-off may occur with incorporating crop residues that are expected to increase soil fertility and water retention capacity, thereby increasing yields at least over the medium-long term. However, where livestock are an important component of the food production system, there is a potential trade-off between residues used for the food crop system versus for livestock feed (Giller et al. 2009). This does not mean that conservation agriculture cannot be successful in areas facing these trade-offs, but rather that local farmers, researchers and extensionists must find ways to directly address these trade-offs.

While there can be trade-offs in terms of average yearly food production in the short term, there are fewer identified negative impacts on yield variability. However, yield variability can increase in the short term where changes in activities require new knowledge and experience, and farmers unfamiliar with such systems require a period to successfully adopt the practice (e.g. fertilizer application or the construction of water retention structures where incidence and severity of both droughts and floods are expected to increase in the future).

2.4 Agricultural mitigation options

In this section, the mitigation impacts of land use changes are assessed. The major sources of terrestrial mitigation from agriculture, following IPCC (2007) are described below.

Cropland management

- Improved agronomic practices generate higher inputs of carbon (C) residue, leading to increased soil C storage (Follett et al. 2001). Such practices include using improved crop varieties, extending crop rotations, avoiding use of bare fallow and using cover crops.
- Integrated nutrient management can reduce emissions on-site by reducing leaching and volatile losses, improving nitrogen (N) use efficiency through precision farming[7] and improving fertilizer application timing.
- Increasing available water in the root zone through water management can enhance biomass production, increase the amount of above-ground and the root biomass returned to the soil, and improve soil organic C concentration. Soil and water conservation measures, such as the construction of soil or stone bunds, drainage measures, and irrigation constitute important aspects of water management.

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6 Adaptation options, which do not directly affect land use, include improved climate forecasting and their dissemination, altering timing of planting/harvesting, and developing weather-based insurance schemes (FAO 2008d, Howden et al. 2007).

Table 2.2: Food production and resilience impacts of changes in agricultural production systems

Food Security/Adaptation Options	Impacts on Food Production	
	Positive	Negative
Cropland management		
Improved Crop Varieties	Generally increased crop yield	
Change from	Higher yields during crop rotation, due to increased soil fertility	Reduced cropping intensity may compromise household food security in short-run
Use of legumes in the crop rotation	Higher yields due to increased N in soil	Reduced cropping intensity may compromise household food security in short-run
Use of Cover Crops	Higher yields due to reduced on-farm erosion and reduced nutrient leaching	May conflict with using cropland for grazing in mixed crop-livestock systems
Increased Efficiency of N Fertilizer/Manure Use	Higher yields through more efficient use of N fertilizer and/or manure	
Incorporation of Residues	Higher yields through increased soil fertility, increased water holding capacity	Potential trade-off with use as animal feed
Reduced/Zero Tillage	Higher yields over long run, particularly where increased soil moisture is valuable	May have limited impacts on yields in short-term; weed management becomes very important; potential waterlogging problems
Live Barriers/Fences	Higher yields	Reduces arable land to some extent
Perennials/Agro-Forestry	Greater yields on adjacent croplands from reduced erosion in medium-long term, better rainwater management; and where tree cash crops improves food accessiblity	Potentially less food, at least in short-term, if displaces intensive cropping patterns
Water Management		
Irrigation	Higher yields, greater intensity of land use	
Bunds	Higher yields, particularly where increased soil moisture is key constraint	Potentially lower yields when extremely high rainfall
Terraces	Higher yields due to reduced soil and water erosion, increased soil quality	May displace at least some cropland
Pasture and Grazing Management		
Improving forage quality and quantity	Higher livestock yields due to more and higher quality forage	
Seeding fodder grasses	Higher livestock yields due to greater forage availability	
Improving Vegetation community structure	Greater forage/fodder in medium-long term	May reduce forage/fooder in short-term
Stocking rate management	Potential increased returns per unit of livestock	Returns at the herd level may decline, at least in the short term
Rotational Grazing	Higher livestock yields due to greater forage availability and potetentially greater forage quality	Short-term losses likely if rotational system supports fewer head of livestock
Restoring Degraded Lands		
Re-vegetation	Improved yields when crops sown in the medium-long run; improved yields on adjacent crop or grassland due to reduced wind, soil and/or water erosion	
Applying nutrient amendments (manures, bio-solids, compost)	Improved yields when crops sown in the medium-long run	

Impacts on Yield Variability and Exposure to Extreme Weather Events

Positive	Negative
Reduced variability where varieties developed for resilience	
Reduced variability due to increased soil fertility, water holding capacity	
Reduced variability due to increased soil fertility, water holding capacity	
Lower variability more likely where good drainage and drought infrequent; experience can reduce farm-level variability over time	Potentially greater variability where drought frequent and inexperienced users
Reduced variability due to increased soil fertility, water holding capacity	
Reduced variability due to reduced erosion and improved soil structure, increased soil fertility	
Reduced variability	
Reduced variability of agro-forestry and adjacent crops	
Reduced variability in well-functioning systems	
Reduced variability in dry areas with low likelihood of floods and/or good soil drainage	May increase damage due to heavy rains, when constructed primarily to increase soil moisture
Reduced variability due to improved soil quality and rainwater management	
Reduced variability where improved forage is adapted to local conditions	Potentially increased variabilty where improved forage more sensitive to climate conditions than natural pasture
Reduced variability where seeded fodder is adapted to local conditions	Potentially increased variabilty where improved seeded fodder more sensitive to climate conditions than natural pasture
Reduced variability due to improved soil structure, reduced erosion	
Potentially lower variability in long-term, where forage availability is key factor in livestock output variability	
Potentially lower variability in long-term, where forage availability is key factor in livestock output variability	
Reduced variability in local landscape due to reduced wind, soil, and/or water erosion	

Sources: Antle et al. 2007, Baudeon et al. 2007, Dutilly-Diane et al. 2003, FAO 2007, Freibauer et al. 2004, Giller et al. 2009, Kwesiga et al. 1999, Lal 2004, Niles et al. 2002, Nyende et al. 2007, Pretty & Hine 2001, Pretty et al. 2003, Pretty et al. 2006, Rosenzweig & Tubiello 2007, Smith et al. 2008, Verchot et al. 2007.

- Tillage management practices with minimal soil disturbance and incorporation of crop residue decrease soil C losses through enhanced decomposition and reduced erosion[8]. Systems that retain crop residues tend to increase soil C because these residues are the precursors of soil organic matter.
- Agro-forestry systems increase C storage and may also reduce soil C losses stemming from erosion. Options include combining crops with trees for timber, firewood, fodder and other products, and establishing shelter belts and riparian zones/buffer strips with woody species[9].

Improved grassland management

- Improved productivity through increasing nutrients for plant uptake and reducing the frequency or extent of fires (e.g. improvements in forage quality and quantity, seeding fodder grasses or legumes with higher productivity and deeper roots, reducing fuel load by vegetation management).
- Improved grazing management by controlling intensity and timing of grazing (e.g. stocking rate management[10], rotational grazing, and enclosure of grassland from livestock grazing).

Management of organic soils[11]

- Draining organic soils for cultivation leads to high GHG emissions. Avoiding drainage is the best option in terms of reduced GHGs; other practices to minimize emissions include avoiding row crops and tubers, avoiding deep ploughing, and maintaining a shallower water table (Freibauer et al. 2004).

Restoration of degraded lands

- Carbon storage in degraded lands can be partly restored by practices that reclaim soil productivity (Lal 2004a) (e.g. re-vegetation; applying nutrient amendments and organic substrates such as manures, bio solids, and composts; reducing tillage and retaining crop residues; and conserving water).

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7 Judicious nutrient management is crucial to humification of C in the residue and to Soil Organic Carbon (SOC) sequestration. Soils under low-input and subsistence agricultural practices have low SOC content which can be improved by judicious use of inorganic fertilizers, organic amendments and strengthening nutrient recycling mechanisms (Lal and Bruce 1999). Also, the use of organic manures and compost enhances SOC pool more than application of the same amount of nutrients as inorganic fertilizers. A combination of integrated nutrient management and precision farming, farming by soil or soil-specific management (i.e. application of nutrients and water as required for the specific soil conditions) can enhance SOC concentration, use efficiency of inputs and soil quality (Leiva et al. 1997).

8 For example, conservation tillage (CT) is defined as any method of seedbed preparation that leaves at least 30% of ground covered by crop residue mulch (Lal 1997).

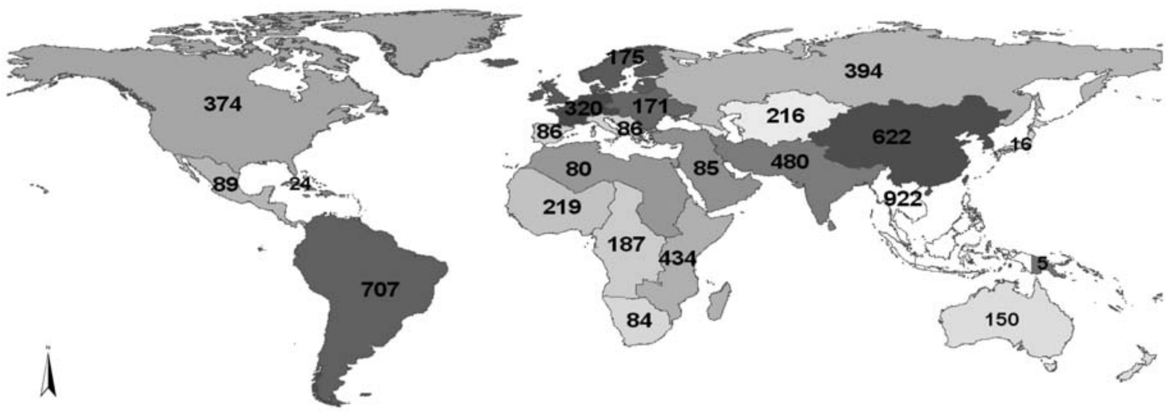
9 The standing stock of carbon above ground is usually higher than the equivalent land use without trees, and planting trees may also increase soil carbon sequestration (Oelbermann et al. 2004).

10 The intensity and timing of grazing can influence the removal, growth, C allocation, and flora of grass-lands, thereby affecting the amount of C in the soils (Freibauer et al. 2004)

11 Organic soils contain high densities of C accumulated over many centuries because decomposition is suppressed by absence of oxygen under flooded conditions. To be used for agriculture, these soils are drained, which aerates the soils, favoring decomposition and, therefore, high CO_2 and N_2O fluxes.

The technical potential for mitigation options in agriculture by 2030, considering all gases, is estimated to be between 4 500 (Caldeira et al. 2004) and 6 000 Mt CO_2e/year (Smith et al. 2008). Figure 2.2 below provides rough estimates of mitigation potential from all agricultural sources by region.

Figure 2.2: Technical mitigation (all practices, all GHGs: MtCO2-eq/yr) by 2030



Source: IPCC 2007, figure 8.5

The global and regional potential of the four most important sources of terrestrial mitigation are summarized below.

- Cropland management: High global potential, spread over the regions. In terms of food insecure regions, potential mitigation is particularly high in South America, Eastern Africa, South Asia and Southeast Asia.
- Pasture and grazing land management: Despite the low C density of grazing land, practices in this category have a high potential for C sequestration because of the large amount of land used as pastures. Data from FAOSTAT indicate that global pasture area accounted for 3 488 Mha in 2002 (69 percent of global agricultural land). On the other hand, conversion of pasture accounted for 65 percent of the increase in arable land from the 1960s to 2005. Improving pasture efficiency, therefore, will avoid further land conversion and concomitant C loss. According to IPCC (2007), potential gains are particularly high in almost all regions of Africa and Asia, as well as South America.
- Restoration of degraded land: Oldeman (1994) estimated that over 2 billion hectares of land were degraded. Degraded land due mainly to erosion was calculated to affect 250 Mha, including 112 Mha in Africa, 88 Mha in Asia, and 37 Mha in Latin America (Oldeman 1994). Thus, there is a large potential to increase carbon sequestration in South America, East and West Africa and South and Southeast Asia through mitigation options falling within this category.
- Restoration of organic soils: These carbon dense soils are often important in developing countries; for example, Andriesse (1988) estimated that the South East Asian region contains the largest expanse of peat deposits. The second most important area is the Amazon basin and the basins bordering the Gulf of Mexico and the Caribbean. These soils are also found in the wet equatorial belt of Africa.

2.5 Costs

A key consideration is the costs of achieving potential adaptation, food security and mitigation benefits from the selected set of changes in agricultural practices. This is critical in determining which synergies to pursue and which trade-offs can be effectively minimized. There are wide ranges in cost estimates by different sources, reflecting the large differences among regions and the type of costs considered in the analyses. For instance, McKinsey (2009) provides cost estimates for mitigation from crop and grassland management, restoration of organic soil, and restoration of degraded land. Average costs per tonne of carbon dioxide equivalent (CO_2e) abated to the year 2030 are computed to be negative for crop and grassland nutrient management and tillage and residue management, indicating that these activities should generate higher benefits than costs over the time frame considered. While this analysis is useful in indicating which practices will be self-sustaining in the long-run, it does not indicate the magnitude of the initial investments required to make the changes, which is a main barrier to implementing many of these practices.

The few project-level costs that are available show very wide ranges due to differences in agro-ecological conditions as well as pre-project land uses and household asset endowments. Because these costs are often largely ignored, table 2.3 presents some project-level estimates of up-front establishment costs associated with the adoption of practices.

In certain cases, agronomic measures such as nutrient management or tillage/residue management have low or zero establishment costs. Nevertheless, in some cases major investments are still needed, e.g. to buy a special no-till drill to simultaneously seed and fertilize annual crops, as in the Morocco case study referenced in table 2.3. Establishing water harvesting structures may be costly but these technologies are often easy to maintain and represent a common practice worldwide. Soil and water conservation structures often require relatively high up-front costs in terms of labor and/or purchased inputs. Establishing agro-forestry systems requires labor costs for land preparation (which vary largely according to slope) as well as input costs for purchasing tree seedlings and fertilizers. Restoration of degraded lands can entail particularly high establishment costs that include labor and equipment needed to construct soil and water conservation structures, expenditures on seeds and seedlings for grasses and trees, and for incorporation of organic and inorganic fertilizers (Wocat 2007, Lipper et al. forthcoming).

These costs constitute a potential adoption barrier as smallholders often lack resources to make the investments needed to realize higher yields and positive net benefits in the longer run. For example, nutrient management is estimated to be highly net-profit positive on average due to a reduction in fertilizer use, and tillage management is expected to lead to a reduction in labor and fuel costs that offset increases in weed control costs at a global scale (McKinsey 2009). However, there are many other barriers to adoption of sustainable land management practices, which are well documented in the literature (WB 2007, Nkonya et al. 2004, Barrett et al. 2002, Otsuka and Place 2001, McCarthy 2004). These barriers include not only limited credit to finance up-front costs, but also issues related to access to information, property rights and tenure security; lack of access to effective research and extension services for capacity building and technical assistance; limited access to insurance; and lack of access to markets. More extensive and country-specific analysis of costs will be needed in future.

Table 2.3: Adoption costs of mitigation technology options

Technology options	Mitigation potential in developing countries (1) Mt CO_2e/ha/year	Practices	Case study	Establishment costs US$/ha
Improved cropland management	warm moist: 0.33-3.93; warm dry: 0.62-5.36	Improved agronomic practices	Natural vegetative strips, The Philippines	84
			Small level bench terraces, Thailand	275
			Fanya juu terraces, *Kenya*	320
			Vetiver grass contour lines, South Africa	140
		Integrated nutrient management	Compost production and application , Burkina Faso	12
			Improved trash lines (weed and crop residue), Uganda	n.a.
		Tillage/residue management	No-till technology, Morocco	600
			Small-scale conservation tillage, Kenya	n.a.
		Water Management	Enhanced runoff harvesting for olives, Syria	88
			Water harvesting on cropland and grazing land, India	240
		Agroforestry	*Grevillea agroforestry system, Kenya*	160
			Belters of trees for farmland, China	125
Improved pasture and grazing management	warm moist: 0.81; warm dry: 0.11	Improved pasture management	Grassland restoration and conservation, Qinghai province, China (2)	65
		Improved grazing management	Area closure for rehabilitation, Ethiopia	390
Restoration of degraded land	3.45	Reclaim soil productivity	Restoration of degraded rangeland, South Africa	230

(1) Latin America and Caribbean, Africa, South and Southeast Asia
(2) Project estimates
Source: adapted from Wocat 2007 and IPCC 2007

2.6 Mitigation and food security: where and how can synergies be realized?

The key regions that require urgent action to reduce food insecurity and build adaptation capacity are Central, East and West Africa, many countries in South and Southeast Asia, the highlands in South America, and certain regions of Central America and the Caribbean.

A comparison of the practices listed above with those analyzed in table 2.2 shows that nearly all of the terrestrial-based agriculture mitigation options are the same as those proposed for sustainable land management and adaptation to climate change. The potential for synergies is particularly high for changing food production practices such as improved crop varieties; avoiding bare fallow and changing crop rotations to incorporate food-producing cover crops and legumes; increasing fertilizer use in regions with low N content (as in much of sub-Saharan Africa), and adopting precision fertilizer management in other regions; seeding fodder and improved forage quality and quantity on pastures expansion of low-energy irrigation; and, expansion of agro-forestry and soil and water conservation techniques that do not take significant amounts of land out of food production. Trade-offs are more likely when mitigation options take land out of production, either temporarily or permanently. For instance, restoration of degraded lands often requires that land not be used for production at least in the short-term, whereas avoiding draining or restoring wetlands would directly take land out of production permanently. Trade-offs may also be important for certain stocking rate and rotational grazing practices.

By combining information from table 2.2 with estimates of mitigation potential by practice, it is possible to derive a chart of the synergies and trade-offs between mitigation and food security for specific practices and regions as shown in figure 2.3 below. Because impacts will vary by agro-ecological conditions, historical land use, and current production systems, the chart is provided only to illustrate the potential synergies and trade-offs that might occur in any one location. Additionally, to simplify the chart, we consider the long-term benefits to food security in order to locate a particular practice on the chart, though it is important to recognize the short-term trade-offs that may occur. For example, changing from continuous cropping to improved fallow can generate moderate mitigation and food security benefits in the long term, though food production may fall in the short run. Restoration of crop and grazing lands can generate high mitigation and food security benefits, though short-medium term food production losses can be significant depending on the restoration strategy pursued. Irrigation can have very high food security benefits, but may have limited mitigation benefits (or even lead to increased emissions) where irrigation is energy intensive. Conservation and organic agriculture could be win-win, or represent a trade-off between mitigation and food production, depending on the specific use and value of crop residues and the capacity to manage weeds. Finally, management of organic soils yields very high carbon benefits, but low (and potentially negative) food production benefits. Further research is needed to derive such charts to capture the specific characteristics of different areas.

Figure 2.3: Examples of Potential Synergies and Trade-Offs

Food Security Potential

Food Security Potential: High Carbon Sequestration Potential: Low • Expand cropping on marginal lands • Expand energy-intensive irrigation • Expand energy-intensive mechanized systems	Food Security Potential: High Carbon Sequestration Potential: High • Restore degraded land • Expand low energy-intensive irrigation • Change from bare to improved fallow • Agro-forestry options that increase food or incomes • Conservation tillage and residue mgmt, where limited trade-offs with livestock • Improved soil nutrient management
Food Security Potential: Low Carbon Sequestration Potential: Low • Bare fallow • Continuous cropping without use of organic or inorganic fertilization • Slope ploughing • Over-grazing	Food Security Potential: Low Carbon Sequestration Potential: High • Reforestation/afforestation • Restore/maintain organic soils • Expanding bio-fuel production • Agro-forestry options that yield limited food or income benefits • Conservation tillage and residue mgmt, where limited trade-offs with livestock

Carbon Sequestration Potential

The key findings of the chapter are:

- There are a wide range of agricultural investment options that improve food security, increase the adaptive capacity of the food system to respond to climate change, and also contribute to mitigation.
- Synergies differ across localities, and thus a necessary first step is to identify where the potential synergies and trade-offs occur in specific circumstances.
- Even where significant trade-offs between food security and mitigation might occur from a proposed land use change, it is important to determine if there are opportunities to minimize such trade-offs.
- The costs of adoption and implementation also vary by locality, and can be significant for both investment and opportunity costs.

3

Enabling action on food security and climate change mitigation: financing options

Current financial resources to support changes in agricultural systems to feed the world are insufficient, while the main financing mechanisms for climate change mitigation largely exclude agriculture. This section of the paper looks at financing options – public, public-private and carbon markets – for actions that address the dual goals of food security and climate change mitigation from agriculture in the context of sustainable agricultural development.

There are several options for financing mitigation actions currently under negotiation that vary in suitability for agricultural mitigation across different countries. These foresee the use of public and private sources of finance, including market mechanisms, and range from project to sectoral levels. One of the key issues associated with establishing financing mechanisms for mitigation is the establishment of systems to measure, report and verify mitigation actions and outcomes. The type and cost of MRV systems could vary by financing source. This chapter discusses some of the main MRV options in the context of various financing mechanisms and their potential for application in agricultural mitigation actions in developing countries.

3.1 Agricultural investment requirements vis-à-vis climate financing

In the framework of the FAO work on "How to Feed the world in 2050", Schmidhuber et al. (2009) estimate that cumulative gross investment requirements for agriculture in developing countries add up to nearly US$9.2 trillion until 2050 or nearly US$210 billion annually[12]. Comparing this with the estimate of the total annual value from the four major mitigation categories (crop and grazing land improvements, organic soil and degraded land restoration) in non-OECD countries of 1.5 Gt/CO_2e/yr[13], and valuing these at $20/t CO_2e, US$30 billion could potentially be generated annually through agricultural mitigation (IPCC 2007). This very rough estimate indicates that carbon finance could be a significant, although insufficient, source of funds for agriculture in developing countries that needs to be taken into account in agricultural planning and policy. Further value can be captured by integrating the investments needed for agricultural development and agricultural mitigation. Potential areas of overlap and savings still need to be quantified, however.

The estimates above also indicate the potential limitations of carbon finance in agricultural investment needs: carbon finance may never contribute more than 15 percent of the overall agricultural investment needs. Considering the strength of the financial muscle of agricultural carbon finance, a combination of long-term international ODA and carbon finance could finance programmes to:

- Leverage public and private investment in adopting sustainable and resilient forms of agricultural production that also enhance mitigation as well as other ecosystem

12 This estimate, like those presented in chapter 2, assumes an 11 % per capita calorie increase and food insecurity remaining at 4 % of the population by 2050. About 39% of the investment demand is in China and India, 61 % has to be invested in agriculture across all other developing countries. Investment costs for agricultural research, rural infrastructure and capacity to trigger the transition are not included. Costs for bringing degraded land into production are also not considered.

13 Economic agricultural mitigation potential: for cropland improvement incl. rice management 0.62 MtCO_2e/yr., grazing land improvements 0.62 MtCO_2e/yr, organic soil restoration 0.17 MtCO_2e/yr, and restoration of degraded lands 0.17 MtCO_2e/yr, (IPCC, 2007)

services. This includes agriculture in ecological zones that have a large sequestration potential and are important for human survival such as watersheds of major rivers and areas with high biodiversity.
- Remove investment barriers for adopting management activities that have substantial long-term food security, agricultural productivity and climate benefit gains, such as restoring degraded lands in high productivity zones.
- Improve food security in climate sensitive areas of LDC countries.

In order to mobilize long-term public and private finance for agricultural mitigation and development from public and private sources, different financing mechanisms related to international sources of funds will be needed. To enable these sources of financing, a regulatory framework and enabling conditions for investments are required. A range of options for financial mechanisms are briefly introduced below.

Climate financial mechanisms

Securing adequate and sustainable sources of international finance to support the adoption of mitigation activities in developing countries is a major issue in the climate negotiations. Climate change financing is not about aid with donors and recipients, but cooperative public and private action considering common but differentiated responsibilities (Neuhoff et al. 2009). Different financing mechanisms have to be coordinated to reach the scale required to meet agricultural production and climate change challenges. Criteria for assessing the financing options include the need to address issues of equity, differentiated responsibilities and regional representation and relevance. Financing can play two main functions in the implementation of agricultural mitigation actions:
- Direct finance to cover incremental costs of implementation, which can include capacity development, or financing to overcome agricultural mitigation adoption barriers such as capital access for smallholder farmers and agricultural inputs and opportunity costs associated with adoption (see chapter 2).
- Facilitating financing to establish the conditions and incentives for other stakeholders to invest in agricultural mitigation. This can include the development of robust policy frameworks that facilitates smallholder access to land and capital such as micro-finance schemes. Facilitating financing could be used to enable private sector financing as well.

These two forms of finance can support three main categories of mitigation costs:
- Up-front finance, in particular from developed countries, is necessary to develop a public-private financing architecture. Up-front financing is crucial for capacity building but also for smallholder farmers to obtain agricultural inputs to increase yields and enhance carbon sequestration. However, to maintain improved long-term agricultural practices, up-front finance has to be combined with finance provided during operations.
- Operations financing can be generated through the cash-flow from the up-front investment or the adoption of the mitigation action. Extension is an important service that can benefit from operational financing to improve the uptake of research and to ensure that research is demand driven. Payments for ecosystem services are one potential source of operation finance as shown by experiences in a number of developing countries.
- Risk coverage is particularly important to facilitate the adoption of new technologies and to mitigate climate risk.

Financing mechanisms can also be supportive of the transition to nationally appropriate forms of climate smart development. Agricultural mitigation has considerable potential to address equity and regional representation issues: it is one of the most relevant types of mitigation actions open to least developed countries and its implementation can affect the poorest segments of the populations. The following section reviews the major financing mechanisms under negotiation for mitigation in developing countries within the framework of agricultural mitigation.

Climate financing sources

One of the main issues under negotiation is how to support mitigation actions, particularly in developing countries. Several options are on the table. For example, financing could be provided from a multilateral fund on climate change receiving the proceeds from a carbon tax on international aviation, maritime transport or from auctioning Assigned Amount Units (AAUs). While a comprehensive analysis of the various options for financing mitigation actions in developing countries is outside the scope of this report, considerations of how mitigation finance could be linked to ODA is clearly critical given the analysis of the potential role of agricultural mitigation finance presented above.

Financing of agricultural mitigation should derive from new and additional resources. ODA for agriculture is not intended for financing agricultural mitigation, but could be directed at actions that will contribute to agricultural development and food security and facilitate the implementation of mitigation actions. ODA could be used to provide budget or sectoral financing support for capacity building for developing changes in agricultural production systems that are likely to generate food security as well as mitigation benefits. Uncertainty and fluctuations in public and private funding (including markets) indicate the need to identify means for achieving long-term sustainable financing mechanisms to attain and maintain desired levels of agricultural mitigation and agricultural development. Utilizing multiple funding streams, including mitigation financing mechanisms, whether fund or market-based, could offer this potential.

Climate financing vehicles for agricultural mitigation in developing countries

Agricultural mitigation actions could be high priority candidates for Nationally Appropriate Mitigation Actions (NAMAs) in LDCs, where agriculture constitutes a highly climate sensitive and economically important sector of the economy. In higher income countries with more diversified economies, agriculture-inclusive NAMAs also have significant potential to contribute to emissions reductions while improving incomes and livelihoods of some of the poorest sectors of the population. Due to their multiple benefits and the need for strong technical and institutional support in the agricultural sector, agriculture-inclusive NAMAs may require an integrated approach with agricultural policy and development at the country level. Most critical for developing countries is that NAMAs or any other agricultural mitigation financing mechanism must have national ownership and be supportive (or at least not harmful) to national development processes. The different financing vehicles to be considered are listed below. See annex 7.7 for more background on NAMAs for agriculture land management in developing countries.

Possible establishment of dedicated funds for mitigation in developing countries: Some agricultural mitigation activities with positive impacts on food security will not be appropriate for financing from carbon markets or private sector due to high transactions costs or other investment barriers. Limited capacity in many countries and regions will also limit the extent to which market approaches could be utilized, at least in initial phases of development. For these reasons it may be necessary to finance agricultural mitigation activities through global multilateral climate funds. Some possible options include: the establishment of one global climate fund, or funds specifically dedicated to agricultural mitigation within or outside the global fund. There are various proposals for how this fund could be established and managed. For example, Mexico has proposed the establishment of a Green Fund, to be financed by contributions from all countries according to the principle of common but differentiated responsibilities. Factors that need to be considered include the potential for establishing long-term and reliable funding sources, the potential for conflicts due to multiple fund objectives and the need for specific financing procedures to support agricultural mitigation.

Linking with carbon markets: Relying solely on public finance significantly reduces potential financial resources for agricultural mitigation. Therefore a step-wise approach to linking NAMAs to carbon markets could be considered. This could be based on country capacity and experience, where certain countries, regions or activities are only considered eligible for non-market funding sources, while other countries and sectors with high capacity and experience with carbon markets are allowed to tap into market sources of finance.

Linking to Reducing Emissions from Deforestation and Forest Degradation (REDD) plus mechanism: Financing for agricultural mitigation could be integrated into REDD plus funding sources and/or eventual financing NAMAs (if REDD plus is integrated into NAMAs), possibly including existing Clean Development Mechanisms (CDM). However, as the development of a REDD plus financing mechanism is well advanced and financing requirements are different, this option could result in the marginalization of agricultural mitigation actions and not capture their full benefits. Linkages between different land-based mitigation actions could be explored by designing similar but parallel phased funding and implementation mechanisms for forest and agricultural land-based mitigation.

3.2 MRV requirements for different financing options

MRV systems are needed to ensure the environmental and social integrity of mitigation actions. MRV systems vary depending on their scale and degree of confidence associated with the estimates they provide. The costs also vary depending on these same factors, as well as by different types of mitigation actions (See box 3.1 for a discussion on measuring changes in soil carbon stocks and annex 7.2 for a detailed discussion of MRV for agriculture mitigation). In this section, existing and proposed MRV options for various financing mechanisms are presented and discussed in relation to their application to agricultural mitigation actions. This is followed by a brief overview of the cost implications related to different MRV systems.[14]

3.2.1 National GHG inventory

The IPCC Good Practice Guidelines (2003) for land use, land-use change and forestry (LULUCF) published detailed GHG inventory and monitoring guidelines for all land-based emissions and removals. National GHG inventories are needed to monitor the impact of mitigation action at sectoral level in the framework of internationally supported NAMAs.

National soil GHG inventories based on Tier 1 approaches require quantitative information on land use, management and climate and soils distribution in order to predict carbon

14 The background and context for outlining options contained in this section were provided by the following documents: Ellis and Moarif (2009) highlighting what needs to be MRVed with a focus on the different metrics and reporting intervals; Breidenich and Bodansky (2009) on legal context of MRV requirements; McMahon and Remi (2009) on the different MRV country positions in the climate negotiations; and UNFCCC submissions by parties.

Box 3.1. Measurement of soil carbon stock changes

Advanced capabilities exist on reliable and cost-effective systems for measurement and monitoring of agricultural soil carbon (C) stock changes and nitrous oxide (N_2O) flux. Priority investment needs are to develop a limited but high-quality network of soil benchmark monitoring sites and to develop improved software packages that help integrate geospatial data (climate, soils), management activity data and appropriate soil carbon models.

Options to quantify soil C stock changes for implementing MRV for agricultural soils include: 1) direct measurements of soil C changes; and 2) a combination of activity-monitoring and C estimation models. A brief description of the approaches is detailed below.

Direct measurement: Overall, the technology to accurately measure soil C contents exists and is widely available at reasonable cost[15]. Thus the challenge in measuring SOC stock changes is not in the measurement technology *per se* but rather in designing an efficient sampling regime to estimate soil C stocks at field-scales. The spatial variability of SOC is often high (Robertson et al. 1997) and the amount of C present in the soil (i.e. background) relative to the change rate is typically high; thus there is a low 'signal to-noise' ratio. Hence a 5-10 year period between measurements is typically needed to adequately detect the cumulative change (Conant and Paustian 2002; Smith 2004).[16]

Integrated activity monitoring and carbon modeling approaches: These approaches build off of field monitoring data and mathematical models of how soil carbon changes in response to specified changes in land use and management. There is considerable knowledge on the general responses of soils to management and land use change, primarily derived from long-term field experiments[17]. A number of reviews, syntheses and meta-analyses of agricultural soil C stock dynamics have been published in recent years (Ogle et al. 2004, 2005; Paustian 1997ab; West and Post 2002) summarizing these data and providing estimates of soil C change for various management practices. This integrated approach is used in national-level soil C inventories reported to UNFCCC (Lokupitiya and Paustian 2006) and for project-level accounting (Antle et al. 2003; Smith et al. 2007). However, there are limitations in these approaches that need to be addressed to increase the accuracy of agricultural MRV approaches over time.

stock changes related to land use change and the adoption of certain management activities. Default values for carbon stocks and stock change factors, for specific land use and management options (i.e. activity-based default values) are provided by IPCC (2006). Moving from Tier 1 to Tier 2 requires country-specific estimates of carbon stocks, stock change factors and emission factors. Tier 3 approaches require the most detailed environmental and land use and management data. In most cases, available data, e.g. through FAO and in-country sources, are sufficient for Tier 1 estimates but capacity and resources for compiling and analyzing the information is the main limiting factor. For higher tiered approaches, additional data collection and research capacity is needed beyond what currently exists in most non-Annex I countries[18] and may entail significant costs. See annex 7.5 for a list of FAO sources of data relevant for MRV.

15 Sample analysis costs for automated CN analyzers in the US are typically in the range of $3-4/sample. The main costs measurements once samples have been taken from the field is involved in sample preparation, i.e., sieving, drying, grinding, weighing, much of which involves hand labor – hence sample preparation costs are largely determined by local labor costs.

16 These remeasurement intervals are similar to those used in forest inventories for determination of biomass increment.

17 There are a few hundred long-term field experimental sites globally, in which soil carbon has been measured (for up to several decades) in replicated management treatments consisting of crop rotations, tillage management, fertilizer levels, irrigation and manuring, often with more than one treatment variable in combination. The majority of these are located in temperate regions (e.g., Europe, North America, Australia/New Zealand), but a large number long-term experiments with measurements of soil C also exist in China, India, and South America, but only a few such sites in Africa.

18 However, many of the larger non-Annex I countries (e.g. Brazil, China, India, Mexico) have the scientific infrastructure to support higher tier inventory approaches.

3.2.2 MRV for NAMAs

It has been suggested that NAMAs could provide an over-arching structure of different action categories:

- actions undertaken by developing countries and not enabled or supported by developed countries (unilateral mitigation actions);
- actions supported by a fund and financed by developed countries (supported mitigation actions); and
- actions that are undertaken to acquire carbon credits (creditable and or tradable mitigation actions)[19].

Depending on the NAMA category, varying levels of detail and accuracy for MRV might be appropriate. A minimum set of MRV obligations might be required for unilateral actions, if they are to be internationally recognized. For actions supported by developed countries additional MRV responsibilities may be necessary to ensure that the investments have the desired climate impact. Finally, substantial MRV capacity has to be first established before robust MRV systems can operate that enable NAMA crediting and trading mechanisms.

3.2.3 MRV for crediting and trading approaches

There is a wide spectrum of possible approaches ranging from public funded policies to crediting mechanisms, with the latter mirroring some of the proposals being made under CDM reform.

The main options for crediting agriculture mitigation under sectoral mechanisms are related to:

- Programme of activities (PoA) using regional baselines; and
- Sector, or potentially sub-sector approaches based on crediting or trading approaches (e.g. lose or no-lose targets)

Bottom-up accounting methodologies developed for specific mitigation activities under the CDM could be used to provide guidance on:

- the methodology applicability conditions;
- the baseline, i.e. carbon stocks and carbon stock changes in a without-project scenario;
- estimating emission reductions and removals for the project scenario; and
- monitoring the emission reductions and removals.

The development of land-based agricultural mitigation methodologies could adapt these existing approaches, with consideration of specific agricultural mitigation characteristics. Baseline development procedures could be informed by the ongoing relevant REDD initiatives. The principal approaches that are important pre-conditions to ensure the environmental integrity of agricultural mitigation, i.e. to prevent leakage and ensuring permanence and additionality, can also benefit from the experience in the forestry sector and the evolving voluntary carbon standards. Considering that land-based accounting may move towards a comprehensive landscape approach (see FAO 2009b), the terminology introduced in the context of REDD could be used (Angelsen et al. 2009).

One of the most promising crediting approaches for agriculture is a programmatic approach, also referred to as program of activities (PoA). Activities based on a single approved methodology can be adopted independent from the sector as a whole and activities can be implemented by different operators, e.g. from the private sector or NGOs in a specific geographical region. Compared to stand alone projects, individual activities do not have to

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19 http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/mitigation1bii140808_1030.pdf (page 4 referring to negotiation text page 94: alternatives to paragraph 75, alternative 2).

BOX 3.2: Concept for a rangeland management PoA in China

Rangelands cover about 400 million ha or more than 40% of China's territory, and nearly the same proportion of the Earth's land area. In China, as elsewhere, large areas of grassland are degraded due to unsustainable management practices. McKinsey and Co (2009) concluded that adopting sustainable grassland management and restoration practices in China is the most important abatement opportunity in China's agricultural sector up to 2030, with an abatement potential of 80 million tonnes of CO_2e.

In provinces like Qinghai, with about 36 million ha of grasslands, a PoA management approach could include a regional baseline established at the province or the prefecture level[20] while project activities could be implemented at county level. Close horizontal and vertical coordination between government agencies and an integrated planning and funding mechanism would be required. Activity monitoring information could be also aggregated at prefecture level. Carbon modeling to predict the mitigation potential of certain management activities could be produced by local research institutes. At village level, community organizations and village committees with technical support from the county grassland management station could conduct participatory land-use planning. The planning process would define the carbon baseline and the management activities that can be adopted to achieve the dual goal of restoring soil carbon stocks while increasing household incomes.

demonstrate additionality or be individually validated, and a regional baseline could be used for land-based activities. This would dramatically reduce carbon related transaction costs. The approach provides the flexibility to up-scale promising agricultural mitigation activities, e.g. sustainable rangeland management over millions of hectares, while benefiting from the reduced transaction costs of the programme framework. Furthermore, the different approaches are already eligible with CDM crediting mechanisms and thus can be linked to existing trading systems.

3.2.4 MRV for support

Developing countries need support to adopt mitigation actions, reflecting country-specific needs and capacity. Financing can be either provided via dedicated multilateral or bi-lateral agreement, and requires a mechanism to trace and monitor support. One option is to build on a system used by the Development Assistance Committee of the Organisation for Economic Co-operation and Development (OECD-DAC) to track all ODA provided by its members. Different options to quantify the support provided would need to be examined. Capacity support and technology could be valued at cost, i.e. at research or expert input costs, priced at market value or by valuing the resulting mitigation and adaptation impacts.

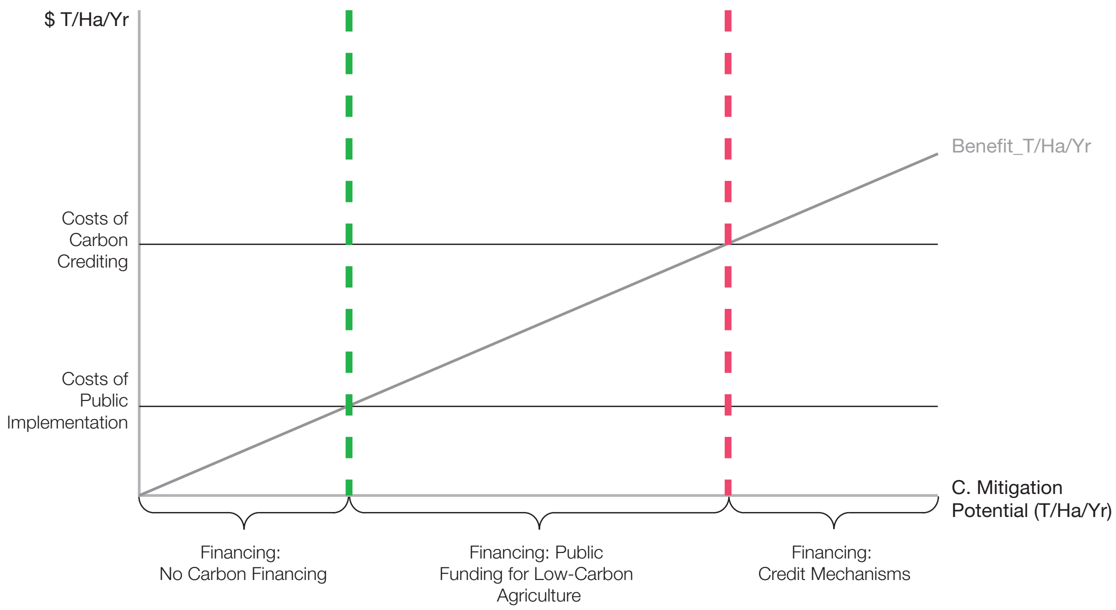
3.3 Economics of MRV

The costs associated with different MRV systems in particular will affect which activities should be pursued in order to gain carbon credits versus those that could be financed through public sources – either national or international. Additional costs include the transactions costs associated with enabling farmers to adopt low-carbon strategies, as discussed in section 2. To highlight the relationship between financing and mitigation potential, figure 3.1 below illustrates how costs of adopting, monitoring, reporting and verifying carbon mitigation activities influence the nature of financing as the potential to

20 In Huangnan Prefecture, Qinghai Province, where Government agencies together with FAO, ICRAF-China and the private sector are exploring opportunities for rangeland mitigation activities, grasslands cover 3.5 million ha (85% of the prefecture's land area). The target county, Zeku County, has 0.65 million ha of grassland covering 98% of the county's land area.

21 In terms of sequestration, the amount sequestered per year will change each year until saturation levels are reached. This simple graph can best be thought of as representing the average increases per hectare per year.

Figure 3.1: Financing Costs and Carbon Mitigation Potential



sequester or reduce emissions increases per hectare. As in figure 3.1, the horizontal axis represents the potential to increase carbon sequestered or reduce emissions per hectare per year (Carbon Mitigation Potential (T/Ha/Yr)), which depends on the type of soil, agro-climatic zone and previous and current land use[21]. The vertical axis represents the monetary costs and benefits from carbon mitigation activities. As the amount mitigated increases per hectare per year, the value of mitigation increases, as shown by the upward sloping Benefits_T/Ha/Yr line, where T/Ha/Yr indicates tonnes of carbon mitigated per hectare per year. This illustrates two potential costs: higher costs associated with accessing carbon credits that may be then sold on the private market; and lower costs associated with public financing.

Activities to the right of the red dotted line capture those activities where C crediting mechanisms are suitable since the benefits in terms of carbon mitigation are greater than the costs of adoption and of meeting carbon crediting MRV requirements. Those to the right of the green line indicate activities where the benefits to pursuing low-carbon agricultural strategies are greater than the costs associated with adoption of basic MRV, therefore non-crediting mechanisms like Policies and Measures (PAMs) outside the carbon market or Sustainable Development Policies and Measures (SDPAMs) may be most appropriate to trigger a low carbon agricultural development pathway. Activities to the left of the green line indicate activities for which there are limited opportunities to pursue carbon mitigation, because adoption costs and/or MRV costs are high relative to the mitigation benefits to be realized.

The simple graph above captures a static picture of what may be current representative costs and benefits. Investments made now can also decrease the costs of both accessing carbon crediting and costs of public financing of low-carbon strategies in the future.

3.4 Conclusions

The key conclusions on financing and MRVs for agricultural mitigation actions in developing countries that emerge from this chapter include:

- Structured and phased financing mechanisms are crucial for agricultural development and to enable agricultural mitigation actions in developing countries.
- Considering the size of the overall required agricultural investments versus the potential income from carbon credits, carbon finance is significant, but more important is shifting agricultural investments towards climate smart agricultural development, which capture synergies.
- Financing is needed for both direct and facilitating actions to enable mitigation, with the former directed at meeting the capacity building, investments and operating costs associated with mitigation actions, and the latter directed at creating frameworks and institutions that enable and incentivize financing from other public and private financing sources.
- National ownership in the design and implementation of NAMAs is critical for their success and only mitigation actions that have synergies with the national development processes are likely to succeed.
- Currently, there is no consensus on MRV needs for financing mechanisms and clearly decisions in this regard will affect the costs and viability of different agricultural mitigation activities. However, to make these systems operational, there is a need for development of capacity and methodologies, as well as at field level to pilot, improve and scale various approaches over time in a phased approach.

Moving from negotiations to implementation: options for action

4

This chapter provides a proposal for taking forward the work needed for realizing the potential of agricultural mitigation in developing countries using a phased approach. Moving forward will require action at both national and international levels.

4.1 Anchoring agricultural mitigation at the international level

4.1.1 High level political commitment

Meeting the dual challenge of achieving food security and mitigating climate change requires political commitments at the highest levels. Two major international meetings at the end of 2009, the World Summit on Food Security (Rome, November 2009) and the UNFCCC COP15 (Copenhagen, December 2009), offer opportunities for a more holistic vision and more appropriate integration of agendas for food security and climate change. This can help to open door to action that captures synergies and manage trade-offs across these two key challenges.

4.1.2 Building international confidence in agricultural mitigation

The analysis presented in this paper has indicated several areas that need further investigation, analysis and clarification before effective implementation of agricultural mitigation can begin. Resolving outstanding methodological questions and building readiness for implementation of agricultural mitigation are needed in order to gain the necessary level of international confidence to support agricultural mitigation in developing countries on a significant scale.

A COP mandate for a SBSTA programme of work on agricultural mitigation in developing countries could provide a vehicle for systematic consideration and debate of outstanding technical issues that could facilitate agricultural mitigation actions in developing countries.

Possible key elements that a SBSTA programme of work could address include:

- Modalities of implementation for different NAMA categories as outlined in this report and agreements for defining a phased implementation approach;
- MRV approaches for various financing options;
- Means of ensuring that benefits from early agricultural mitigation action are enabled to provide incentives for innovation and investments;
- Assessment of the potential for fast-tracking sectoral and programmatic approaches to agricultural mitigation from land-based sources in order to realize cost-effective mitigation in the near term.
- Reference levels for agricultural mitigation.

4.1.3 Establishing an international network of agricultural carbon pilots

Currently, there is limited practical experience on how to integrate carbon finance in smallholder crop and livestock systems as a livelihood enhancing source of income. Sub-national pilot projects, embedded in a global and country-driven support and learning network, will be important in assessing the extent and means of cost effective implementation of agricultural mitigation activities that support food security as well as other co-benefits. Pilots are also necessary to inform implementation models and as a basis for exploring the viability of programmatic and sectoral up-scaling and MRV mechanisms.

One option for fully exploiting the potential benefits of pilot activities is the possibility of establishing a coordinated network of pilot project activities together with national partners. The size of the network of pilots will depend on the level of interest in investing in carbon assets from agricultural mitigation linked to improvements in food security, including both public and private investors. Recognizing the need to facilitate real transactions, an Agricultural Carbon Finance Platform involving private and public investors could be considered to mobilize carbon funds for pilot projects.

4.1.4 Securing long-term financing and partnerships: in search of the champions

Securing adequate and sustainable streams of financing is a critical next step that could be embedded in the ongoing discussions of financing agricultural development, as well as mitigation in developing countries.

The role of government is crucial in providing a supportive policy framework for climate mitigation actions. The private sector can play a role in the provision of technical and process innovations and to upscale local investments that have global food security and climate benefits based on existing platforms, such as the Sustainable Agriculture Initiative and the Sustainable Food Laboratory group. Civil society plays a role in advocating for and enhancing related social and environmental integrity and safeguards. Multilateral organizations, including those focusing on agriculture are well positioned to facilitate partnerships and to support a consensus building process that this report aims to initiate. Finally, donor champions are needed to support a wide consultation process and early mitigation actions.

4.2 Anchoring agricultural mitigation at the country level

4.2.1 Ensuring nationally appropriate action

Nationally appropriate agricultural mitigation actions must be grounded in country-led and owned national development strategies and processes. Effective implementation of agricultural mitigation on any significant scale in developing countries will require integration into existing agricultural institutions and policies, such as research and extension services, financial mechanisms and institutions that govern rights of access to resources. However, in many developing countries these institutions, particularly those that serve smallholder farmers, would benefit from capacity building. The integration of agricultural mitigation programmes into agricultural development strategies will thus need to be part of the overall effort to improve the sector's performance and the livelihoods of small farmers. FAO is currently developing guidelines for integrating mitigation and adaptation into agricultural planning (Bockel and Smith 2009).

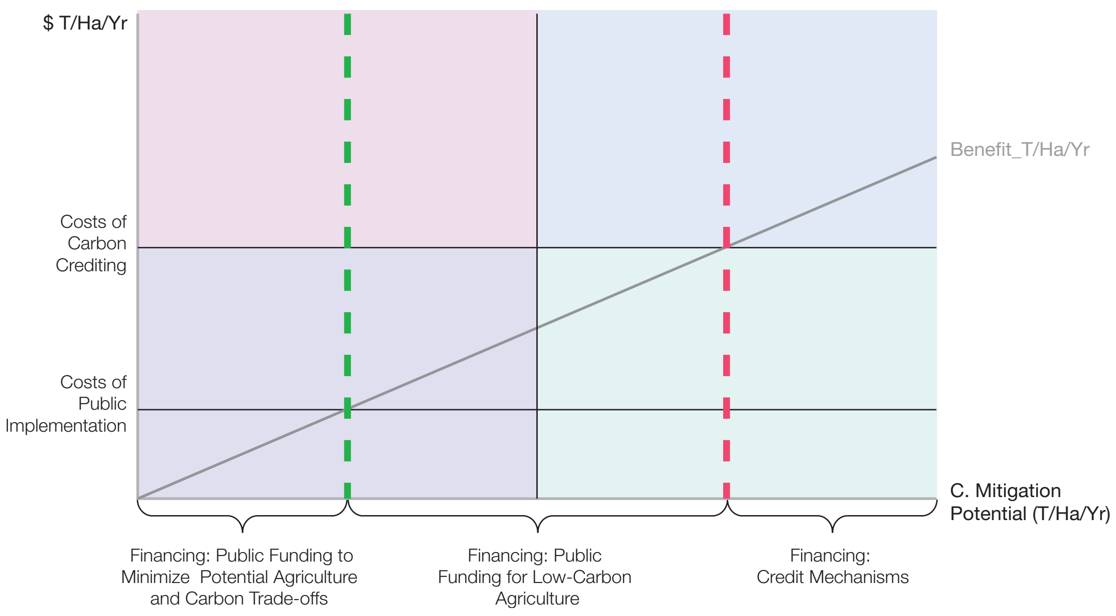
4.2.2 Prioritizing agricultural mitigation actions

Countries considering the potential of agricultural mitigation for inclusion in NAMAs may wish to tailor programmes to fit their national capabilities and circumstances through a process of prioritization of mitigation actions. The analyses provided in chapters 2 and 3 provide important insights into the factors countries may wish to consider when prioritizing actions: their impacts on food security and adaptation to climate change, as well as their costs of implementation and MRV requirements necessary to secure financing. Figure 4.1 below shows the potential synergies and trade-offs by overlaying figures 2.2 and 3.1.

Quadrants in the upper half of the figure capture those activities that increase food security. Those in the right hand quadrant capture high carbon mitigation potential. Activities in the upper right hand quadrant to the right of the red dashed line represent win-win activities that can also be financed through the carbon credit market. Activities in the lower quadrant to the right of the red line represent activities where carbon mitigation activities can still participate in carbon markets, but where impacts on food security are relatively low. Activities to the right of the green line and in the upper quadrants represent win-win activities that can be financed through public funding. On the other hand, activities in the upper left-hand quadrant represent agricultural growth opportunities that have large impacts on food security, but with minimum carbon sequestration potential so that sources other than carbon financing would be required. However, even in these cases, it may be possible to shift these food security beneficial practices into a climate smart strategy in the future with public investments. Synthesizing the information on the potential mitigation and food security benefits from potential changes in agricultural systems with information on costs and barriers to adoption will yield an indication of where the best options lie for obtaining synergies between mitigation and food security. This same analysis will also give insights into the type of carbon financing mechanisms that might be best used for realizing the mitigation benefits. However, in order to be able to conduct such an exercise, country-level information must be collected and/or collated. Research and data management both provide instances where investment decisions in the agricultural sector made now can contribute to realizing the goals of increased agricultural growth, food security and carbon mitigation.

The increased availability of information from spatially referenced databases will be particularly useful for identifying potential synergies and trade-offs. In addition to the map of technical mitigation potential found in IPCC (2007), FAO has produced a map of the "carbon-gap" that allows for the identification of areas where increases in soil carbon storage are potentially greatest (FAO 2007). Overlaying these maps with maps of areas in cropland production and indicators of poverty gives some indication of where synergies between food security and carbon sequestration might be most likely to occur (see annex 7.6). Additionally,

Figure 4.1: Synergies and Trade-offs in Food Security and Carbon Mitigation



models are being developed to estimate the mitigation potential and food security benefits from changes in agricultural production systems, such as the Ex-ante Appraisal Carbon-Balance Tool (Ex-Act) presented in annex 7.3.

Country-level analyses of the implementation costs and barriers are also needed. Adopting the marginal abatement cost curve assessment approach (see McKinsey 2009) is one way of identifying options that are likely to generate long-run net social benefits. However, further information on initial investment costs at the farm level, as described in chapter 2, is required, along with the additional institutional and infrastructure investments required to ensure sustained adoption. In particular, institutional investments are needed to develop carbon value chains and to ensure that smallholders participate fully. These investments are considered in the sections below.

Most countries will face both mitigation and adaptation challenges. It is important to assign high priority to mitigation actions that have strong adaptation benefits. Lower priority could be assigned to mitigation activities that have no adaptation benefits. Financing preferences should generally go to the former, and a top-up based on the adaptation asset value could be considered. MRV systems to quantify the adaptation asset value, based on mutually agreed accounting units would need to be developed. Combined mitigation and adaptation activities are expected to reduce substantially transaction costs.

4.2.3 Assessing potential institutions for a carbon value chain

The value chain approach provides a useful framework to understand the institutional requirements and the steps involved for removing carbon and reducing emissions. The required institutions to establish an agricultural carbon value chain may exist already, but in order to fulfill their role, capacity building may be required and a business model may need to be adapted.

Carbon value chains can be either integrated into an agricultural commodity chain or included in a landscape or watershed integrated management approach. The different institutional requirements result in distinct institutional arrangements (See box 4.1 presenting respective pilot initiatives). When carbon is integrated into an agricultural commodity chain there is a strong market pull factor. For example, adopting best coffee management practices often results in more coffee and additional carbon removals. However, without sufficient incentives, adoption barriers such as the lack of specialized extension providers can not be overcome. In a landscape setting, a large variety of agricultural practices exist and a number of new mitigation practices can be adopted. However, given that many different management objectives and cropping systems exist and interact. Mitigation actions have to be identified via farmer needs assessments and participatory planning exercises, and broader implementation support provided in the value chain.

4.2.4 Making the link to smallholders—what is needed?

Ensuring that smallholders can and will participate in such mitigation actions will require specific actions at the country level. Mirroring similar debates in the REDD context, Angelsen et al. (2009) identified three main principles for promoting the effective participation of indigenous peoples and local communities that are also applicable in the agricultural context: 1) rights to land, territories and resources including ecosystem services; 2) representation in decision making at international and national levels, including access to dispute resolution mechanisms; and 3) integration of mitigation actions into long-term development plans. Lessons from payment for environmental service programmes indicate that such programmes can promote equity by providing alternative sources of income, expanding asset endowments and promoting vehicles for better governance and regional management (Wunder 2006; FAO 2007).

Box 4.1 Integrating soil carbon payments into small-holder value chains in Kenya

The Government of Kenya, with support from the World Bank BioCarbon Fund, started two soil carbon sequestration pilot projects together with partner organizations. One project in the Mount Kenya region promotes the adoption of mulching, agroforestry and soil erosion control activities in small-holder coffee and mixed cropping systems. The 9000 farmers organized in the Komothai Smallholder farmer's cooperative will use the carbon revenues to invest in better coffee management that is expected to increase coffee yields from currently 1.5 kg to 5 kg per tree. ECOM Agroindustrial Corp, the international coffee marketing agent of the cooperative, acting as an aggregator between the Carbon Fund and the Cooperative, is supporting farmers to produce certified quality coffee by providing targeted extension and certification support. Farmers receive 100 percent of the carbon revenues in this scheme to bridge the initial investment gap between the adoption of best coffee management practices, until the investment increases farm income from coffee and crop production for subsistence use. The other pilot project in Western Kenya with sub-projects in the Kisumu and Kitale, areas are using a landscape/watershed approach. Registered farmers' associations representing 80 000 small-scale farmers together with the NGO VI Swedish Cooperative Centre are adopting SALM practices including agroforestry to improve people's livelihood and to enhance the resilience of farmers to cope with climate change. The carbon project covers an area of 86 000 ha and is expected to generate 2.2 tCO_2/ha/year of additional terrestrial carbon (soil and biomass carbon).

Supporting existing institutional arrangements to aggregate mitigation actions across a large number of smallholders are a necessary preparatory step. Institutions such as group credit schemes, existing community-based natural resource management programmes, farmer field schools and other farmers' organizations and women's groups can all be innovative options to provide required arrangements.

Managing risk is needed to facilitate the participation of smallholder farmers. Index-based weather insurance contracts for smallholders could provide some important lessons on how to cope with climate risks and for designing carbon payment programmes (Lipper et. al. forthcoming; Osgood 2008).

4.2.5 Building confidence and readiness for implementation

Differing national capacities and circumstances indicate that phased approaches may be needed to enable transitioning towards sustainable development that can meet national economic development, food security and mitigation/adaptation goals. An initial phase might focus on building confidence, capabilities and national strategies, during which capacity building, technical assistance and financial incentives would be supported by public funds, possibly from a Multidonor Trust Fund using proceeds from auctioning allowances. Eventually emission reductions (ERs) generated from pilot projects could be purchased. Such ERs would not be used for compliance, but rather to gain experience and indicate to farmers that environmental services can be financially rewarded. An intermediate phase might begin implementation of strategies, up-scaling projects and, where nationally appropriate, sectoral mitigation approaches using public funding and simple methodologies (e.g. Tier 1). Developing countries, which have or acquire capacity and knowledge could transition, if they deem it nationally appropriate, to progressively greater quantification of emissions reductions, utilization of incentives from market mechanisms and more robust MRV methodologies with ex-ante safeguards to ensure social and environmental integrity. This in turn might open the door, if so desired, to a NAMA carbon trading mechanism for emission reductions/removals. This could help to leverage private sector investment and innovation capacity and could possibly lead to the eventual development of national cap and trade systems in developing countries, where deemed to be nationally appropriate.

4.3 Measuring, Reporting and Verification (MRV) requirements – part of a step-wise approach

Developing agricultural MRV approaches would need to consider purpose, costs and country specific capacity. Countries will require, different transition periods to adopt accurate MRV systems for monitoring emission reductions and removals. Financial assistance, capacity building and technology transfer is required for developing countries to develop MRV systems for agricultural mitigation activities. Higher accuracy is expected for offsetting through market based approaches. A step-wise approach with agreed increasing accuracy thresholds might be best suited to enable learning by doing approaches and to encourage urgently required early mitigation actions. As noted in Chapter 3, one of the most important steps needed to build confidence in MRV systems for terrestrial mitigation from agriculture is the establishment of a high-quality network of soil benchmark monitoring sites.

4.4 Conclusions

An immediate learning and confidence building process for all stakeholders in the agricultural sector could help to build commitment for actions on agricultural mitigation. Steps to achieve international and national levels of confidence outlined in this chapter include:

- High level political support for synergistic action on food security and climate change could form part of the outcomes of the World Summit on Food Security and COP15 in Copenhagen. The latter could agree to provide a mandate to SBSTA to work on methodological issues and possible parameters for agricultural mitigation.
- Agricultural mitigation actions need to be placed in national development strategies and tailored to country specific circumstances. This may be achieved through a process of prioritization based upon the potential of agricultural mitigation actions to generate synergies with adaptation and food security, as well as their associated implementation and MRV costs and national institutional capacity.
- Differing national capacities and circumstances indicate that phased approaches will be needed to build required confidence, capacity and experience at the country level. Adequate and sustainable financing to support a phased implementation approach at national level would be required.

Conclusions and recommendations

5

This paper has explored the potential synergies and trade-offs between food security, adaptation and climate change mitigation from agricultural practices in developing countries, indicating promising mitigation options, options for their financing, and possible elements in designing country implementation processes. It is intended to stimulate dialogue; among policy makers involved in the World Summit on Food Security (Rome, November 2009), the UNFCCC COP15 (Copenhagen, December 2009), those involved in policy formulation at national level, and more generally those that see sustainable agriculture policies and practices as part of the solution to addressing climate change and food insecurity across the developing world. In so doing, it has sought to initiate a process to clarify some of the key choices and steps involved in enabling and designing country-led and country-specific implementation processes.

Main conclusions

Synergies and trade-offs between agricultural mitigation and food security

- A wide range of agricultural investment options can improve food security, increase the adaptive capacity of the food system to respond to climate change, and contribute to mitigation. Others may involve difficult trade-offs, some of which can be managed.
- A more holistic vision of food security, agricultural mitigation, adaptation and development is needed if synergies are to be maximized and trade-offs minimized. This needs to be mainstreamed into global agendas and national strategies for addressing climate change and food security.
- Synergies between food security and agricultural mitigation are mostly found in strategies for agricultural intensification and for increased resilience of the food production system, while trade-offs tend to occur with changed land use.
- Realizing the synergies and minimizing trade-offs between agricultural mitigation and food security will require financing that values such re financi1i2
  climate financing with ODA.
- Further research is needed to identify locationinanci1inditions where food security adaptation and mitigation benefits intersect in ai1ist-effective way.

Enabling action on food security and climate change mitigation: financing options

- Structured and phased financing are crucial in enabling actions to capture the synergies between agricultural development, food security and agricultural mitigation in developing countries.
- Given the size of overall agricultural investment requirements versus the magnitude of potential financial flows for terrestrial based mitigation in the agricultural sector, leveraging finance from mitigation to support climate smart agricultural development strategies that support food security, adaptation and mitigation will be most effective for capturing re fi.
- Both direct and facilitating financing is needed to enable mitigation action. The former can cover capacity building, investment and operating 1istinassociated with mitigation actions, while the latter can support the creation of frameworkinanciinstitutions that enable anciincentivize financing fr om other public and private financing sources.

- National ownership in the design and implementation of NAMAs is critical for their success. Mitigation actions that have synergies with the national development processes will be more likely to succeed.
- There is currently no consensus on MRV for financing mechanisms, but decisions in this regard would affect the costs and viability of different agricultural mitigation activities. Making any eventual MRV system operational would require a phased approach tailored to country specific agricultural conditions and capabilities using pilot approaches and capacity building to build confidence and expertise.

Moving from negotiations to implementation: options for action

An immediate learning and confidence building process for all stakeholders in the agricultural sector could help to build commitment for actions on agricultural mitigation. Specific steps to achieve international and national levels of confidence outlined in this chapter include:

- High level political support for possible next steps could form part of the outcomes of the World Summit on Food Security and COP15 in Copenhagen. The latter could agree to provide a mandate to SBSTA to work on methodological issues and possible parameters for international/national frameworks for implementation, including a coordinated set of pilot activities.
- Agricultural mitigation actions need to be embedded in national development strategies and tailored to country specific circumstances. This may be achieved through a process of prioritization based on the potential of agricultural mitigation actions to generate synergies with adaptation and food security, as well as their associated implementation and MRV costs and national institutional capacity.
- Differing national capacities and circumstances indicate that phased approaches will be needed to build required confidence, capacity and experience at the country level. Adequate and sustainable financing to support a phased implementation approach at national level would be required.

Main recommendations

1. Capturing synergies and managing trade-offs between food security and agricultural mitigation can be part of the solution to these two global challenges. Governments may wish to consider reflecting this in the outcomes of the World Summit on Food Security and UNFCCC COP 15 in Copenhagen, including their means of implementation.
2. The formulation and implementation of climate change and food security strategies should benefit from greater awareness of the potential synergies and trade-offs between these two policy areas within the agriculture sector, and ohow they might be best managed to generate multiple benefits rather than perverse outcomes.
3. Capturing the potential of agricultural mitigation and its co-benefits will require new and additional resources, multiple funding streams, innovative and flexible forms of financing, and the unequivocal eligibility of agriculture, including soil carbon sequestration, in existing and any new financing mechanisms.

4. Beyond Copenhagen, possible next steps that Parties may wish to consider include:
   (i) A work programme on agriculture could be initiated within the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA), with technical support provided, *inter alia*, through already ongoing IPCC-FAO cooperation. Such a work programme could address methodological issues, including those related to reference levels, financing, and MRV. A decision in this regard could be taken by the UNFCCC Conference of Parties, at its fifteenth session in Copenhagen.
   (ii) A suite of country-led pilots could be launched to build readiness, confidence and capacity for implementation of nationally appropriate agricultural mitigation action. The modality of implementation could be a phased approach, linked to country-specific capacities, circumstances and sustainable development processes.

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Annexes

The annexes will be incorporated into the final version of the report.
They are now available electronically at the following url
ftp://ftp.fao.org/docrep/fao/012/ak596e/ak596e00.pdf

7.1 Synergies and trade-offs between agricultural mitigation and food security

7.2 Measuring, Reporting and Verification (MRV) requirements for agricultural mitigation.

7.3 Ex-Ante Tool to assess mitigation benefits of investment projects

7.4 External implications of domestic agricultural mitigation policy

7.5 FAO sources of data relevant for measuring, reporting and verification (MRV) of agricultural mitigation

7.6 Use of spatially referenced tools to map the opportunities for mitigation: a FAO example from The State of Food and Agriculture (SOFA).

7.7 Technical background paper on Nationally Appropriate Mitigation Actions (NAMA) for developing countries in the context of agricultural land management.

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