CLIMATEFOCUS

Carbon market and climate finance for agriculture in developing countries

Prepared for:
Agriculture & Carbon Market Assessment
DFID Climate Change, Agriculture and Food Security Policy Research Program

25 April 2011

United Kingdom Department for International Development
Abercrombie House
Eaglesham Road
East Kilbride, Glasgow G75 8UA

Version 1.0

Prepared by:
Climate Focus North America Inc.
1025 Connecticut Ave NW, Suite 1102
Washington, DC 20036
USA

IIASA
Schlossplatz 1
A-2361 Laxenburg
Austria

UNIQUE GmbH
Schnewlinstr. 10
79098 Freiburg im Breisgau
Germany

Disclaimer
The views expressed are solely those of the authors and do not necessarily reflect the positions or policies of the United Kingdom and government agencies. Funding for this report was provided by the DFID Climate Change, Agriculture and Food Security Policy Research Program.

Content

1. Executive Summary

The UK Department for International Development has commissioned this study to assess the value and effectiveness of carbon market and climate finance strategies to enhance agricultural investment and food security in developing countries, particularly for smallholders, while reducing GHG emissions. The assessment will inform recommendations to implement these strategies through national development policies or international agreements and cooperation.

Two of the greatest challenges facing the world this century are interrelated: feeding 9 billion people by 2020, and reversing the build-up of greenhouse gases (GHG) in the atmosphere. Agriculture covers 1.5 billion hectares of the planet having expanded more than 2.7 million hectares annually between 1990 and 2005, more than any time in human history.[1] Agricultural production must rise still further to meet future demand without relying on inefficient agricultural practices and clearance of the world's remaining forests, the largest reservoir of terrestrial biodiversity and carbon besides soils.

An emerging set of agricultural practices and policies can help deliver climate benefits and food security through sustainable agricultural intensification and improved agronomy. These measures are not yet standard practice due to transaction costs, lack of financing, inadequate knowledge, and local implementation barriers. Our findings enable policymakers to identify and begin to act on climate finance opportunities that sustainably supply the world's food and biofuel, improve the lives of rural poor and stabilize GHG emissions in the agriculture sector. This research is the result of comprehensive global land use modeling and examination of the productivity and mitigation benefits of individual agricultural practices and financing approaches.

The opportunity

As the primary source of methane and nitrous oxide emissions, agriculture is directly responsible for 10-12% of global GHG emissions (5.1 to 6.1 $GtCO_2e$ in 2005), and the main driver of land use conversion and deforestation in the tropics. The sector's percentage of emissions rises to about 30% if indirect deforestation and supply chain emissions are included. Sources of demand in the agricultural sector – population, income (GDP per capita) and bioenergy[2] consumption – are all expected to rise during the 21st century creating unprecedented demand for arable lands. This is only partially counterbalanced by improved intensification, efficiency and technology. Yet, in a business-as-usual scenario, developing countries are expected to experience land degradation, food insecurity, declining rates of yield growth and unabated deforestation.

There is an opportunity for significant GHG mitigation, food security and livelihood benefits. The IPCC estimates biophysical emission reduction potential in the sector is 5.5-6 $GtCO_2$-eq/yr. Improved agricultural practices can also increase productivity and resilience in developing countries where agriculture is a main economic engine employing 65% of the workforce and contributing 29% of GDP (compared to the global average of 4%). Poverty reduction is also inextricably tied to GDP growth in the agriculture sector which is about twice as effective at reducing poverty relative to GPD growth outside the sector, according to the World Bank's 2008 World Development Report.

The challenges of working in the sector, however, are formidable. Long-standing development challenges in the agricultural sector include i) low investment and productivity; ii) poor infrastructure; iii) lack of funding for agricultural research; iv) inadequate use of yield-enhancing technologies; iv) weak linkages between agriculture and other sectors; and v) unfavourable policy and regulatory environments. Agriculture

[1] Declines in industrialized and transition countries (-0.9 and -2 million respectively) were eclipsed by increases of 5.5 million ha annually in developing countries.

[2] Bioenergy demand remains approximately constant at 2005 levels and constitutes tree plantations that generally do not compete with food production.

is also composed of location-specific practices operating at vastly different scales with uneven access to markets. This reflects a rapid commercialization of food production systems in the developing world, shifting demand preferences, and new links between domestic and international agricultural markets. Despite these challenges, pioneering efforts to support sustainable farming practices can build on early successes and existing knowledge.

Stakeholder Analysis

The stakeholder consultations solicited views from civil society, government agencies, research institutions, and farming association representatives regarding appropriate financing mechanisms and agricultural practices to secure climate and smallholder benefits.

Strategy to encourage agricultural mitigation and adaptation: Stakeholders expressed a clear preference for workable, practical systems to pilot and scale agricultural mitigation and adaptation projects prior to or in parallel with a readiness process, but initial progress could be made independent of a readiness track.

Role of agriculture in an international climate agreement: Several developing country representatives (government and civil society) identified political opposition to market-based climate mechanisms for the agricultural sector due to: i) preference for adaptation, rather than mitigation, in the treatment of the agricultural sector by the UN Framework Convention on Climate Change (UNFCCC); ii) resistance toward international market-based offsets for agriculture. Few developing countries have the resources or initiative to push this agriculture agenda forward in the UNFCCC (comparable to the campaign for REDD by the Coalition of Rainforest Nations[3]). This raises the possibility for supporting appropriate advocates (such as key African nations) to articulate an agricultural position and coordinate a diplomatic campaign.

*Relative role of markets and governmen*t: Resistance to agricultural carbon markets focused on the expense, complexity and uncertainty of establishing new market infrastructure, and the fears that this would expose countries and farmers to excessive delays, lack of liquidity, transaction costs and downside risks or disturb policies promoting more efficient agricultural practices. This is not to preclude private sector engagement: a role for the private sector in designing, financing, and/or implementing agricultural mitigation projects was not opposed. Rather, opposition centered on a carbon-market approach. Other points raised include:

- High transaction costs involved with changing individual behaviour; distributing financing through centralized systems would be high and likely impractical.
- Climate finance should pursue a dual strategy to i) strengthen government facilitated agricultural knowledge-sharing networks, including complimentary private and NGO supported initiatives, and ii) open market-access at the national level and preserve the option to directly incentivize farmers.

Food Security: Food security must be a central aim for climate strategies in the agricultural sector to work. No mitigation measure should be permitted that dislocates or interferes with regional food supply without compensatory systems; measures that increase productivity must also raise demand in domestic or international markets.

Climate finance governance: Two key domestic and international issues were raised: country-appropriate administration of funds, and coordination of international financing both among funders and within countries.

- Domestic: a purely local or purely national strategy for mitigation financing was seen as flawed; suggested system of internal checks and balances through decentralized selection of activities and implementation by communities/local jurisdictions with national oversight/accountability.

[3] REDD+ is defined in the Cancun Agreements as reducing emissions from deforestation and forest degradation in developing countries; and the conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries.

- International: Financing should be coordinated at the international level to complement developing country-led objectives (mitigation, food security, and poverty) through harmonized and transparent funding strategies.

Barriers: Barriers identified were diverse but can be summarized as:

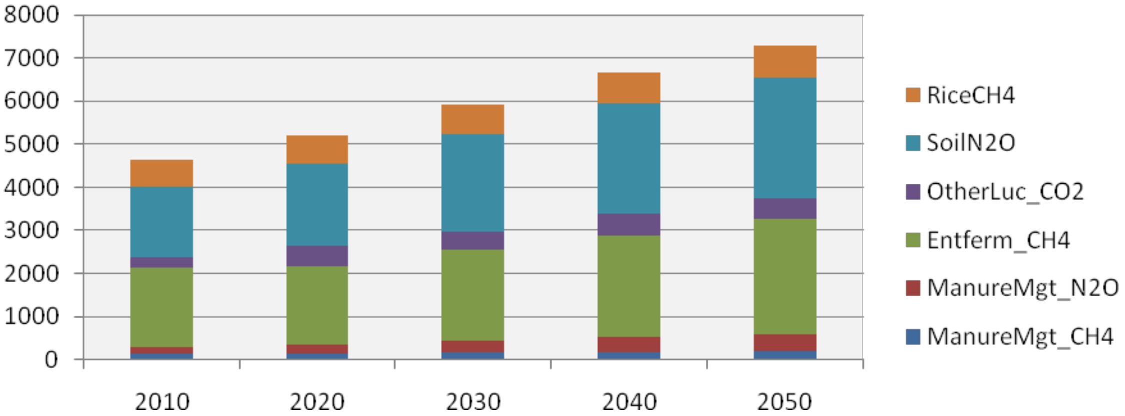
- Lack of strong legal and regulatory frameworks will be a limiting factor to implement agricultural mitigation measures through climate finance.
- Knowledge remains a key barrier to implementing agricultural projects and policies. "There is no consensus on what is known or what we need to know," stated one respondent.
- UNFCCC negotiations fail to provide appropriate incentives.
- International understanding of MRV concepts and practical design is relatively limited and negotiators will be hard-pressed to design workable systems given this limited knowledge base.

Modeling the future

The mitigation and economic potential of agricultural practices and measures were estimated using the Global Biosphere Optimisation Model (GLOBIOM) developed by IIASA, under different future scenarios of global land use.[4] Our model results suggest emissions, while significant, can be drastically reduced by a shift toward sustainable agricultural intensification and global trade, improvements in technology, and conservation measures such as reduced emissions from deforestation and forest degradation (REDD).

Emissions: Agricultural emissions in developing countries are projected to increase between 57% and 70% by mid-century in a business-as-usual (BAU) scenario (Figure 1). If the pace of crop technology improvements is static, as is conservatively assumed, sectoral emissions (primarily from developing countries on an absolute if not per capita basis) could reach 8,600 $MtCO_2$ per year by 2050, equivalent to about 10-15% of baseline emissions across IPCC scenarios.[5] Livestock (feed production, methane from enteric fermentation, and manure management) as well as global expansion of fertilized cropland into natural ecosystems account for the largest share of GHG emissions and account for more than 90% of total emissions (Figure 1).

Figure 1: **Developing country emissions from agriculture by category** ***(MtCO2eq p.a.)***



Legend: Rice methane (CH4) from paddy production; Soil nitrogen (N_2O) from fertilizer applications and soil disturbance; Other land use change (CO_2) carbon dioxide from natural biome encroachment; livestock enteric fermentation (CH_4); livestock manure management (N_2O and CH_4).

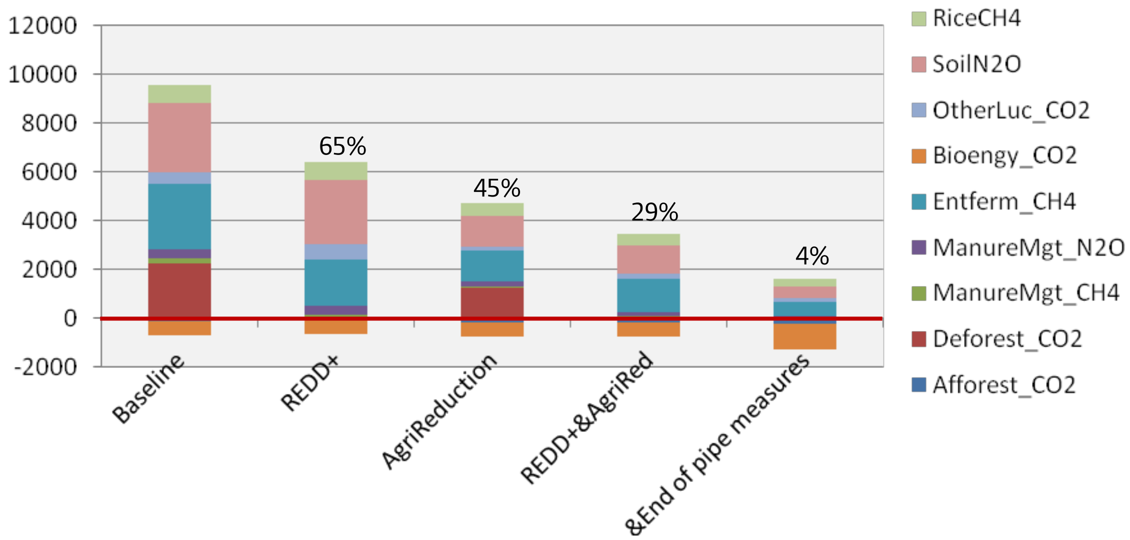
Emission reductions: Agricultural abatement measures could cut emissions up to 55% (3,600 $MtCO_2e$/yr) from a baseline of 8,600 $MtCO_2e$/yr by 2050, according to the model. This increases with implementation

[4] The model simulates land use decision in 27 global regions, as well as agricultural practices associated with these factors

[5] A2, B2 and B1

of REDD (71%) and end-of-pipe measures (96%). The primary sources of agricultural emission reductions are livestock, cropland/grazing land management and avoiding land use changes such as deforestation (Figure 2). The impact of measures reducing soil carbon losses are likely to be large, but were excluded from the model because of greater uncertainty in the data[6] that led to an exclusion of soil carbon in the modeling assumptions.

Figure 2: Land use emission reduction potential by practice (GHG balance in developing countries by 2050)*



Forests and REDD: Forest clearance could continue at the rate of 12 million ha/yr of forest by 2050, almost equal to the worst annual global losses of tropical forest between 1990-2010, without crop improvements or an effective REDD mechanism. Rising demand for agricultural products will continue to make forest encroachment cost-effective. While ending deforestation will likely be a political decision in the end, financial incentives, perhaps through REDD targets or regulations, appear necessary to slow or halt deforestation since there will be ongoing demand for agricultural land (under conservative modeling assumptions). Improvements in agricultural technology, trade and efficiency are necessary but not sufficient conditions to achieve this.

Outlook: Global land use (the terrestrial biosphere), driven by the agricultural sector and forest conservation, could sequester almost as much GHG emissions as is emitted by 2050 if on-farm measures for cropland and pastureland management are combined with REDD, aggressive end-of-pipe mitigation measures and biofuels. We found Sub-Saharan Africa and Asia are focal points for agricultural mitigation and sustainable intensification efforts given their expected increase of agricultural emissions from 2020-2050. Sub-Saharan Africa, in particular, is expected to nearly triple agricultural production by 2050, according to the FAO, reflecting its expansion of domestic food production to meet rapid population growth and relatively low regional agricultural output (Schmidhuber *et al.* 2009). All developing regions, however, show significant early agricultural abatement potential.

Globally, our model shows agricultural mitigation measures could reduce terrestrial GHG emissions 96% below the BAU baseline. Although technically possible, this is unlikely given the socio-economic barriers, implementation challenges and prohibitive transaction costs of (e.g. policy enforcement or lack of alternative livelihoods for those engaged in deforestation). Emissions reductions from REDD are also expected to diminish beyond 2050 as forest loss slows (due to successful REDD measures or dwindling

[6] Soil carbon analysis depends on initial soil carbon content and global soil information maps do not provide sufficiently precise initial carbon stock information.

forests), while fertilizer and other inputs continue indefinitely. Yet even realizing a moderate share of the sector's mitigation potential represents globally significant GHG reductions.

Food security and a stable climate: the agricultural connection

A number of effective and well-established agricultural practices are suitable for fast-start mitigation actions. Measures identified as promising early investments through our literature review and field research are:

- *Cropland management (sustainable land management and nutrient applications):* The most promising cropland mitigation practices are input-based, using organic or synthetic fertilizer, soil and water conservation or irrigation, extending crop rotations including cover crops, green manure and agroforestry and increasing cropping intensity by introducing more than one crop per year and yields on existing agricultural land. These create GHG emission reductions and carbon sequestration above ground and below ground.
- *Pasture and grazing land management:* Better pasture and grazing land management to increase grazing productivity and soil carbon sequestration may involve seeding fodder grasses and legumes and often require temporary de-stocking to match the grassland carrying capacity with the number of animals. Medium intensity grazing often maintains the highest soil carbon stocks as well as plant biodiversity.
- *Livestock management:* Improved land management is usually implemented in a package together with advanced livestock management practices, adopting better feeding practices (including food additives), animal breeding, marketing and value adding activities and veterinary services. Advances in livestock management in general will reduce the emissions per unit of output, but not necessarily overall emissions if the global trend to consume more emission intensive meat continues.
- *Land use, land use change, REDD:* Land use changes (forest to grazing land or grazing land to cropland) result in substantial emissions and biodiversity loss. These can be prevented through better land use planning and market-driven or regulatory enforcement mechanisms. Sustainable intensification of fertile land and preventing agricultural expansion on marginal land generally lowers emissions.

There are a number of widely accepted, no-regret mitigation options within these categories known to offer strong food security and adaptation benefits: preventing land use changes, encouraging crop rotations with legumes to enhance soil nutrient status, agroforestry, carbon sequestration on smallholder farms and low-energy or water efficient irrigation systems. These could be implemented immediately and be supported by available fast-start public climate finance, although it should be noted that the practices mentioned above face implementation challenges due to capital (e.g. irrigation) or labour (e.g. composting and residue management) constraints, as well as investment or implementation barriers.

Finance

Pledged climate financing from public sources, about USD8 billion annually across all sectors, is inadequate to meet mitigation and adaptation needs in developing countries. Agricultural adaptation investments alone are estimated to be USD7 billion annually.[7] Existing agriculture mitigation finance mechanisms for developing countries are limited to the Clean Development Mechanism (CDM), which has proven to be inappropriate for the majority of agricultural mitigation options. The CDM is not mobilizing agricultural emissions due: i) to a lack of eligibility of land use mitigation options; ii) non-scalable project approaches; iii) challenges of aggregating smallholders and deploying effective practices; and iv) insufficient and untested carbon measurement systems. However, new climate finance mechanisms may address these challenges by using innovative financial instruments to address the unique needs of the agricultural sector;

[7] As of 2010, climate finance from the UNFCCC, multilateral and bilateral sources including the CDM, GEF Trust Fund, Adaptation Fund, World Bank Climate Investment Funders and others amounted to USD8 billion annually. HAGCCF (High-Level Advisory Group on Climate Change Financing), 2010, "Report of the Secretary-General's High-Level Advisory Group on Climate Change Financing." 5 November 2009.

support the building of legal/policy frameworks; and integrate measurement, reporting and verification (MRV) systems.

Prioritized domestic or international actions can be matched with climate finance instruments, as well as linked to bilateral and multilateral funds. Determining the most appropriate climate financing method for the agricultural sector is unlikely to yield a single answer. Our experience shows broad distinctions are possible for financing categories of agricultural mitigation/adaptation measures – grant or performance-based, bilateral or multilateral, public or private, however, the appropriate institutional arrangements for each country will depend on i) effective agricultural practices; ii) evolution of climate policy under the UNFCCC; iii) national social and political circumstances.

The two most promising approaches for climate finance in the agricultural sector are a) market-oriented incentives for direct investments; and ii) regulatory and economic reforms/incentives. The latter may involve results-based payments for nationally appropriate mitigation actions (NAMAs) or REDD. Climate-specific financing can add crucial financial and political resources, and act as a convening force for agricultural investments, complementing conventional financial instruments. Options for each of the two approaches are listed below.

Market-oriented incentives for direct investments

- Risk management: Designing and supporting financial instruments that reduce or redistribute risks for investments in agriculture
- Monetizing agricultural/carbon/ecosystem service revenue streams: Financial instruments (e.g. bonds) monetizing revenue streams from improved agricultural productivity and/or ecosystem services
- Direct purchase: Purchase or creation of sustained demand for carbon credits, potentially with a quota for credits derived from agricultural projects
- Transition cost subsidies: Creation of funds and financial instruments that subsidize upfront costs for transition to improved agricultural practices

Regulatory and economic reforms

- Subsidies or tariffs: Removal or modification of domestic subsidies or tariffs that encourage unsustainable agricultural activities – or disincentivize more efficient production – with international trading partners
- Regulatory mandates: Implementation and enforcement of regulatory mandates for adoption of specific agricultural practices, minimum standards, lowering transaction costs for adoption
- Sustainability criteria: Creating, recognizing or mandating market-based sustainability criteria and labeling (within the borders of current WTO agreements)
- Regulatory infrastructure: Investments in the regulatory infrastructure that lower the transition costs of adopting agricultural methods
- Land use planning and tenure reform: Investments in land use planning and tenure reform to support sustainable land management practices, enforcement, monitoring and improved governance

Engagement options

A climate finance strategy for agriculture should focus first on lifting investment barriers and increasing incentives for sustainable agricultural intensification while considering carbon-markets approaches for the future once enabling conditions are in place. The options below are intended to mobilize public and private sector funds for GHG mitigation, enhanced productivity, food security and improved livelihoods.

Reducing barriers to adopt sustainability standards: Transitional fund model

Transition funds are designed to subsidize the costs of adopting sustainable practices connected to industry-wide environmental and social standards. Suppliers of global agricultural commodities, many of which involve extensive networks of smallholder out-growers, are extremely price-sensitive and difficult to influence through standards with low premiums or significant upfront costs. Transition funds are assumed to catalyze the shift toward improved productivity and efficiency gains that offset higher costs related to meeting these standards over time. Subsidies to farmers and agricultural processers can ultimately be phased-out. This model appears most promising for cash crops where a quality premium is paid and additional environmental and social costs can be partly covered by this premium.

Addressing risk
Farmers, particularly the rural poor, face market volatility and harvest risks with little or no insurance against input loss and crop failure. As a result, farmers reduce inputs as a risk reduction measure triggering a cycle of land degradation and production declines. Climate finance support for risk-sharing instruments can correspond to improved productivity and GHG mitigation and resilience/adaptation. These instruments include innovative forms of crop and input insurance, loan guarantees for private investors replacing collateral (often preventing smallholders from taking loans), group loans and microfinance systems. Pilot projects independent of climate finance have shown promise as an effective, cost-efficient measure.

Technology access and dissemination
Agricultural research is mainly funded by the public sector in developing countries. A lack of private sector engagement at the research stage often means that innovations subsequently lack the private sector finance needed if they are to be commercialised and applied at scale. A fund could fill this void by attracting private sector capital to invest in agricultural mitigation and adaptation innovations designed to meet multiple social and environmental objectives. These include irrigation technology to increase biomass production and soil carbon sequestration; precision farming technology enabling more efficient fertilizer application; and carbon monitoring systems that are simple, cost effective and locally managed by private sector entrepreneurs.

Strengthening public sector capacities for national climate-smart agricultural initiatives
International climate finance can be used to support countries that have demonstrated their commitment to establish the infrastructure and capacity to monitor agricultural emissions, along with policies and measures to reduce agricultural emissions. Financial support could be provided for an agricultural readiness process, strengthening agricultural monitoring and evaluation (M&E) systems to provide the basis for the establishment of national agricultural GHG monitoring systems. This includes national reference emission levels and related capacity building. Financing could be linked to milestones related to the MRV system development and reporting accuracy. Performance payments for emission reductions achieved would provide incentives not only to set-up monitoring systems but also to adopt agricultural mitigation activities. The fast-start financing committed under the Cancun Agreements could provide suitable financing pathways such as NAMAs or bilateral initiatives.

Harnessing carbon markets
Global carbon markets represent a large potential source of finance for sustainable agriculture. However, it appears the carbon market is a promising option in the future, rather than during the short to medium-term, for the following reasons:

- Demand for carbon credits (or related allowances within domestic trading systems) from the agricultural sector is limited
- Cost-effective MRV protocols and aggregation/extension structures are not yet in place.
- Political support for new market mechanisms limited during last two Conferences of the Parties
- High risks low returns initially; costs come early in the project while benefits accumulate gradually over years or decades

Laying the foundations for MRV and market finance now will immediately benefit non-carbon market finance efforts. We recommend strategic purchases of agricultural carbon credits and/or direct financing of strategic projects in cases where efforts create the scientific and institutional foundation for broader activities that might be scaled through other means. This will support the development of viable agricultural carbon projects and contribute to beneficial agricultural research.

2. Introduction

2.1. Objectives

The UK Department for International Development (DFID) has commissioned this study to assess the value and effectiveness of carbon market and climate finance strategies that enhance agricultural investment and food security, particularly for smallholders, while reducing GHG emissions. This will inform recommendations to implement these strategies through national development policies, bilateral cooperation and international agreements.

A consortium composed of Climate Focus, the International Institute for Applied Systems Analysis (IIASA) and UNIQUE has examined i) the role of agricultural mitigation practices for greenhouse gas (GHG) abatement and food production through extensive economic modeling of the land use sector; ii) existing and proposed market-based projects, programs and policies that engage the private sector in agricultural mitigation and adaptation activities in developing countries through the short, medium and long-term; iii) feasible mitigation strategies with an assessment of their design, scope, effectiveness and relevant barriers. The focus was on sustainable agricultural practices that benefit development, food security, adaptation and mitigation, shaped by the contexts of specific countries.

2.2. Methods

The study builds on four components carried out by the consortium: i) modeling of the global agricultural and land use sectors to assess the emission reduction potential and opportunities for abatement; ii) assessment of climate finance mechanisms (existing and proposed); iii) assessment of an array of feasible land use practices for agricultural mitigation, and potential benefits for smallholders; iv) synthesis of this data based on the literature review, policy analysis, modeling and field experience to formulate conclusions about agricultural practices offering food security and climate benefits.

The IIASA team, led by Michael Obersteiner, developed a partial-equilibrium economic model to analyze the global agricultural and land use sectors. The model, known as the Global Biosphere Optimization Model (GLOBIOM), simulates an economically "optimized" world where rational firms and individual actors maximize net welfare given the financial, geographic and technological constraints of the model. Our modeling results supply insights about the direction of agricultural trends (cultivated area, crops selection, and preferred practices), economic forces in the sector, drivers of demand and supply, and the critical components of a global agricultural strategy to achieve adaptation, mitigation and food security objectives.

The model does not predict a single outcome for 2011-2050, but generates a series of possible outcomes under different GHG emission and land use scenarios given reasonable economic and environmental assumptions. These findings informed our recommendations of agricultural practices and climate-finance mechanisms that deliver large scale GHG mitigation and food security in the context of macroeconomic pressures shaping agriculture during the next century. The methodology we used to reach these recommendations was designed to identify and select promising opportunities that meet the following criteria: i) cost-effective GHG mitigation potential; ii) enhancing or maintaining productivity gains and food security; iii) value for climate change adaptation; iv) feasible potential for implementation.

Our analytical methodology consisted of the following steps:

1.	Conduct extensive literature review and stakeholder consultations on agricultural mitigation opportunities, barriers, priorities and risks.

2.	Parameterize the IIASA GLOBIOM model to simulate global economic activity and constraints in the agriculture sector (including related land use activities) from 2010-2050. The following underlying scenarios were selected (baseline, with/without REDD, with/without biofuels demand, with/without technical improvements to agricultural productivity) as well as all major agricultural practices/measures identified as potential sources of GHG emissions or abatement: rice cultivation (CH_4), soil management (N_2O), bioenergy (CO_2), enteric fermentation (CH_4), manure management (N_2O and CH_4) and deforestation/afforestation (CO_2).
3.	Run the GLOBIOM model and organize datasets for analysis.
4.	Assess each agriculture measure/practice in the selected scenarios (see the second step above) analyzing potential GHG abatement volume, scale, geographic distribution, and timing through literature review and field expertise/data.
5.	Assess macroeconomic trends in the agriculture sector to understand probable future conditions and extrapolate relationships between agricultural measures/policies and relevant factors such as food demand or natural resource constraints and deforestation or agricultural trade.
6.	Survey market and performance-based climate finance opportunities (existing and proposed) in the agricultural sector based on literature review, stakeholder interviews and global surveys. Research focused on identifying a) international climate finance sources, esp. performance or market-linked, b) suitable mechanisms or arrangements associated with these to delivering financing in the agricultural sector. The analysis considered the IPCC classification from Smith et al (2007), but reduced the number of options reflecting the most promising mitigation categories with a focus on feasible practices contributing to sustainable agricultural intensification and smallholder participation
7.	Identify feasible agricultural practices and financing opportunities based on the modeling and scoping process described above. Review of agricultural mitigation practices for smallholder farmers with adaptation and food security benefits. Final options were based on comprehensive literature review, policy research and field experiences of the author assessed according to the ability to deliver sustainable productivity and food security gains, economic viability and climate mitigation potential.

2.3. Definitions and assumptions

The agricultural sector in this report is considered to include all land use activities related to cultivating, producing and processing food, fiber and fuel. While broadly defined, we have limited our detailed analysis to agricultural activities that show potential for emission reductions and climate-resilience benefits in developing countries, particularly those that accrue to smallholders. The following assumptions identified in the Terms of Reference have guided our work (although at times we have qualified these in our analysis):

- Investment in agriculture needs to i) build resilience and protect the poor and ii) reduce GHG emissions relative to the business-as-usual (BAU) scenario
- New or reformed financial mechanisms that comprehensively cover land use emissions including agriculture should be used to help scale finance to low-income countries and reduce overall mitigation costs
- Potential climate finance flows for least developed countries could be substantial
- Agriculture will be relevant for post-2012 climate agreement/regime and research for this study should inform DFID's policy position as well as assisting in guiding climate finance flows

The results and recommendations in this report are based on the best available information but subject to significant uncertainties regarding the impacts of climate change, estimates of food production and the effects on food security around the world (Vermeulen *et al.* 2010). Actions taken on the basis of this information should be revaluated over time as new data becomes available and experience adds to the understanding of policies and financing mechanisms.

3. Background

Agriculture contributes 4% of global GDP and provides employment for 1.3 billion people, about one-fifth of the global population (Smith *et al.* 2007; World Bank 2007). In developing countries, this proportion is even higher where: an average of 29% of GDP and 65% of the workforce depends on agriculture, particularly among the rural poor (World Bank 2007). In short, agriculture is the central economic engine and labor demand in many developing countries. The sector's importance -- and vulnerability -- will only grow in the coming decades as the areas devoted to agriculture expand, cultivation intensifies and extreme climatic conditions become more common.

There is not much room for error. Stocks of agricultural commodities are at all-time lows. Food price shocks are increasingly common as spare production capacity shrinks. The global food system appears increasingly fragile as individual nations have temporarily cut off exports in times of crisis. The rate of technological improvement in the sector is also continuing its decade-long decline, with the future expected to bring more of the same.

During the next half-century, the demands placed on the agricultural sector will be unprecedented: i) the global population growth is set to rise from 7 billion in 2030 to more than 9 billion by 2050; ii) growing affluence is driving demand for resource-extensive diets iii) an interconnected global food system is subject to price shocks; and iv) competition for land, water and energy is intensifying in constrained regions. At the same time, the agricultural sector is needed to deliver GHG emission reductions in order to meet the Intergovernmental Panel on Climate Change (IPCC) targets for avoiding dangerous interference with the climate system (Vuren *et al.* 2009; Foresight 2011).

As a result, agriculture is rapidly ascending on the world's agenda for development and climate mitigation. There is emerging discussion -- voiced by agricultural researchers, development agencies, governments and economists -- that the world will need to feed itself more efficiently and sustainably if we are to satisfy future demand without serious environmental and social damage. Poverty reduction, food security, and cost-effective GHG abatement and climate adaptation are often complementary goals in developing countries (Nelson *et al.* 2010a). While tradeoffs exist, particularly between agricultural expansion and GHG mitigation, agricultural practices exist that can enhance food security and GHG mitigation, and mobilize new sources of financing. Pilot projects in Kenya (see box below) and elsewhere have shown this to be true on a small scale. Sustained investment in improved agriculture may demonstrate this on a global scale as countries and development agencies strive to meet development targets such as the Millennium Development Goals that call for halving the proportion of people with income less than USD1/day between 1990-2015, most of whom live in rural areas.

Box 1: Kenya agricultural carbon project case studies: Kisumu and Kitale

The Government of Kenya, supported by the World Bank BioCarbon Fund, is sponsoring soil carbon sequestration options developing a carbon project and accounting methodology suitable for smallholder farmers. Project sites in Kisumu and Kitale were selected based on a competitive tender. Using a farm enterprise extension approach, the project proponent NGO VI Agroforestry in Western Kenya enables 60,000 small-scale farms to adopt Sustainable Agricultural Land Management (SALM) practices that increase the productivity of mixed-maize farming systems, enhance climate resilience and pay farmers for increasing soil carbon stocks. The carbon accounting methodology (based on consultations with leading soil carbon experts) uses an activity monitoring approach with modeling based on default-values validated by long-term agricultural research trials in Kenya. The methodology passed the first validation for the Verified Carbon Standard (VCS) in February 2011. When the second validation is successfully complete, it can be approved by the VCS Association. Subsequently the project can be validated, verified and emission reductions can be registered and transacted. The carbon project area covers a region of

116,000 ha. SALM practices are to be adopted on 45,000 ha abating 1.2 million tCO_2 during a 20-year period. Project roll-out started in January 2010. SALM is now practiced on 14,500 ha. A carbon purchasing contract was signed in November 2010.

Barriers

Long-standing development challenges in the agricultural sector include i) low investment and productivity; ii) poor infrastructure; iii) lack of funding for agricultural research; iv) inadequate use of yield-enhancing technologies; iv) weak linkages between agriculture and other sectors; and v) unfavourable policy and regulatory environments (ECA 2009). These also apply to climate financing for the sector, where climate impacts (shifting weather patterns and extreme conditions) have also emerged as a new challenge.

Solutions to these challenges will not be universal. Agriculture, particularly in the developing world, differs enormously region by region due to location-specific methods, local knowledge, and unique economic pressures. For example, land-conversion in Sub-Saharan Africa is driven by small-scale agriculture while in Latin America large-scale agriculture for export markets is the dominant driver in the midst of widespread subsistence farming (FAO 2002). In Southeast Asia, rapid commercialization of food production systems is occurring in response to domestic food demand and integration with international agricultural markets leading to more exports.

In many places, this is enlarging land holdings, increasing agricultural specialization and reducing reliance on non-traded inputs (e.g. family labor) (Pingali 2007). Over time, decisions about how to farm (and by extension adapt to climate change or mitigate GHG) will become increasingly dependent on large-agribusiness or the regional and global political economy rather than farmers or local factors (Burton and Lim 2005). As a result, efforts to confront these challenges will need to be designed with the country-specific context, as well as global market and political conditions, in mind.

The central challenge for climate finance will be the lack of a strong domestic legal and regulatory framework or a robust international mechanism supporting sustainable land management. Creating a new mechanism for the agricultural sector seems unlikely, as developing countries do not have an organized coalition to advocate for agriculture in the climate negotiations (on par with the Coalition of Rainforest Nations support that propelled REDD onto the international agenda), and many are still divided about whether climate mitigation, rather than adaptation, should be a primary focus of international action. This is further complicated by issues of international trade, MRV, land tenure and carbon-rights (Perez et al. 2007).

Regardless of how agricultural mitigation and adaptation is financed, however, low-carbon development paths that target the agricultural sector appear to offer a promising model for delving multiple benefits of food security, economic growth and GHG mitigation. Agricultural mitigation measures can restore soil carbon and improve production efficiency while buffering against fresh water scarcity, soil degradation, climate variability and flooding (World Bank 2007). Agricultural investments are also one of the best ways to drive down poverty rates: the 2008 World Development Report by the World Bank notes that GDP growth originating in agriculture is at least twice as effective in reducing poverty as GDP growth originating outside the sector.

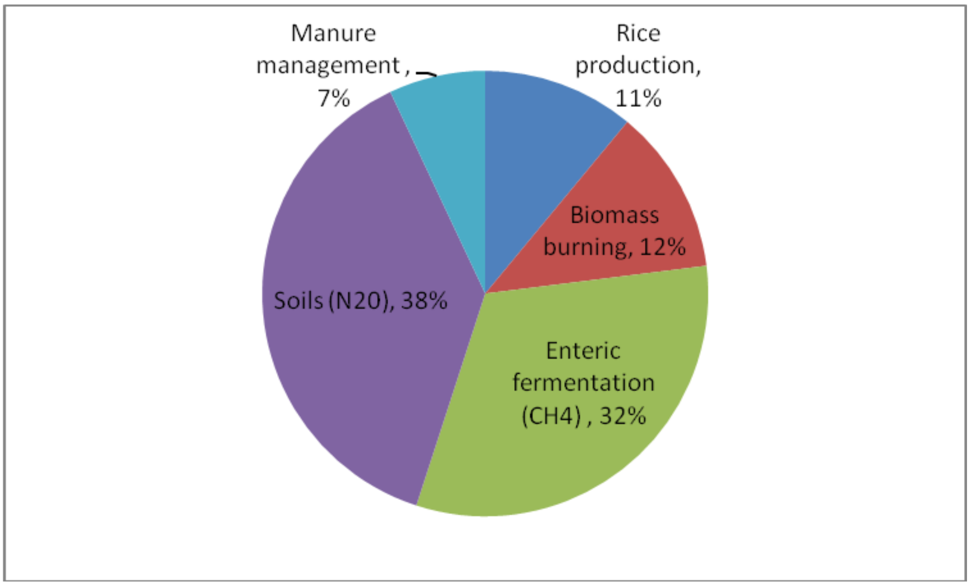
For now, governments and organizations can take immediate action by experimenting with agricultural mitigation and adaptation practices and financing strategies that build the foundation for future increases in productivity to promote economic and environmental sustainability. Strategic investments in agriculture, as well as the policy and incentive framework for the sector, have the potential to address the interrelated issues of energy, water, infrastructure land management, climate and conservation on a global scale (Foresight 2011).

3.1. Mitigation

Climate mitigation in the agricultural sector promises to pull the once separate strands of climate and development policy together through a systematic climate finance approach that delivers social, economic, and environmental benefits (Smith *et al.* 2007). Yet the knowledge and capacity to do this, despite new research initiatives such as the CGIAR Research Program on "Climate Change, Agriculture and Food Security" and emerging market-based incentives for agricultural investments, are limited. This section examines the scientific, economic and political context of GHG mitigation and food security in the agricultural sector.

Agriculture is one of the world's largest GHG emitting sectors (Smith *et al.* 2007) responsible for an estimated 10-12% of total GHG emissions (5.1 to 6.1 GtCO_2e). This proportion rises to about 30% when accounting for tropical deforestation driven by agricultural expansion for food, fiber and fuel. The sector is responsible for most of the world's non-CO_2 GHG: 58% of its nitrous oxide (N_20) emissions and 47% of the world's methane (CH_4) from the production and application of nitrogen fertilizers, livestock production, and rice cultivation (Smith *et al.* 2007). Remaining GHG emissions are from biomass burning (12%), rice production (11%), and manure management (7%) as shown in Figure 3 below.

Figure 3: Direct GHG emissions in the agriculture sector (Smith et al. 2007)[8]



Most of the recent increase in agricultural GHG emissions has occurred in developing countries where emissions rose 32%, compared to an average decline of 12% in developed countries. The primary drivers of this divergence were adoption of sustainable land-use policy and productivity gains in developed countries where the terrestrial carbon sink has grown through reforestation and other land use shifts. In developing countries, this GHG trend is expected to continue in both absolute and relative terms for the foreseeable future driven by population, increasing affluence, diet, and new technologies (Martino 2009). New innovations and behavioral shifts may slow this growth.

Despite this emission profile, agriculture's global mitigation potential (5.5-6 GtCO_2-eq/yr) is roughly equal to its total emissions of 6.1 GtCO2-eq/yr until 2030 (2005; Smith *et al.* 2007), rivaling the theoretical abatement potential of the energy and industrial sectors (See Figure 4). As with GHG emissions, most mitigation potential is located in developing countries, particularly Asia, Latin America and eastern Africa (Figure 5).

[8] Excluding land use change; IPCC.

Figure 4: Relative GHG mitigation potential by sector (reproduced from Smith et al. 2007)

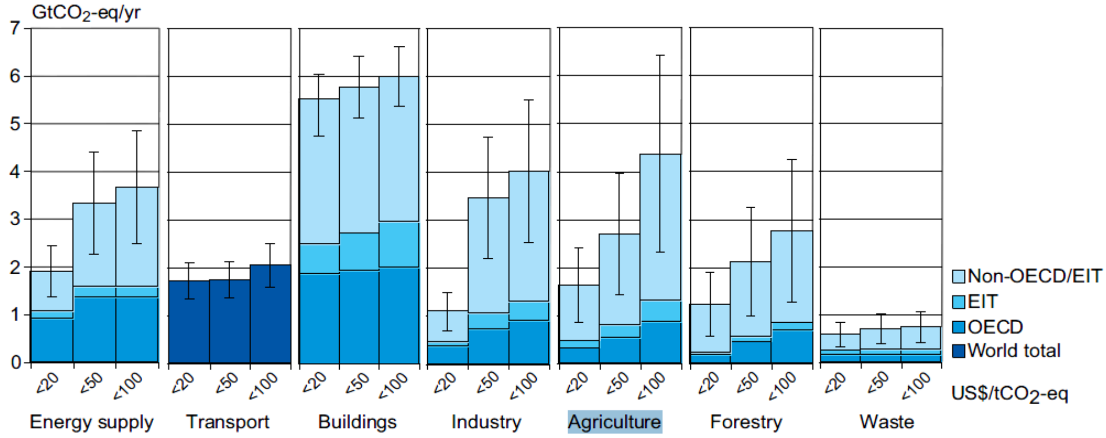
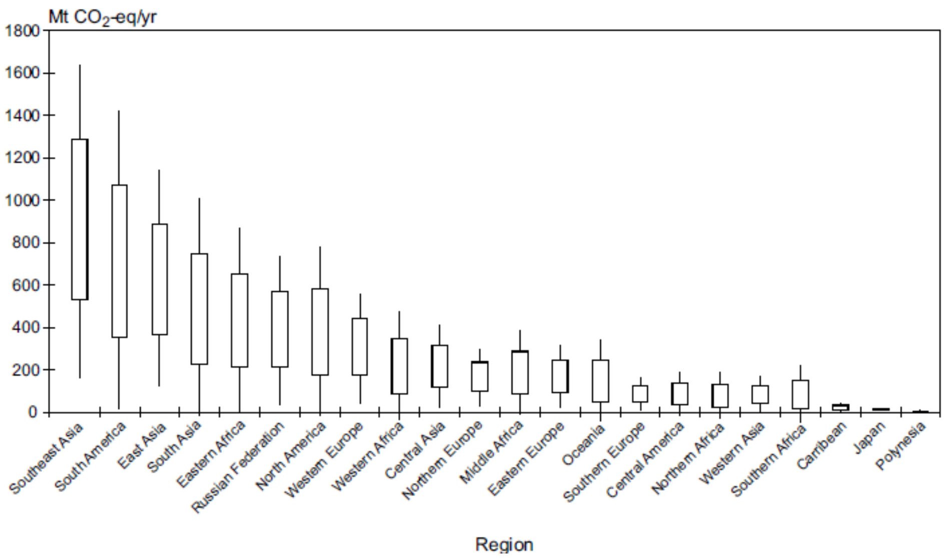


Figure 5: Total technical mitigation potentials (all practices, all GHGs) for each region by 2030 (reproduced from Smith et al. 2007)

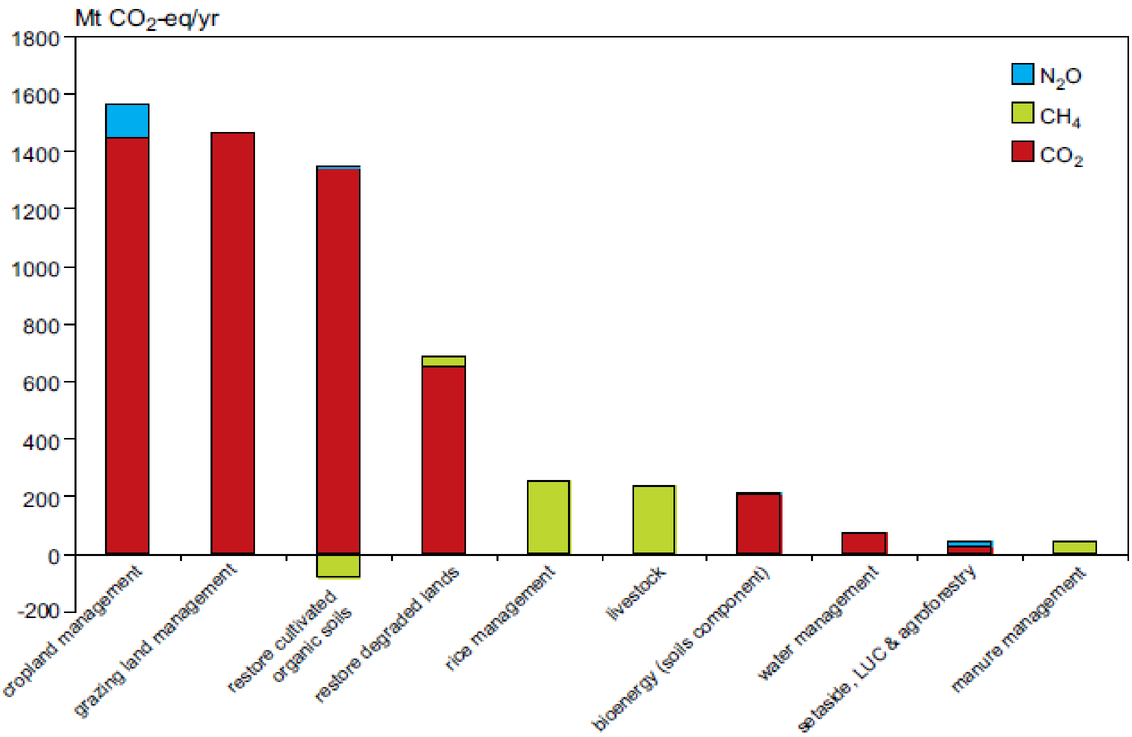


Over time, however, soil carbon stocks will reach equilibrium (or saturation) and net emissions from the agricultural sector must increase since food production-related emissions can be reduced but not eliminated. The EU Commission estimates, even under effective GHG mitigation scenarios, agriculture could still contribute about one-third of total GHG emissions by 2050 (European Commission 2011). The agricultural mitigation potential is also limited by what fraction will be feasible or economical compared to non-agricultural options. Economic global mitigation potentials based on opportunity costs (
Figure 2) diverge widely: 1500-1600 MtCO2-eq/yr at USD20[9]; 2500-2700 MtCO2-eq/yr at USD50; and 4000-4300 MtCO2-eq/yr at USD100 through 2030, according to the IPCC (Smith et al. 2007). As a result, meaningful global abatement from agricultural practices must increase or maintain net agricultural production and scale, and clear numerous political, implementation and financial barriers, beyond simply meeting opportunity costs.

[9] USD/per tCO_2e

The most promising agricultural GHG mitigation options likely to meet these criteria include i) improved crop and grazing land management (e.g. nutrient use, tillage, and residue management); ii) restoration of drained organic land; and iii) restoration of degraded lands (
Figure **6**). The greatest economic potential appears to be in improved crop and grazing land management offering combined mitigation potential of about 1.5 $GtCO_2e$ per year, mostly in developing countries. The biophysical mitigation potential in the agricultural sector is primarily soil carbon sequestration (about 90%), methane abetment (9%) and soil N_2O abatement (2%), reports IPCC (Smith et al. 2007).

Figure 6: Global GHG mitigation potential of agricultural practices in 2030 (Smith *et al.* 2007)



Quantifying the effective costs and benefits of these practices – rather than merely the theoretical opportunity cost of alternative land uses -- is critical. Yet comprehensive country-by-country marginal abatement costs are not well understood. The primary reasons are the complex interdependent economic and agronomic systems that exist in each country, region or locality. With the exception of larger, industrial agricultural systems, it is difficult to predict the value and economic beneficiaries of specific practices in isolation or accurately estimate or measure the real costs and implementation barriers. The few available examples show extreme variability, and true investment and transaction costs have not been studied on a large scale (and may resist such inquiry) (FAO 2009). Uncertainty, with regard to the economic mitigation potential, will continue considering the state of scientific knowledge, vast scope of activities, diversity of agricultural landscapes, and inherent uncertainties associated with climate change impacts.

3.2. Adaptation

Adaptation is essential as the growth of GHG emissions now exceed the most pessimistic emission projections developed by the IPCC (Raupach *et al.* 2007). Observed CO_2 concentrations in the atmosphere stand at 391 parts per million (up from about 325 ppm in 1965) implying global temperatures and sea level rise will "all be near or above the high end of the CO_2 emission projections of the United Nations-IPCC"

(Raupach *et al.* 2007). Temperature increases between 3.2 to 7.2°F (1.8-4.0°C) during the 21st century, if not inevitable, appear plausible. [10]

The most pronounced changes are expected in tropical and subtropical regions of developing countries where impacts will be "predominately negative" (Padgham 2009). Long-term shifts in temperature and precipitation are likely to alter production seasons, pest and disease patterns, increase the frequency of extreme weather events and modify the available set of crops and management practices (FAO 2010c). These changes are already being felt. The UN Office for the Coordination of Humanitarian Affairs reports that about 70% of disasters are now climate-related, up from 50% two decades ago, and affect 2.4 billion people compared to 1.7 billion (Sheeran 2010). Traditional farming societies report unprecedented seasonal patterns, failed rains, difficulties in growing historical crops and other phenomena.

Politically, adaptation in developing countries will primarily focus on producing enough food to feed a population of 5.5 billion people vulnerable to price shocks and climate change. As noted by government officials and community representatives, food security is the "non-negotiable" priority for developing countries facing an increasingly volatile global market for food, and uncertain climate conditions in the future. Yet climate change is expected to make securing reliable and affordable supply of food increasingly difficult. Climate models differ on the specifics but the overall trend is strongly negative for crop yields in developing countries. By 2030, cereal yields could decline in most developing countries with harvest reductions for maize (30%) and wheat (15%) in Southern Africa by 2030 (Lobell *et al.* 2008), grain harvests in Latin America might fall 30% by 2080 (Parry *et al.* 2004). Overall, the UN Food and Agricultural Organization (FAO) predicts that 49 million more people will be at risk of hunger due to climate change by 2020 (FAO 2005).

As a result, adaptation in agriculture faces four primary challenges: i) maintaining productivity; ii) strengthening food security; iii) increasing resilience to future climate shocks; and iv) expanding sustainable climate-smart intensification while providing a route out of poverty for the rural poor. Many effective adaptation measures already exist to cope with climate variability but considering the expected temperature increase and the anticipated rise in extreme events substantial research and experimentation are required to achieve food security in particular beyond 2050. Proactive adaptation will demand, at a minimum, improvements in "crop varieties and species, livestock breeds, cropping patterns, water resource management, changes in rural livelihood strategies and related policy interventions" (Thornton 2011). Sustainable economic growth itself, particularly in agriculture, offers a powerful form of climate change adaptation that can reduce poverty, increase GHG mitigation and strengthen adaptation. Trade, as well, may prove crucial in ensuring the food is grown most efficiently for the most number of people.

Climate change adaptation in the agricultural sector appears "manageable" through 2050 assuming adequate investments in productivity enhancements and agricultural resilience (Nelson *et al.* 2010a). If GHG abatement measures are unsuccessful and temperatures increases up to 4°C by 2080, the severity of challenges climbs dramatically. Model scenarios from the FAO predict global crop yields decline between 1.3-9% by 2030, 4.2- 12% by 2050 and 14.3-29% by 2080. In Africa, as much as a quarter of countries could see climatic conditions over cultivated areas with "no current analogues" meaning few if any resources are readily available to adapt to these new conditions (Thornton 2011). More profound steps may be necessary as local climatic conditions diverge from historical norms and the resilience of existing ecological and human systems diminishes over time.

---

[10] CO_2 emissions from fossil-fuel burning and industrial processes have been accelerating at a global scale, with their growth rate increasing from 1.1% y–1 for 1990–1999 to >3% y–1 for 2000–2004. The emissions growth rate since 2000 was greater than something is missing herefor the most fossil-fuel intensive of the Intergovernmental Panel on Climate Change emissions scenarios developed in the late 1990s. Global emissions growth since 2000 was driven by a cessation or reversal of earlier declining trends in the energy intensity of gross domestic product (GDP) (energy/GDP) and the carbon intensity of energy (emissions/energy), coupled with continuing increases in population and per-capita GDP." (Raupach *et al.* 2007)

While a comprehensive review of climate change impacts in the agricultural sector is outside the scope of this study, we have summarized regional impacts below and review the adaptation potential, benefits and tradeoffs associated with the agricultural options recommended in Section 8.

Table 1: Specific climate impacts on agriculture by region (summarized from Padgham 2009)

Region	Impacts
Sub-Saharan Africa	One of most vulnerable regions for food security due to repeated exposure to extreme climate events, very high reliance on rainfed agriculture, agrarian driven economic growth, entrenched poverty. Warming temperatures and aridity amplify vulnerabilities.
Middle East and North Africa	Increasingly vulnerable to combined effects of population growth, climate change, and natural resource base degradation. High temperatures, low and erratic precipitation, prolonged drought, and land degradation constrain agriculture currently -- intensification will make food production increasingly untenable.
South Asia	Higher incidence of flooding in flood-prone areas, persistence of drought in semiarid areas, temperature increases. Reductions in both yield and area of suitability of region’s two main cereal crops (wheat and rice). Long-term changes to the region’s water resources caused by loss of glacier melt water. Sea-level rise is a threat to rice production in low-lying coastal zones and river deltas.
East Asia and the Pacific	Temperature rise, flooding in Southeast Asia, sea-level rise in the Mekong and other major river deltas, and an increased intensity of El Niño–induced drought in Indonesia. Impacts on rice production and (in China) wheat and maize yields. Agricultural productivity in northern Asia could increase as a result of temperature rise, with potential benefits greatest where water is not limited.
Central Asia	Increased flood and drought risks from glacier retreat and melt water. Northern Central Asia (along with Northern Europe) may benefit from a longer growing season. Southeastern Europe could be negatively affected by temperature rise and increased moisture deficits.
Central and South America	Intensification of moisture deficits in northeastern Brasil and parts of the Amazon and Central America. Increase flood risk in southern Central America and southeastern South America. Positive benefits to agriculture in southern cone region of South America from an increase in the number of frost-free days. Profound effects on water budgets in the Andes as glaciers retreat over the next several decades and temperatures rise in high elevation mountain ranges.

3.3. Political context

Agriculture was historically on the sidelines of international climate negotiations. Although mentioned explicitly in the 1992 United Nations Framework Convention on Climate Change (UNFCCC), the emphasis has focused on adaptation and food production (Article 2; Article 4.1e).

> Article 2: “The ultimate objective of this Convention ...is to achieve...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." [Emphasis added]

Article 4.1 (e): "Cooperate in preparing for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, *water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods;"* [Emphasis added]

The sector only recently received special consideration for mitigation despite early recognition of its potential by the UNFCCC (Article 4.1c):

Article 4.1 (c): "Promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, *agriculture, forestry and waste management sectors;"* [Emphasis added]

Under the Kyoto Protocol[11] developed countries have the option of using net "direct human-induced" changes in GHG emissions and removals by sinks to meet their emission reduction targets.[12] By contrast, the Clean Development Mechanism (CDM), a mitigation crediting mechanism for developing countries, limits eligibility of sequestration projects to afforestation and reforestation projects. The primary mitigation opportunities (especially for smallholders) to enhance soil carbon stocks through cropland or rangeland management are excluded.

Countries are discussing agriculture in the context of cooperative sectoral approaches in the context of the Ad-Hoc Working Group on Long-term Cooperative Action (AWG-LCA) established after the 13th session of the conference of the parties (COP) to the UNFCCC. The draft decision text of COP15 and COP16 (not adopted) called for countries to promote research and cooperate on measures to reduce emissions through shared agricultural technology and practices (FCCC/AWGLCA/2009/L.7/Add.9). It emphasized activities that "improve the efficiency and productivity of agricultural systems in a sustainable manner" while contributing to adaptation. The text recognized the interests of "small and marginal farmers" as well as the rights of indigenous peoples, in the course of implementing these actions, and stressed - in brackets - that these should not impose "arbitrary or unjustifiable discrimination….or restriction on trade." Finally, any sectoral or sector-specific actions in the agriculture sector were to take into account the interrelated aspects of agriculture and food security, adaptation and mitigation. The AWG-LCA also requested the Subsidiary Body for Scientific and Technological Advice (SBSTA) to establish a work programme on agriculture to enhance the implementation of the decision.

COP15 failed to reach agreement on agriculture. However, the COP took "note" of the Copenhagen Accord opening the door for the submissions from at least 43 countries on nationally appropriate mitigation actions (NAMAs), submitted as of January 2011, of which 20 countries included agricultural activities such as the restoration of grasslands, fodder crop production, introduction of combined irrigation and fertilization techniques to increase the efficiency of fertilizer application and methane capture in livestock and chicken farms (See Annex 9.4 for a full list). Morocco and Papua New Guinea, notably, submitted quantitative voluntary agricultural mitigation targets, while Brasil quantified emission reduction commitments in relation to particular activities such as restoration and conservation, improved live stock management, conservation tillage, N-fixing activities.

---

[11] The Kyoto Protocol (KP) was negotiated in 1997 and entered into force in 2005.

[12]These countries are obligated to report certain agricultural emissions (mainly CH4 and NO2 emissions from human-induced biological processes) while CO2 removal or emission from cropland management is optional (Article 3.4).[2] Only a few countries have elected to do so (FAO 2010b). Those 'net changes' must be "measured as verifiable changes in carbon stocks in each commitment period" (Kyoto Protocol). Forest carbon stocks by developed countries are treated separately (Article 3.3 KP; Article 3.4 KP).

It was hoped that COP16 (29 Nov – 10 Dec 2010) would reach an agreement on agriculture based on a text negotiated by the AWG-LCA.[13] Although the Cancun Agreements set the stage for a new climate agreement after 2012 by legitimizing emission targets in the Copenhagen Accord and restoring trust among diplomatic negotiators prior to COP17 in 2011, no deal on agriculture was included in the final text. A decision on agriculture failed because of the unfortunate coupling of action on agriculture with bunker fuels under the joint header of cooperative sectoral approaches and dispute over language concerning trade, a highly controversial topic in international negotiations, despite consensus on the role of agriculture as a major factor in GHG emissions, its mitigation potential and the importance of food security.[14]

[13]The AWG-LCA was set-up by the Bali Action Plan as a subsidiary body under the Convention. Its initial mandate (in effect until 2009) has been extended by the COP and the outcome of the LCA's work is to be presented at COP 16

[14]In a section in the AWG-LCA text on "*cooperative sectoral approaches and sector-specific actions*" including agriculture was ultimately deleted in the final version adopted by the UNFCCC. The first complication was the conflation of agriculture and bunker fuels under one heading (FCCC/AWGLCA/2010/CRP.1) without differentiation or separation. However, prolonged disagreement on a formulation for trade-related language, namely the reference that cooperative sectoral approaches and sector-specific actions in the agriculture sector should not cause "*arbitrary or unjustifiable discrimination of a disguised restriction on international trade*"[4] led to the sections removal from the final Cancun Agreements. The elimination of that chapter means that SBSTA has no mandate to establish a work programme on agriculture.

4. Stakeholder analysis

The stakeholder consultations solicited views from civil society, government agencies, research institutions, and farming association representatives regarding appropriate financing mechanisms and agricultural practices to secure climate and smallholder benefits. A diverse range of views was expressed; however the central points are summarized below and are reflected in appropriate sections of the report. Interviews with key stakeholders were held at the Global Conference on Agriculture, Food Security and Climate Change in The Hague, Netherlands (31 October - 5 November 2010); the United Nations climate change conference (CP16 / CMP 6) in Cancun (29 November – 10 December 2010), and through direct communication with relevant organizations and individuals throughout the year. (Please see Annex 9.1 for a list of interviewees.)

Strategy to encourage agricultural mitigation
There was a clear preference for workable, practical systems to pilot and scale agricultural mitigation and adaptation projects based on existing institutions and agricultural M&E frameworks. The support mechanisms for agricultural projects and programs, several interviewees stated, should emphasize action in addition to readiness, and act as a pathway to scaling up activities rather than waiting for an elaborate readiness process. They noted many agricultural reforms and/or intensification trends were imminent or underway, and waiting longer would preclude climate finance from having a larger impact.

Some representatives stressed the need for systematic change in the sector by leveraging policies and economic incentives, if not a formal readiness process. Gerald Nelson of the International Food Policy Research Institute stated: "The problem is that the project focus is a relatively short time frame and does not set up the enabling environment: human capacity, development, physical infrastructure to support human capital on the research and outreach side, but also policies…[sometimes] we don't need new agronomists but to build more roads." The transactions costs involved with changing individual behaviour, and distributing financing through centralized systems would be high and likely impractical.

Role of agriculture in an international climate agreement
Several developing country representatives (government and civil society) displayed resistance to two main points that will complicate integrating market-based climate mechanisms in the agricultural sector: i) opposition to agriculture as a mitigation measure as it is currently negotiated under the UNFCCC, instead of an adaptation-driven element of the climate regime; ii) creation of fungible market-based offsets in an international system of crediting emission reductions for agriculture. This opposition was not universal – some African countries are considering ways to support agricultural mitigation through markets – but there appears to be a general aversion to international carbon-market based approaches to agricultural mitigation, apart from the US and to some degree Australia, and a dearth of UNFCCC advocates among developing countries that could push this agenda forward as the Coalition of Rainforest Nations did for international forestry and REDD.

Resistance to agricultural carbon markets focused on the expense, complexity and uncertainty of establishing new market infrastructure, and the fears that this would expose countries and farmers to excessive delays, lack of liquidity, transaction costs and downside risks. A second fear was that offsets would disturb policy goals designed to push the agricultural sector toward more efficient agricultural practices. Country representatives thought policies could and should play this role, but an offset market risked optimizing for short-term carbon credits rather than systematic, long-term sustainability strategies.

This does not preclude private sector engagement. A role for the private sector in designing, financing, and/or implementing agricultural mitigation was not opposed – rather, it was the carbon-market means to do so that raised opposition. Exceptions were noted in situations where incentive payments (either market or non-market based) are made for domestic agricultural offsets in relatively straightforward agricultural applications such as fertilizer reduction or efficiency. These cases generally represented domestic policy for developed or major emerging market economies.

Role of government in carbon and agricultural markets
Assuming a carbon-market structure was in place, opinions diverged about whether mitigation incentives should be mediated by government or open to direct demand from international markets. The most common recommendation was that climate finance should pursue a dual strategy to strengthen government agricultural extension programs, including complimentary private and NGO-supported extension, while opening market-access at the national level and preserve the option to directly incentivize farmers for improved practices.

Respondents suggested favouring one option or the other would fail if markets, infrastructure and training were underdeveloped – as they are in many countries. Stronger roles for governments – national, regional and/or local, or even a collaboration of these -- were emphasized in places where the quality of infrastructure, commercial sophistication, agricultural productivity and enabling conditions was low. The specific points raised by interviewees regarding this issue were:

- The feasibility of carbon market project mechanisms such as the Clean Development Mechanism (CDM), voluntary markets and others depend on the legal and regulatory context at the national level and thus a universal recommendation was not possible.
- Direct links between carbon-markets and farmers already exist in some countries but a public sector intermediary may be appropriate for the agriculture sector to ensure that activities do not threaten food security or unfairly exploit smallholders.

Food security
The overriding priority of food security was a common refrain: “Mitigation cannot threaten food production,” “Focus on productivity, not emission reductions [in negotiations with developing countries],” “Any climate mitigation measures that do not ensure food security will be a non-starter.” However, food security is not merely a function of agricultural productivity. It is also a matter of access to food, food utilization, political stability and other important food security components. Respondents were clear that hunger – like other social problems – could not be simplified into single cause or solution. There was agreement that food security must be a central aim for climate strategies in the agricultural sector to work. No single means to achieve this were offered, however the range of issues raised were:

- Measures to increase productivity must ensure that demand – either through domestic markets or links to wider international buyers – increases proportionally
- Negotiations with developing countries under the UNFCCC or through bilateral discussions need to recognize this; activities should prioritize smallholders and increasing rural income
- No mitigation measure should be permitted that dislocates or interferes with regional food supply without compensatory systems

Climate finance governance
The question of administering financial mechanisms (and initiatives) for agriculture revealed strong views on two key domestic and international issues: country-appropriate administration of funds, and coordination of international financing both among funders and within countries. These were seen as important to ensure countries disbursed international financing effectively, and reduce administrative and reporting burdens on developing countries. The essential points are summarized below:

Domestic financial governance:

- Either a purely local or purely national strategy for financing was seen as flawed. Interviewees suggested a system of internal checks and balances through decentralized selection of activities and implementation by communities/local jurisdictions with oversight and accountability by national governments.

- In some cases, where local governance was inadequate, there was some potential seen for federal government expansion of agricultural extension services and other mechanisms that directly support farmers; however, the perceived risk was higher.

International financing arrangements:

- Financing should be coordinated at the international level to complement developing country-led objectives – mitigation, food security, and poverty – through harmonized and transparent funding strategies.
- Financing mechanisms processes to apply, receive, and report on climate funds should be integrated into the larger climate financing frameworks for developing countries under the UNFCCC or bilateral initiatives.

Barriers

- Strong legal and regulatory frameworks will be a limiting factor to implement agricultural mitigation measures through climate finance.
- Developing countries lack – and could benefit from – a coherent, organized and forceful advocacy coalition to include agriculture in a future climate finance mechanisms or agreement similar to the Coalition of Rainforest Nations support that propelled REDD onto the international agenda.
- Developing and developed country views on the inclusion of agriculture in a future climate agreement diverge. Most developed countries are in favour of both mitigation and adaptation, whereas many developing countries insist on adaptation but are wary of mitigation.
- UNFCCC negotiations will struggle with the issue of trade and it may emerge that trade is not discussed in the context of sectoral approaches. Language in draft agricultural decision text (not adopted) stated that measures should not constitute "arbitrary or unjustifiable discrimination of a disguised restriction on international trade" proved too contentious.
- International understanding of MRV concepts and practical design is relatively limited and negotiators will be hard pressed to design workable systems given this limited knowledge base. It is likely that only high-level principles can be established politically, but it is important that the technical limitations and applications are communicated effectively.
- Knowledge remains a key barrier to implementing agricultural projects and policies. "There is no consensus on what is known or what we need to know," stated one respondent.

5. Modeling GHG in the agriculture sector

Our assessment used the GLOBIUM global land use model designed by IIASA to evaluate the GHG emissions and abatement potential in the agricultural sector in 27 global regions, as well as agricultural practices associated with these factors.[15] The results produce estimates of GHG volumes, relative cost, and geographic distribution. The categories of variables in the model were:

- *Agricultural mitigation measures:* The measures include intensification, productivity increases, redistribution of cultivation for higher yields, agricultural trade increases, crop switching and others. They primarily reduce non-CO_2 GHG emissions and increase carbon sequestration in biomass.
- *Livestock measures:* These measures include adoption of better breeds, improved animal health, feed changes, and system changes. For example, GHGs emissions are reduced as producers move from extensive to intensive systems as defined by the FAO livestock categorization.
- *Geographic shifts:* Such measures promote a shift of cultivated land from more arid regions to grasslands and other productive biomes.
- *Demand shifts*: These are behavioral changes leading to lower human consumption of meat and decreased demand on livestock production.
- *REDD and land use changes:* These simulate economic incentives for conservation of forest carbon through payments under a global incentive scheme for reduced emissions from deforestation and forest degradation (REDD).
- *Biofuels:* Such measures anticipate future government-mandated demand for biofuels compliant with biofuels standards.

Scenarios were run under three different annual crop growth assumptions -- 0.0%; 0.5%; and 0.5% combined with enhanced livestock productivity -- to compare how these assumptions affected the final output. The "crop growth" factor is important, particularly for future deforestation rates. It describes the annual input-neutral improvement of seeds, genetic stock, pest and disease management, and waste.[16] Historically, this has improved at a rate which is consistent with the 0.5% input-neutral crop growth assumption per year, leading to large productivity increases without proportionally expanding agricultural land area. However, this pace has slowed significantly and the impacts of climate change will make this still harder to maintain in the future. We therefore conservatively assume input-neutral crop growth is 0%, and 0.5% if historically consistent. Higher input-neutral crop growth scenarios (>0.5%) have not been analyzed as the underlying physiological processes to incorporate in the biophysical crop growth model are not known.

Table 2: Growth rates of agricultural production (percent/yr)[17]

Regions	1961-2007	1981-2007	1991-2007	2005/07 – 2030	2030-50	2005/07 - 2050
Developing countries	3.5	3.6	3.5	1.8	1.1	1.5
(idem, excl. China and India)	3.0	3.0	3.1	2.1	1.4	1.8

[15] Global Biomass Optimisation Model (GLOBIOM)

[16] Input neutral means more production is achieved independent of intensification due to additional fertilizer and irrigation water inputs and agrochemicals.

[17] Expert Meeting on How to Feed the World in 2050, 24-26 June 2009)

Sub-Saharan Africa	2.6	3.3	3.1	2.7	1.9	2.3
Near East/North Africa	3.0	2.7	2.5	2.1	1.3	1.7
Latin America and Caribbean	3.0	3.0	3.4	2.1	1.2	1.7
South Asia	2.8	2.8	2.4	2.0	1.3	1.6
East Asia	4.3	4.5	4.3	1.3	0.6	1.0

It is important to note that the GLOBIOM model does not simulate carbon sequestration potential from soils because the initial carbon values of soils are too poorly quantified to give robust estimates of agricultural management impacts on soil carbon. Given its global importance, particularly for smallholders, we have included this as a central agricultural opportunity in our final analysis based on IPCC data estimating 89% of total agricultural GHG abatement potential resides in soils (extrapolated from an extensive body of scientific literature, economic potential and field trials). There is still contention over how much of this is ultimately feasible (Baker et al. 2007), the lack of scientific certainty around soil carbon benefits from conservation tillage/no-till (B. Govaerts et al. 2009; Baker et al. 2007; Luo 2010), and clarity about sequestration mechanisms (Govaerts et al. 2009; Luo 2010). Despite these concerns, most soil carbon measures remain "an important technology that improve soil processes, controls soil erosion and reduces production cost" independent of soil carbon sequestration rates (B. Govaerts et al. 2009).

5.1. Modeling results

Agricultural emissions in developing countries are projected to rise through the middle of the century by 57% to 70% under a BAU scenario.[18] By 2050, total annual emissions in the sector are expected to reach 8,500 MtCO_2 per year if yield growth assumptions remain flat. The fundamental drivers of demand in the agricultural sector – population, income (GDP per capita) and bioenergy[19] consumption – all rise steadily during the 21st century, with meat/food consumption growing fastest to 50% above 2000 levels. These conditions exert mounting intensification and conversion pressure on croplands and forests for agriculture, only partially counterbalanced by the expected levels of intensification and crop improvements. The different categories of agricultural emissions are described in Table 3.

Table 3: Agricultural emission category definitions

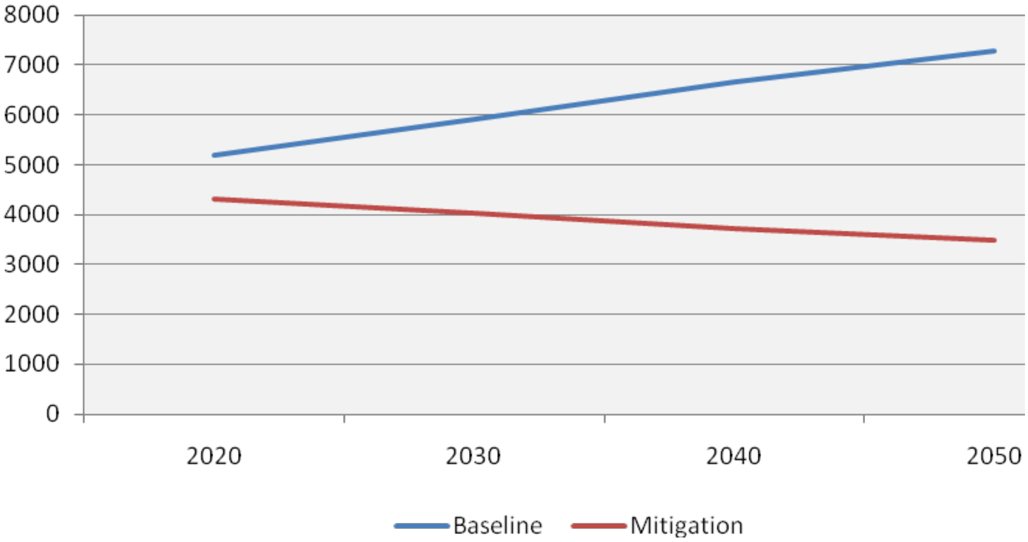
Category	GHG Source	Associated mitigation measures/practices excluding end-of pipe type measures
Rice	Methane (CH_4) from the anaerobic decay of biomass, usually submerged	Substitution with other cereals, geographic relocation, optimized agronomics
Soil	Nitrous oxide from the application and waste of chemical fertilizers	Relocation of agricultural production, optimized agronomics
Other Land use changes	CO_2 from biomass decay/oxidation in conversion of non-forest biomes	Minimize carbon emissions when expanding cropland and grassland
Enteric fermentation	CH_4 from incomplete food digestion in ruminant stomach	Relocate production, shift out ruminant production, livestock system shifts, improved animal nutrition
Manure management	N_2O, CH_4 from manure decomposition	Relocation of production, livestock system shifts, improved animal nutrition
End-of –pipe measures	Fertilizer, tillage, and emissions from other processing activities	Technological-oriented solutions including more efficient fertilizer application, nitrogen suppressants on fields and other treatments

[18] Modeled as 0.5% and 0% input-neutral crop growth, optimistic and conservative scenarios respectively

[19] Bioenergy demand remains approximately constant at 2005 levels and constitutes tree plantations that generally do not compete with food production.

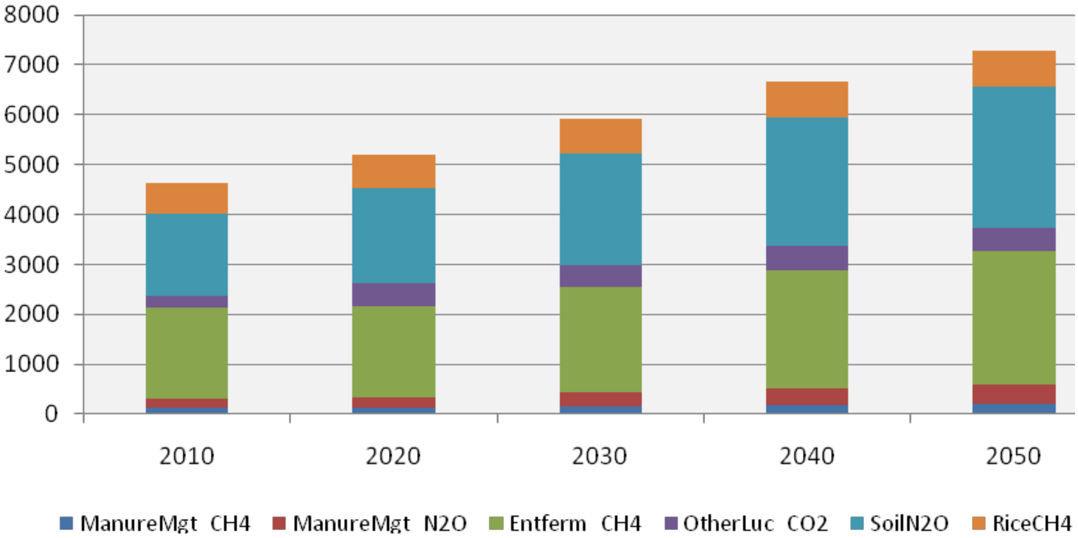
The GHG emission trends are modeled below (Figure 7 and Figure 8). The largest share of GHG emissions is attributable to livestock (primarily methane from enteric fermentation, but also manure management) and the global expansion of (often inefficiently) fertilized cropland onto natural ecosystems. Together, these categories account for more than 90% of total emissions (Figure 8).

Figure 7: Developing country emissions (MtCO2eq p.a.) (blue) relative to mitigation scenario (red) consistent with IPCC 450ppmV stabilization scenario*



** Agriculture in 0.5% input-neutral crop yield growth BAU scenario*

Figure 8: Developing country emissions from agriculture by category** *(MtCO2eq p.a.)*



***Legend: Rice methane (CH4) from paddy production; Soil nitrogen (N_20) from fertilizer applications and soil disturbance; Other land use change (CO_2) carbon dioxide from natural biome encroachment; livestock enteric fermentation (CH_4); livestock manure management (N_20 and CH_4).*

The largest abatement potential, as categorized in modeled mitigation areas, are improved livestock management and reduced nitrogen emissions from croplands by using fertilizer more efficiently. The livestock sector is also a crucial element of mitigation as it affects multiple emission drivers including methane from enteric fermentation, pasture/cropland management and indirect land use changes such as deforestation. These global mitigation measures curb GHG emissions through two mechanisms: (i) increase production efficiency (milk or meat per livestock head, yields per hectare); (ii) reduce the absolute total number of animals and cultivated area relative to the baseline by optimizing the geographic location of production.

As noted, this model excludes soil carbon sequestration because spatial information on current soil carbon stocks, which is required to assess the soil carbon gap, is not globally available with reliable quality. However, we integrate this into our review of agricultural practices in Section 6. A range of mitigation actions achieve both GHG emission reductions/removals and increases in food production offering significant mitigation potential in developing countries. The abatement measures shown below (Figure 9 and Table 4) depict GHG emissions from the entire land use sector (broken down by source) for developing countries in the baseline scenario followed by four mitigation scenarios (REDD, agricultural reductions, combined, and end-of-pipe measures) for developing countries. Emissions fall from 3,600 $MtCO_2e$/yr from baseline 8,600 $MtCO_2e$/yr by 2050.

Figure 9: Total terrestrial GHG balance for developing countries in 2050 under different policy scenarios including end-of-pipe measures (% represent fraction of baseline emissions)

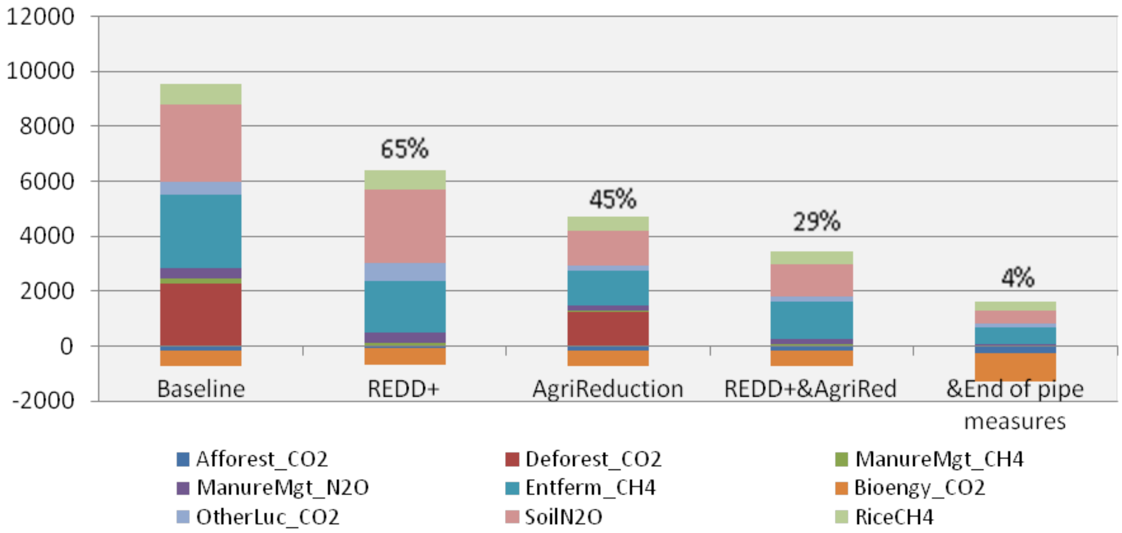


Table 4: Agricultural emissions from abatement measures relative to the baseline ($MtCO_2e$); negative values refer to sequestration.

Activity	Baseline	REDD	Agri Reduction	REDD & AgriRed	&End of pipe measures
Afforestation (CO_2)	-140.0	-85.1	-159.8	-171.5	-257.2
Deforestation (CO_2)	2,257.6	1.5	1,222.6	1.5	1.5
Manure Management (CH_4)	192.3	140.0	86.6	92.1	27.6
Manure Management (N_20)	396.3	369.0	177.3	153.9	46.2
Enteric fermentation (CH_4)	2,681.2	1,868.7	1,261.0	1,353.2	608.9
Bioenergy (CO_2)	-577.6	-579.3	-577.4	-576.6	-1,037.9
Other land use change (CO_2)	470.3	657.9	188.2	226.0	158.2
Soil and fertilizer emissions (N_2O)	2,813.2	2,648.8	1,261.3	1,164.1	465.7

Rice cultivation (CH_4)	733.5	719.5	513.0	477.0	310.1

The relative climate impact of agriculture will grow if aggressive energy sector mitigation and REDD measures consistent with the IPCC-goal of limiting atmospheric GHG concentrations to 450 ppm are implemented. By 2050, half of the total GHG emissions could come from the agricultural sector even if abatement measures are adopted (assumes large GHG reductions in other sectors). Agriculture would also account for most global non-CO_2 emissions (primarily N_2O and CH_4) representing about 5,000 $MtCO_2$/year by 2050 of which some 3,500 MtCO2eq/year coming from developing countries. This suggests an increasingly important role for agriculture in the global GHG budget assuming effective constraints are imposed on industrial and energy-related GHG emissions.

Deforestation

Deforestation continues in each of the baseline scenarios. Without external incentives for forest carbon conservation, the economic pressure to clear forest land will drive continuous net deforestation through 2050, mostly in the tropics. We project a minimum deforestation rate of 4.5 million ha per year under optimistic scenarios for crop improvements (0.5% and 0.5% plus livestock improvements), while 12 million ha could be cleared to meet demand for agricultural land without such improvements or REDD incentives as shown in Figure 10. Our model also finds cropland under cultivation will not decrease through 2050, despite intensification and crop improvements. Even under the most stringent abatement scenarios, the model predicts slight increases in irrigated, high-input and subsistence cropland with only slight declines in high-input agricultural areas.

Figure 10: Rate of deforestation (millions ha/yr) under different baseline assumptions for crop and livestock improvement

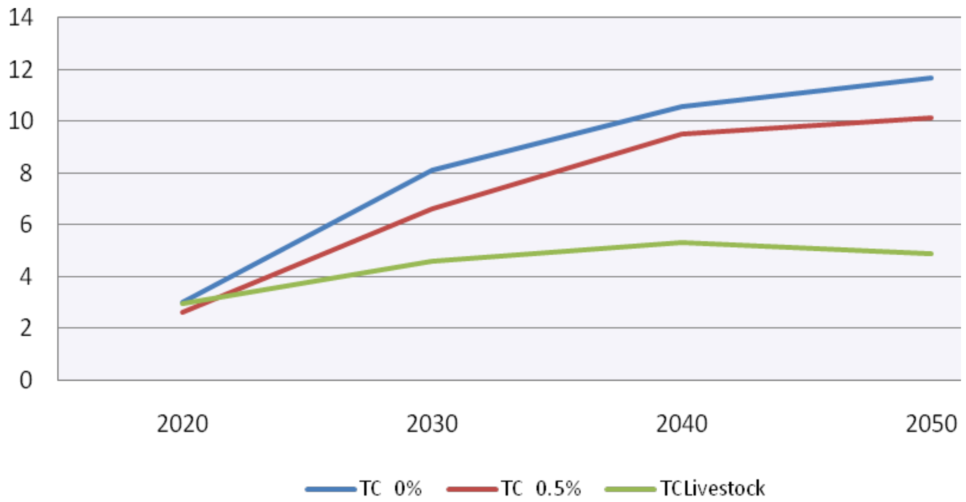
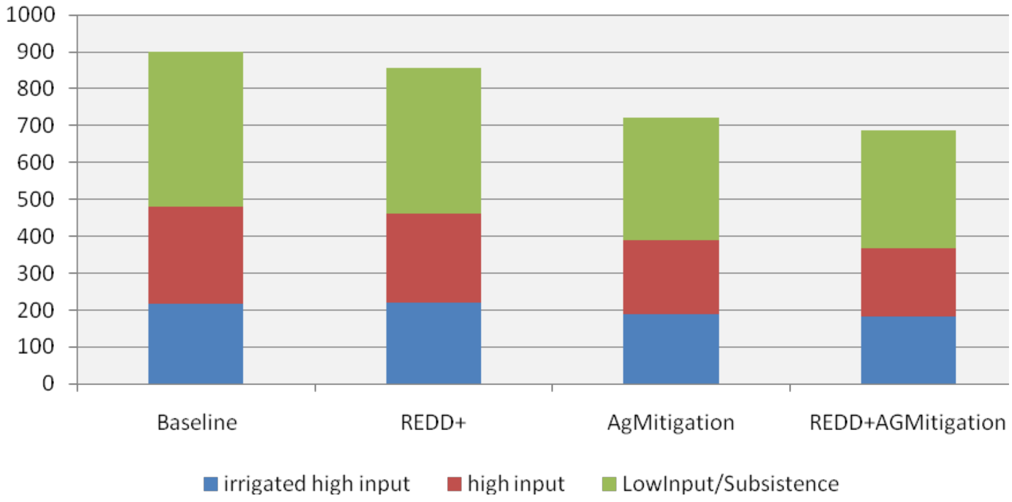


Figure 11: Cropland area expansion under different management practices for GHG measures (M ha)



5.2. Analysis

Agriculture covers 1.5 billion hectares of the planet having expanded more than 2.7 million ha annually between 1990-2005, more than any time in human history (World Bank 2010).[20] Our model results suggest agricultural expansion will continue, along with a rapid shift toward agricultural intensification and global trade. This may drive deforestation, and perhaps even accelerate it, if REDD or other forest conservation measures are not in place. The ability to achieve significant GHG abatement in the agricultural sector, stabilize emissions and boost productivity, will depend primarily on improvements in crop production and livestock management (see Figure 9) followed by reduced nitrogen emissions from croplands (particularly through encroachment on natural biomes). Global mitigation measures can both increase production efficiency (milk or meat per livestock head, yields per hectare) and curb land expansion (land-sparing measures) by optimizing the geographic location of production and thus reducing the absolute total number of animals or cultivated area relative to the baseline.

These findings are distilled into four points below. Although the model outputs rely on informed assumptions about the nature of the economic, environmental and social trends in the land use sector, the results are illustrative of the magnitude and direction of future trends.

- Agricultural abatement measures can cut emissions 55% (3,600 MtCO_2e/yr) from the baseline of 8,600 MtCO_2e/yr by 2050 from a theoretical perspective (feasible volumes are likely much lower)
  - Combining this with REDD results in emission reductions of 71% from the baseline
  - Adding end-of-pipe measures results in a 96% reduction in agricultural GHG
- Livestock, cropland/grazing land management and REDD are the primary sources of emission reductions.
- Expansion of agriculture into forests and other biomes, particularly grasslands, will continue or even accelerate without countervailing polices and/or economic incentives (such as REDD).
- Abatement measures and REDD will not be enough to prevent all forest clearance or encroachment on natural ecosystems. Projected agricultural demand and resources constraints (productivity per hectare) implies that minimum deforestation is needed to create enough land for future agricultural expansion given technological (crop growth improvement) assumptions.

Our model is in broad agreement with FAO predictions that food production (in value terms) will need to rise 70% by 2050 to meet agricultural demand, implying a 49% rise in the volume of cereals (extra billion

[20] Declines in industrialized and transition countries (-0.9 and -2 million respectively) were eclipsed by increases of 5.5 million ha annually in developing countries.

tons) and 85% rise in meat production (200 million extra tons) (Bruinsma 2009). To better understand how this future could unfold, we have outlined two extreme scenarios in the agriculture sector identified by Grieg-Gran (2010) that constrast two possible (and opposite) agricultural development pathways for this century: "no productivity increases" and "no expansion of cultivated land." While some middle path of intensification and expansion seems likely, these opposing scenarios reveal the implications of increasing demand, limited resources and climate impacts.

In a "no expansion" scenario (where agricultural land area is constant), cereal yield growth must increase 1.07% annually in developing countries to meet demand. Although yield growth rates of 2.2%/yr were achieved between1961-2007 on average (Grieg-Gran 2010), this pace has been steadily eroding in recent years. Future growth rates of 0.5% or 0% are considered more likely, especially if considering land degradation and climate impacts. Conversely, a "no productivity improvements" scenario implies that 600 million additional hectares will need to be converted for cereal production by 2050, equivalent to historical deforestation rates of about 13 million hectare annually (Grieg-Gran 2010).

This highlights agriculture's role converting forests and other natural ecosystems that is driving terrestrial GHG emissions. Without regulation or REDD incentives, our model shows it will remain cost-effective to clear forests for farmland through 2050, and perhaps beyond. Assuming a pessimistic scenario (neither crop improvements nor a REDD mechanism), agricultural demand will cause the loss of 12 million ha/yr of forest through 2050 – almost equal to the worst annual global losses of tropical forest between 1990-2010. The corollaries to these modeling assumptions are:

- Ending deforestation must ultimately be a political decision to extend incentives or regulation for forest conservation. Economic demand from the agricultural sector will rise and forest encroachment remains cost effective in the absence of compensation to conserve forest (or other terrestrial) carbon stocks.
- Improvements to the effectiveness and productivity of crop species and livestock management regimes, as well as their adaptive capacity, can profoundly affect future demand for additional agricultural land and, thus, the rate of deforestation.

Overall, however, we find the opportunities for GHG abatement in the agricultural sector – and terrestrial carbon more broadly – are significant and promising. Globally, emissions from global land use, driven by the agricultural sector, could be substantially offset with on-farm measures for cropland and pastureland management combined with aggressive end-of-pipe mitigation measures such as REDD and bio-energy/biofuels by 2050. Theoretically, this reduction is 96% below the terrestrial GHG baseline. Although carbon-neutral food production is probably not achievable, even a moderate share of this mitigation potential represents globally significant GHG reductions.

The emissions path for aggressive agricultural mitigation is explained in more detail below. Figures 12 to Figure 15) and show emission reduction potential from specific agricultural measures within geographical regions. The first estimates are *without* REDD, the second includes REDD incentives. Sub-Saharan Africa and Asia are focal points for agricultural mitigation and sustainable intensification efforts given expected increases of agricultural emissions from 2020-2050, although most developing regions show significant early abatement potential (see Figure 12 and Figure 14).

Figure 12: GHG emissions by region in the GLOBIUM model (baseline; 2020 (left) and 2050 (right) *without REDD*

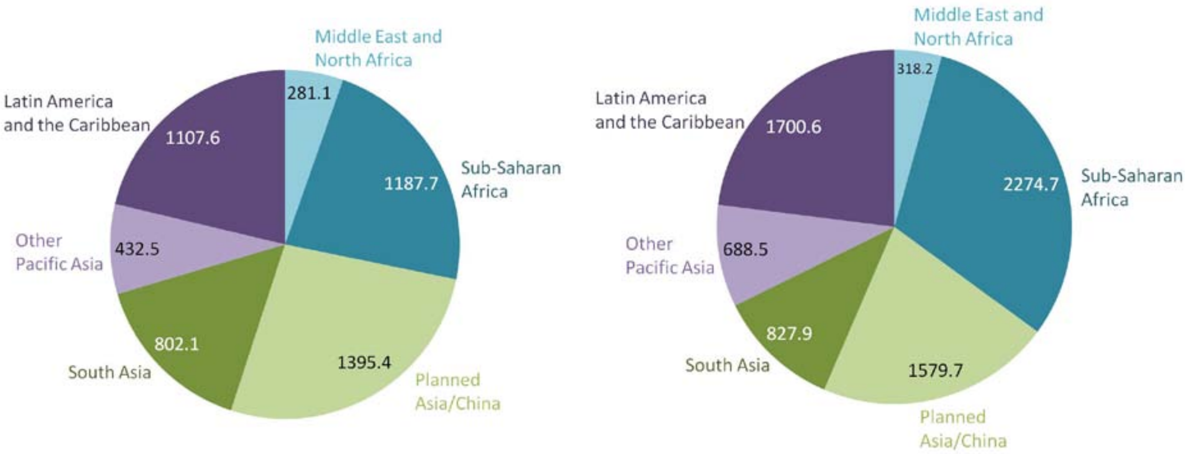


Figure 13: Emission reduction potential by GHG category and region (2020; baseline scenario; $MtCO_2e$)

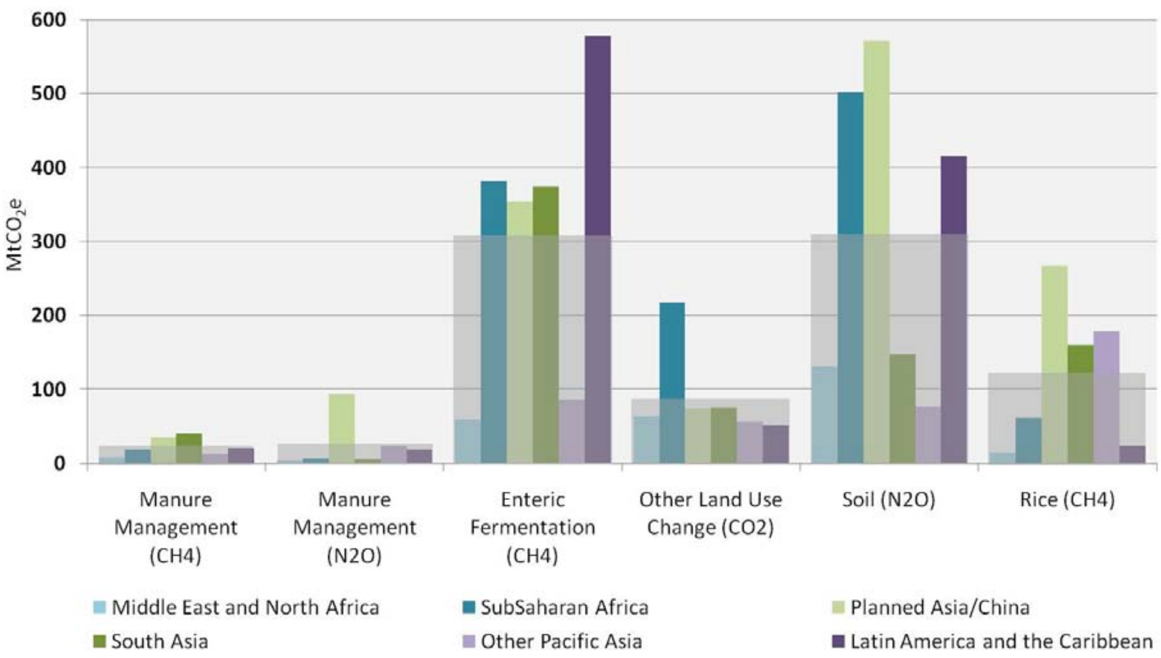


Table 5: GHG abatement country potential (top three) by practice/region in 2020; REDD scenario

Type of emission	Highest emitter	Second highest	Third highest
Manure management (CH_4)	South Asia	Planned Asia/China	Latin America (L.A.) and the Caribbean
Manure management (N_2O)	Planned Asia/China	Other Pacific Asia	L.A. & Caribbean
Enteric Fermentation (CH_4)	Latin America and the Caribbean	South Asia	Planned Asia/China
Other land use change (CO_2)	Sub-Saharan Africa	South Asia	Planned Asia/China
Soil (N_2O)	Planned Asia/China	Sub-Saharan Africa	L.A. and the Caribbean
Rice (CH_4)	Planned Asia/China	Other Pacific Asia	South Asia

Figure 14: GHG emissions by region in GLOBIUM model (REDD scenario, 2020 (left) and 2050 (right) *including REDD*

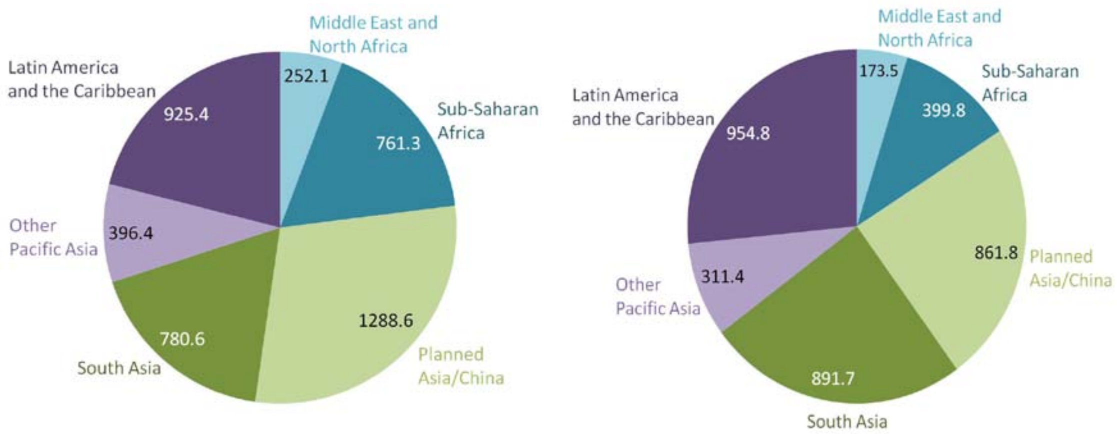


Figure 15: Emission reduction potential by GHG category and region (2020; REDD scenario; MtCO2e)

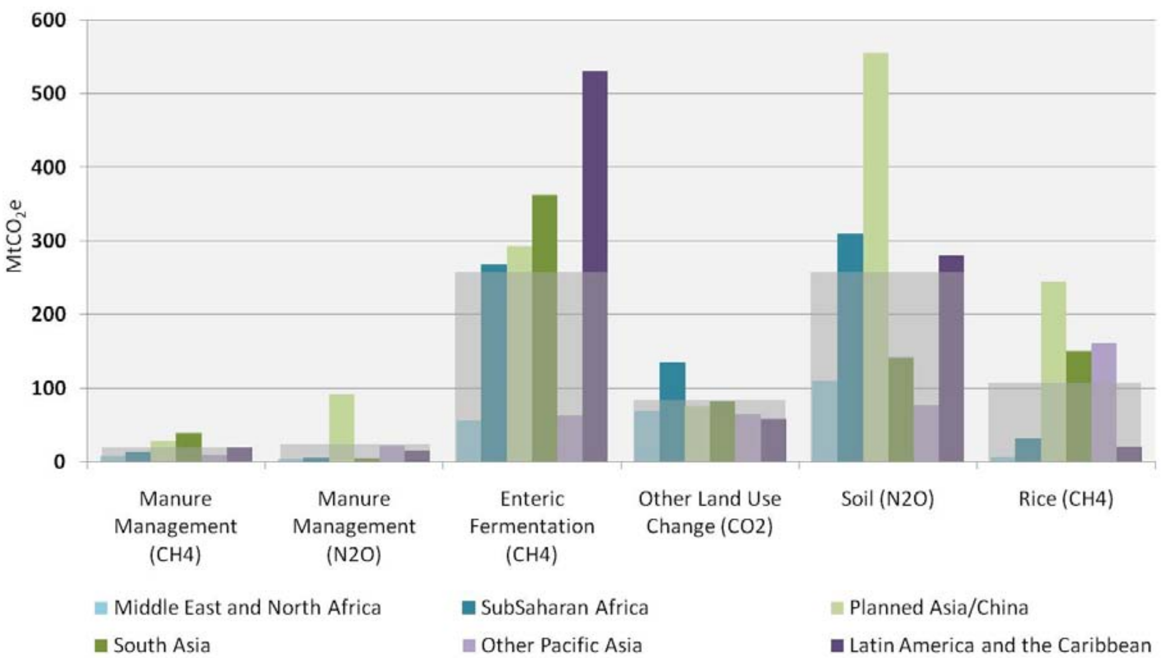
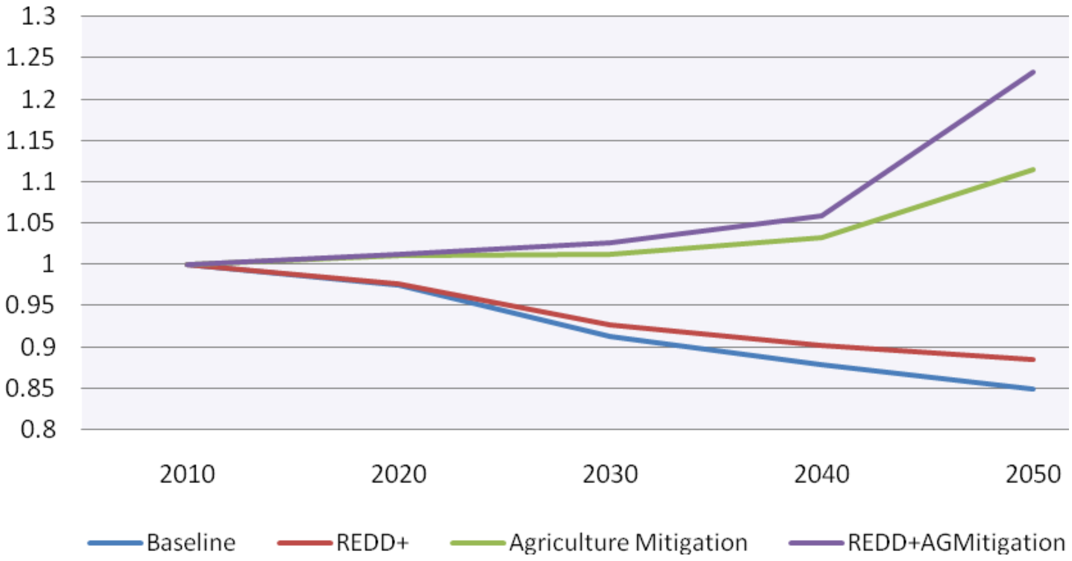


Table 6: GHG abatement country potential (Top three) by practice/region in 2020; REDD scenario

Type of emission	Highest emitter	Second highest	Third highest
Manure management (CH_4)	South Asia	Planned Asia/China	L. America & Caribbean
Manure management (N_2O)	Planned Asia/China	Other Pacific Asia	L. America & Caribbean
Enteric Fermentation (CH_4)	L. America & Caribbean	Sub-Saharan Africa	South Asia
Other land use change (CO_2)	Sub-Saharan Africa	South Asia	Planned Asia/China
Soil (N_2O)	Planned Asia/China	Sub-Saharan Africa	L. America and the Caribbean
Rice (CH_4)	Planned Asia/China	Other Pacific Asia	South Asia

This emission abatement could come at a cost. Assuming the price of agricultural mitigation (that is, the cost of realizing the carbon benefit) is not compensated, real crop prices could rise in the modeling scenario. This is most pronounced in future years as resource constraints arise. In many cases, agricultural practices that sequester carbon or reduce GHG can pay for themselves through higher productivity and greater resilience (despite upfront costs or implementation barriers). Alternatively, GHG abatement could be compensated by an external carbon market (or other financial incentives), as are REDD costs in this model. Under this scenario, agricultural mitigation costs are externalized leaving agricultural commodity prices relatively unaffected by mitigation measures. This implies payments for agricultural emission reductions, market-based or otherwise, could also alleviate crop price increases.[21]

Figure 16: Crop price Index under the 0.5% crop improvement and livestock improvement scenario[22]



Angelsen (2010) also suggested that there may be an unpleasant choice between REDD and feeding the hungry, but data shows that during the last two decades agricultural productivity increased, while annual gross deforestation for agricultural land area rose by just 0.3%, confirming our modeling result that REDD and food security can be achieved simultaneously *if* substantial improvements in "crop growth" – or the technological increase of production – are sustained. Assuming crediting or compensation mechanisms exist, food prices could also remain stable or fall. It is also worth emphasizing the importance of underlying crop improvement rates. A 0% crop growth scenario implies price increases of 10% independent of any mitigation measures, and investments costs of irrigation, fertilizer, and intensification could add to the price even more. On the other hand, crop growth rates in the historical range will profoundly reduce pressure on agricultural expansion and price.

Finally, trade is crucial to increasing the efficiency of the global agricultural sector, managing price increases and ensuring food security leads to GHG abatement. Agriculture is using less land by shifting and concentrating production in more favorable areas. The logical consequence is an increase in trade. However, land-use policies can only concentrate production if economic development is triggering urban migration and reducing land use pressure from the most marginal agricultural production places. Under an aggressive mitigation scenario, wheat trade volumes rise 60% above the no-mitigation baseline of 13% of global wheat harvest. Yet, today, the FAO (2010) estimates only 20% of wheat production is

---

[21] It is worth noting that price gains in baseline crop growth scenarios relative to 0.5% in crop productivity result in real prices 15-17% below 2000 levels compared to of 15% for no improvement.

[22] The drop in crop prices under a REDD+ scenario are to a large degree the results of "leakage" or agricultural expansion into grasslands and other natural land with low carbon stocks.

traded/exported, while most other agricultural commodities are even less heavily traded. The obvious limitations to achieving these levels of trade volumes suggest major constraints on achieving efficient global mitigation in the agricultural sector.

Agricultural model comparison

The GLOBIOM model used for this analysis is the only total land use model with a detailed geospatial representation of agricultural production options and detailed agronomic measures to boost production and abate GHGs ("bottom-up" approach). It is a multi-scale (sub-national, national, global) model that simulates aggregate world demand, supply, and prices for commodities and land with biophysical and economic constraints. The model parameters include engineering costing of measures; total land use representation (agriculture, forestry, bioenergy, natural conservation); international trade and commercial barriers; and other environmental services (biodiversity, water, nutrient cycling, etc).

We have briefly reviewed the differences with existing agricultural modeling efforts. We found most models focus on deforestation but consider agriculture only as a driver of deforestation rather than as a direct source of GHG emissions. A list of major regional and global models that incorporate agriculture is summarized from the Terrestrial Carbon Group (2009) below.[23]

- *Global Timber Model (GTM):* simulates global competition between forestry and agricultural land; non-spatially explicit. Considers avoided deforestation, afforestation and biofuels. Difficult to scale results to national or sub-national levels.
- *Land Use Carbon Sequestration model (LUCS model)*: Rural land use change as function of population demographics and land use/land management data, non-spatially explicit model, national scale.
- *SimAmazonia 1:* Regional deforestation rates determined by opportunity costs versus agriculture and timber rents, existing and proposed protected areas, and current and future roads; Incorporates two models at sub-national scale. Future deforestation based on transportation and utility infrastructure, protected areas, and biophysical features.
- *Terrestrial Carbon Group "Three Filters":* Predictive deforestation model of 76 developing countries with REDD incentives. Spatially-explicit carbon stock model excludes areas with legal protection biophysical unsuitability, and / or economic infeasibility; national and partially global scale (Terrestrial Carbon Group, 2008);
- *GTAP model and derivatives (LEITAP, MIRAGE):* Land use simulation (general equilibrium approach) does not deal directly with emissions. Provided indirect land-use change assessments for California.[24]

There are a limited number of explicitly linked climate and agriculture models. The most prominent scenarios have been conducted by Stanford University's Multi-Gas Mitigation and Climate Change project (EMF 21) with agricultural mitigation estimates derived from marginal abatement cost curves.[25] The IMAGE group has produced agricultural GHG emissions estimates with LEITAP scenarios predicting baselines and model diet changes (Stehfest and Kabat 2009). Finally, the Potsdam Institute for Climate Impact Research is working on sectoral emissions is the MagPIE model (Popp et al. 2010).

[23] The full list of forest cover/ REDD+ models are available from TCG (2009): http://www.theredddesk.org/sites/default/files/resources/pdf/2010/TCG_Policy_Brief_2_Tools_for_Setting_Reference_Emission_Levels_Jun_09.pdf

[24] https://www.gtap.agecon.purdue.edu/models/landuse.asp

[25] http://emf.stanford.edu/research/emf21/

6. Agricultural systems and measures

A number of effective and well-established agricultural practices are suitable for fast-start mitigation actions (FAO 2010) from intensified smallholder production of cash crops such as cocoa or coffee to sustainable grazing practices on pasturelands and more efficient livestock management. These apply key techniques including minimal tillage, use of nitrogen fixing cover or tree crops, increased or reduced but more efficient application of nitrogen fertilizers, erosion prevention, woody perennial intercropping, rotational grazing, and manure management, improved quality of feed and livestock conversion efficiencies, and conservation of natural ecosystems. Research and expertise from a number of pilot initiatives including the 40 projects covering 12.75 million ha reviewed in the framework of the Foresight Global Food and Farming project (Pretty *et al*. 2011) provide useful, if preliminary, guidance to establish scaleable initiatives.

In this section, we briefly review promising agricultural systems amenable to mitigation practices with strong synergies for smallholders, as well as the barriers to implementing them. We review four primary agricultural opportunities -- promising candidates for short to medium-term actions – that frame our recommendations for agricultural initiatives in Section 8.

- Cropland management (sustainable land management and nutrient applications)
- Pasture and grazing land management
- Livestock management
- Land use, land use change, REDD

These systems and opportunities (integrated agro-eco regions, farming practices and/or technologies) were selected by reviewing: i) abatement potential from GLOBIUM model; ii) published analyses and the scientific literature; iii) stakeholder reviews; and iv) consulting our field expertise with feasible systems for interventions with smallholder benefits in the developing world (where there are 500 million small farms with less than 2 ha; Wiggins *et al*. 2010).[26]

6.1. Cropland management

Cropland management describes the location-appropriate farming techniques to maintain/increase yields over the long term and sustain soil fertility, water, biodiversity and other resources. The key dynamic in this system is the return of residue biomass and nutrients to the soil improving soil fertility and soil structure leading to larger more reliable yields and increased soil carbon (Lal 2011). The GLOBIOM model shows increasing soil fertility enables sustainable intensification to achieve food security without the need for proportional cropland expansion.

Practices and measures
Technologies to increase soil carbon sequestration are readily available and among the most promising fast-start mitigation actions in the agricultural sector. Soil carbon sequestration measures in general require a two-pronged approach: i) increasing biomass production and decomposition in the soils and ii) preventing soil carbon losses (e.g. composting systems and erosion control). The costs (marginal abatement curve) are expected to be low or negative as yields increase, but capacity building and front loaded investment costs are implementation barriers.

[26] When prioritizing the opportunities, we excluded four agricultural measures (from the GLOBIOM model) because they are standalone activities and/or require a much broader policy discussion: 1) geographic shifts; 2) behavioral change/demand shifts; 3) bioenergy; and 4) some categories of processing, post-harvesting and emission reduction activities.

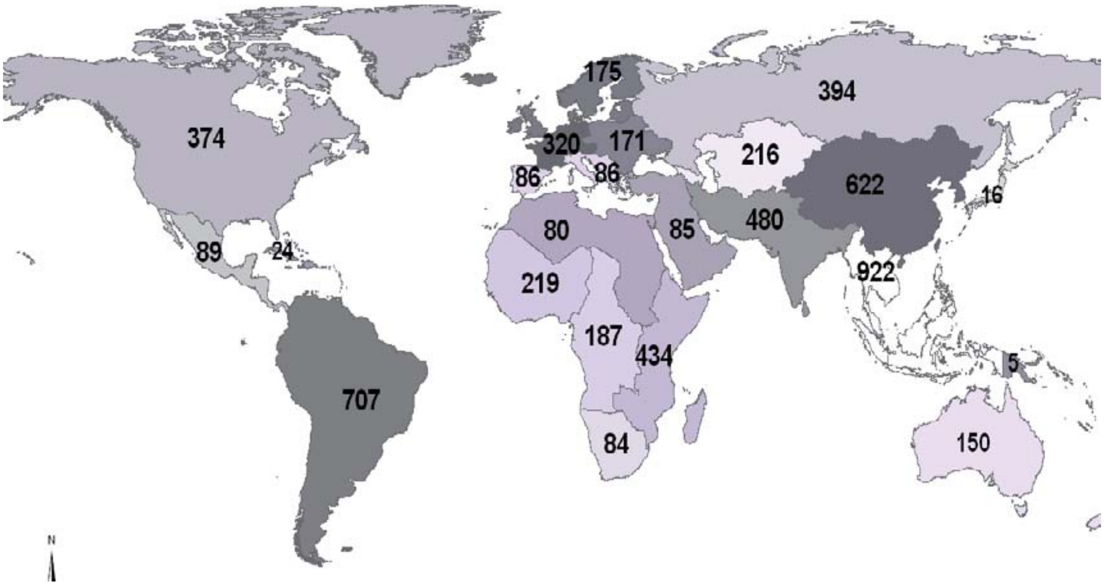
The most promising practices to reduce GHG emissions through intensification or input-based cropland management[27] are:

- Improved organic and synthetic fertilizer management to intensify food production and increase soil carbon sequestration
- Residue management, although there are often competing uses for feed, fuel and fertilizer
- Reduced or zero tillage; the latter is not effective if residues are removed as feed
- Mid-season wet rice drainage and crop breeding efforts to maximize risk adjusted yields and resistance to pests and diseases
- Pest treatment[28] (prevent crop losses and related reductions in soil carbon sequestration rates)
- Effective extension and access to finance to invest in inputs and labour to adopt agricultural activities
- Biochar: potential for long-term carbon soil carbon storage and soil improvement benefits (nutrients, water retention, etc.), although feedstock availability and opportunity costs often constrain the applicability of this technology, in particular in smallholder systems

More generally, increasing crop productivity also depends on investments in research, in particular in plant breeding and in the sustainable intensification of agriculture. Investment in irrigation and geographic shift of production intensity, without triggering land use changes, will also contribute to reach the productivity enhancement target as outlined in the GLOBIOM model.

Potential
Demand pressures and declining soil fertility means improved cropland management will become a critical feature of agriculture in the future. The technical mitigation potential for agriculture (see Figure 17 below) is concentrated in developing regions of Asia, Latin America and eastern Africa, primarily related to soil carbon sequestration. Economic mitigation for croplands is estimated to be about 563 million tCO_2e/yr (non-Annex I countries at a carbon price of USD20 using the IPCC climate scenario (B1 SRES; Smith *et al*. 2007).

Figure 17: Technical mitigation potential in $MtCO_2e$/yr by 2030, by region (Smith et al, 2007)



[27] as efficient organic or synthetic fertilizer use, soil and water conservation or irrigation, and extending crop rotations including cover and mulch crops and agroforestry
[28] Production and use of fertilizer and pesticide are also sources of GHG emissions although these can be more than compensated by deploying them under the right circumstances.

Investments in soil carbon sequestration and other agricultural intensification activities could have a strong impact on poverty reduction, and help ignite a more sustainable "green revolution" and broader economic transformation eluding regions such as Sub-Saharan Africa where agricultural productivity has stagnated in recent decades (Diao *et al.* 2010). It is almost certain that such investments will be necessary if we are to maintain or even approach the yield improvement gains of the past. Since 1961, global cropland area grew 27% while yields rose by 135% (Burney *et al.* 2010). Growth is expected to be significantly slower than during the previous four decades (1961-2010) with production area increases of 9% through 2050 while crop intensity and yield growth drops to 16% and 75% respectively (Bruinsma 2009).

Case studies
China: A typical Chinese farmer uses nearly twice as much fertilizer per area compared to his or her counterpart in Britain, and 130 times more fertilizer than a farmer in Uganda. Each year, China emits 0.4-0.84 $GtCO_2e$ through the use of 27 Mt of nitrogen fertilizer, equivalent to 8-16% of China's energy-related emissions. Cutting fertilizer use 20% through improved application and production efficiency could reduce emissions by 0.29 GtCO2e/year (Kahrl *et al.* 2010). This results in negative abatement costs of EUR41/tCO_2e, according to McKinsey (2009). This was confirmed by Kahrl *et al.* (2010) who also estimated the costs of a nationwide fertilizer efficiency program in the range of USD10/tCO_2e.

Tanzania: Green manure and agroforestry can achieve the dual objective of meeting local caloric requirements and modest reforestation of multipurpose trees in areas with low population-density (Palm *et al.* 2010). In high population density areas, only mineral fertilizer enables sufficient yield increases to meet the same objectives. While mineral fertilizer can be crucial to kick-start biomass production, organic amendments are important to maintain soil health and high crop production in the long-term (Giller *et al.* 2010). The labor demand related to green manure and agroforestry practices are often underestimated and must be addressed.

6.2. Pasture and grazing land management

Pasture and grazing lands store 30% of the world's soil carbon (Tennigkeit & Wilkes 2008). In grassland ecosystems, with limited above-ground biomass, as much as 98% of carbon is stored below-ground (Hungate *et al.* 1997). Restoring grasslands to a healthy state can lead to long-term livelihood benefits for small pastoralists and higher incomes from increased and sustained livestock production over longer periods assuming the appropriate market infrastructure is in place. Improving their management includes practices that increase carbon uptake, climate resilience and productivity while reducing emissions related to soil degradation and livestock. Rangeland degradation has been the result of the breakdown of traditional resource management regimes and cessation of beneficial rangeland management practices driven by inappropriate rangeland management and development policies (IPCC 2000).

Practices and measures
Restoring soil carbon stocks to their maximum equilibrium level is the primary mitigation mechanism for grasslands. Better grazing management and seeding fodder grasses and legumes are often only effective if combined with improved livestock feeding, marketing and value adding activities and veterinary services. Medium-intensity grazing, generally, can maintain the highest soil carbon stocks as well as plant biodiversity (Milchunas and Lauenroth 1993). Restoration of degraded grasslands may also require temporary de-stocking (which presents a major implementation barrier). However, markets must reward herders for fewer but more productive and healthier livestock or higher quality livestock products. We summarize these management practices below.

Table 7: Pasture management practices with potential to sequester carbon or decrease emissions (Tennigkeit & Wilkes 2009)

Increasing C inputs	Decreasing C losses
1. Increasing biomass carbon inputs to soil by improved grazing management, e.g. – Improving (reducing or increasing) stocking rates – Rotational, planned or adaptive grazing – Enclosing grassland from livestock grazing.	*3. Improved management of land use conversion*, e.g. – Converting agricultural land use to permanent grassland – Avoiding conversion of grassland to cultivation – Avoiding conversion of forest to pasture
2. Increasing biomass, by – Seeding fodder grasses or legumes – Improving vegetation community structure Fertilization.	*4. Fire management and control*
	5. Alternative energy technologies to replace use of shrubs / dung as fuel.

Potential

The economic mitigation potential for soil carbon on pasturelands is estimated to be 619 million tCO_2e/yr considering comparable model assumptions for cropland (Smith *et al.* 2007). This mitigation potential does not include the potential to restore degraded land which is estimated at 110 million tCO_2e/yr. The benefits for smallholders are also large. Globally, more than 120 million pastoralists manage 3.5 billion hectares of land, according to FAOSTAT data. This is equivalent to 26% of the global land area or 69% of the global agricultural land. Significant areas of land are also devoted for livestock feed production - about 470 million hectares or 33% of cropland. This will need to increase, along with intensification, as meat and milk consumption rises. Ideally, degraded and underutilized land would be used to produce the additional feed (cereals such as maize, barley and wheat or soybeans), since land use changes from grassland to cropland will result in soil carbon losses (Guo and Gifford 2002).

Case studies

Qinghai province, China[29]: The 3 Rivers Project, situated in the Qinghai province of north China, will be using carbon finance to fund grassland restoration and livestock productivity improvements. Money earned through the sale of emission reductions covers costs and foregone income during a transition period. Under the proposed pilot, herders will be offered a menu of options designed to fit their specific land use, which includes a combination of grassland restoration zoning and stocking rate management, in an incentive-based system. Given the current overstocking rates (about 45%), considerable reductions in income are expected during the first years of the project, for which herders will receive compensation. In the following years, as incomes are expected to grow in response to increased livestock productivity (and possible other small business support measures), compensation will decrease progressively until year ten. Overall, after the first ten years of the project, households will have fewer but more productive livestock. The pilot project is supported by FAO and a number of research and implementation agencies in Qinghai province.

6.3. Livestock management

Improved feeding practices, reducing livestock disease burden and mortality, specific agents and dietary additives and animal breeding can increase production efficiency and reduce emissions. Efficiency accounting using emission per standardized product unit is considered the most suitable approach, first to identify the emission reduction potential based on lifecycle analysis, and secondly to account for emission reductions for livestock management. This approach also ensures that emission reductions do not undermine food security. However, this only increases production efficiency without necessarily contributing to overall emission reductions (Murray and Baker 2011).

[29] Personnel communication with Prof. Wang Shiping from the Institute of Tibetan Plateau Research, Chinese Academy of Sciences.

Practices and measures

Intensification of livestock management is the major mitigation pathway for this sub-sector.[30] Improving the quality of feed, animal health and more efficient breeds are three primary options. Regional emissions per kg of fat and protein corrected milk unit vary from 1.3-7.5 kgCO_2e (FAO 2010). The former are representative for advanced milk production systems in New Zealand, while the latter represent conditions in Sub-Saharan Africa. As such, livestock intensification options vary depending on the baseline scenario and farm size (FAO 2010e). Small-scale farmers can significantly reduce emissions if they have the know-how, incentives and the option to produce or feed nutritious feed as most emissions occur on the farm rather than in subsequent processing stages.[31] The obvious advantage from high intensity livestock production should not ignore the value of extensive systems related to biodiversity conservation and related ecosystem functions (Snapp *et al.* 2010).

Potential

The livestock sector contributes 7.1 GtCO_2 per year or 18% of global emissions (this includes land use and direct GHG emissions), according to FAO (2010). [32] As meat and milk demand is expected to rise by 68% between 2000 and 2030, livestock is among the most urgent agricultural sub-sectors to target for reducing emissions (FAO 2010). The GLOBIUM modeling results also confirm this potential as discussed in Section 5. The potential for livestock-specific measures under different baselines are below:

Table 8: GHG emissions from agricultural measures under different scenarios (2020; MtCO2e)

Activity	Baseline	REDD	Agri Reduction	REDD & AgriRed	&End of pipe measures
Manure Management (CH4)	192.3	140.0	86.6	92.1	27.6
Manure Management (N20)	396.3	369.0	177.3	153.9	46.2
Enteric fermentation (CH4)	2,681.2	1,868.7	1,261.0	1,353.2	608.9

Case study

Danone Group: The world's largest fresh dairy company identified GHG emissions associated with its products and designed a program to improve the health, sustainability, and milk quality of these products while reducing the climate impacts. The first step was a lifecycle analysis of the supply chain followed by identification of GHG emission sources and the development of an effective MRV system. An innovative technology measuring the composition of milk proved to be a cost-effective proxy for measuring GHG emissions from enteric fermentation (a primary GHG source). The firm launched a pilot program in 2005 involving 20 French farmers to adopt improved feeding practices and is now scaling up the program to more than 500 farms. The results showed improved milk quality, reduced GHG (methane) and yield increases of 8-10%, as well as better cow health with comparable feed costs. Although undertaken in developed countries, this efficiency-oriented approach holds promise for similar initiatives in the developing world.

6.4. Land-use change and REDD

Land use planning and improved agronomy can directly address the causes of agricultural inefficiencies, land degradation and deforestation – a major source of direct and indirect GHG emissions from the agricultural sector. As tropical forests are the primary source of new agricultural land, agriculture is the

[30] At the same time, sustained shifts away from diets on meat and milk, and protein sources with a high carbon footprint (e.g. beef compared to chicken) will also be necessary although this is beyond the scope of this analysis.

[31] e.g. 93% of all dairy-related emissions including land use

[32] This figure is not comparable with the IPCC classification, i.e. methane and nitrous oxide emissions of 2.7 GtCO2 and 2.2 GtCO2e respectively are included.

main driver of land use changes related to deforestation and forest degradation. According to Gibbs *et al.* (2010) more than 80% of the new agricultural land came from intact and disturbed tropical forests between 1980 and 2000.

Practices and measures
The measures to address agricultural-related emissions from land use change and deforestation are:

- *Sustainable intensification:* Angelsen (2010) suggests spatially delinking agricultural intensification policies to allow expansion of agriculture in areas with the greatest productivity and lowest climate impacts. Intensification should be supported in the lowlands while in the uplands and frontier forests policies should be adopted that do not increase deforestation pressure such as payments for environmental services including REDD. In practice this will delink also food production and food security priorities, the latter depending on food access, income and market distribution.
- *Investments in agricultural research and development:* We have suggested that the rate of crop improvement – 3.3 to 3.4% annually -- may not continue given the worsening outlook for climatic conditions and available biological options. However, investments in agronomic research designed specifically for developing countries and changing climatic conditions will increase the chance that this rate of improvement can be maintained.
- *Agricultural trade:* International food trade is still quite low, e.g. only about 12% of cereals produced are exported (FAO, 2010). Increasing food trade may increase market liquidity and reduce food price volatility -- a serious risk for the rural and urban poor who rely on food markets. Increasing trade and cultivating food crops efficiently on the most productive land, will both contribute to ensure food security. .

Potential
The potential of direct and indirect emission reductions through the improved agricultural practices above and REDD measures is significant, but a function of several interdependent factors make precise estimates difficult to calculate. The GLOBIUM modeling results suggests robust REDD and agricultural measures could theoretically halve the emissions from indirect land use change (226 MtCO_2e), and soil and fertilizer emissions (1,164 MtCO_2e), while virtually eliminating deforestation (1.5 MtCO2e from 2,258 MtCO2e).

Table 9: GHG emissions from agricultural measures under different scenarios (2020; MtCO2e)

Activity	Baseline	REDD	Agri Reduction	REDD & AgriRed	&End of pipe measures
Deforestation (CO2)	2,257.6	1.5	1,222.6	1.5	1.5
Other land use change (CO2)	470.3	657.9	188.2	226.0	158.2
Soil and fertilizer emissions (N2O)	2,813.2	2,648.8	1,261.3	1,164.1	465.7

Case studies
Brasil: Cattle ranching in Brasil is associated with 80% of Amazonian deforestation, an area that has suffered the largest global forest loss between 1996 and 2005 (Nepstad *et al.* 2009). In line with the National Policy for Climate Change" (NPCC) Brasil unilaterally announced in 2009 that it would reduce GHG emissions between 36-39% below BAU levels by 2020. Subsequently, the environmental agency (IBAMA) and the land institute (INCRA) at the federal and state level enforced land use zoning plans. Leaders of the meat and soya industry, as well as the financial sector, excluded deforesting agents from markets and financing. Improved fodder grass varieties, zero tillage and green manure technologies were also introduced to sustainably intensify production. Based on the combination of regulatory and market actions deforestation rates slowed down rapidly within the last five years. However, this process was aided

by the economic downturn in the soya and cattle industry, and is only applicable in areas that have this level of extension and governance capacity (or where it could be created).

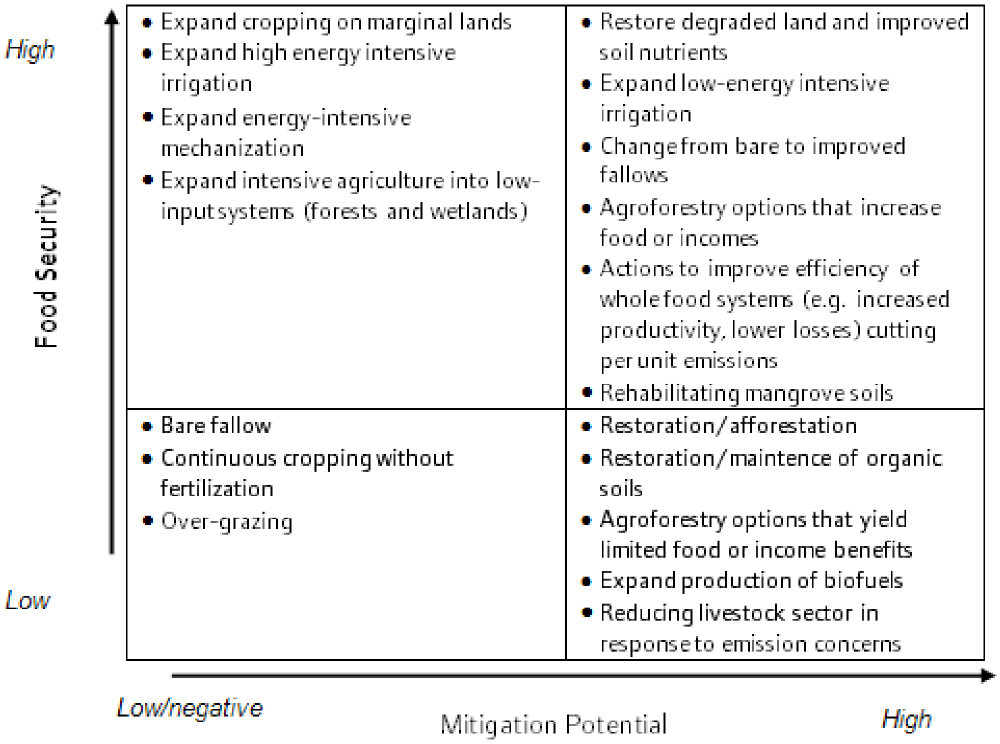
6.5. Risks and challenges

The biggest risk of the proposed mitigation practices are:

- trade-offs related to food security
- timing and delivery of financing
- MRV

Food security: The figure below highlights which practices have strong synergies with food security and those that may have trade-offs with food security depending on the local context. No regret options in the upper right corner of the figure are related to land restoration, expanding low energy intensive irrigation adopting improved fallows, agroforestry systems increasing food production and all actions improving the production efficiency.

Figure 18: Expanded from the Table: Examples of Potential Synergies and Trade-offs (FAO 2009, Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies)



Timing of finance: The time scale is also important. For example improved fallows using green manure will increase yields and soil carbon but may reduce cropping intensity in the short -term. Similarly, restoration of degraded grasslands will increase the grassland carrying capacity in the long-term but destocking might be necessary to rehabilitate grasslands. A number of mitigation practices require upfront investments or temporary compensation payments to bridge the time gap until a higher productivity level is reached.

MRV: Approaches to measure mitigation impacts in agriculture already exist at international, national, programmatic and project levels. These approaches have been developed under the Convention and sub-national compliance or voluntary market-based mechanisms. However, agricultural monitoring and evaluation systems are generally weak according to a global survey (Lindstrom 2009), which means the capacity and data availability for MRV is limited and substantial investments are required. Challenges include

- lack of long term experimental data in most developing countries, particularly related to soil carbon stock changes and N2O fluxes based on different agricultural practices, to calibrate models and derive emission factors predicting sequestration rates.
- lack of capacity to design, collect and analyse statistically robust and meaningful quality agricultural activity data and to conduct independent data quality verification, hence the data uncertainty is often simply not known.
- IPCC guidelines measure absolute GHG emissions per unit of land rather than emission intensity per unit of output. The latter is a useful complimentary approach to identify efficiency enhancement potentials and to meet the information need of consumers to understand the carbon footprint of their consumption. However, respective Live Cycle Analysis (LCA) methods are not yet standardized and the data required to analyse the production efficiency often does not exist.)

The UNFCCC does not have a platform to agree on MRV issues related to agriculture GHG emissions, e.g. if countries choose to develop agricultural NAMAs the MRV system and related quality bar needs to be approved at a case by case level. Different reporting levels need to provide consistent and well integrated data sets in order to gradually improve the monitoring system The standing committee on financial mechanisms related to the Green Climate Fund and the work program to define the role of registries and links to financial mechanisms may provide MRV guidance in this sector.

7. Climate finance and agriculture

Private and public investments in the agricultural sector are crucial to achieve the GHG emission reductions goals identified by the IPCC, execute REDD strategies,[33] and ensure adaptation in tropical and arid regions in developing countries. Yet financing for climate change mitigation and adaptation in the agricultural sector is modest. Private carbon markets source about 6% of the USD136 billion market in GHG offsets from the agricultural sector (2008-2009, excluding bioenergy),[34] and an even smaller percentage that involves soil carbon sequestration or smallholders.

Public sector climate financial flows for agriculture, while large, are also an order of magnitude less than the expected mitigation and adaptation needs of developing countries. The combined climate finance from the UNFCCC, multilateral and bilateral sources including the CDM, GEF Trust Fund, Adaptation Fund, World Bank Climate Investment Funds and others amounted to USD8 billion across all sectors in 2010.[35]

Considering annual agricultural adaptation investment needs are about USD 7 billion (Nelson *et al.* 2010b), climate finance is unlikely to meet most of developing countries' mitigation and adaptation needs.[36] Competition from other sectors will also stretch the available climate financing given that the annual cost for mitigation and adaptation (USD80-140 billion and USD9 – 68 billion, respectively) exceeds today's total public climate finance available funds, according to estimates from Parker et al. (2009; reproduced in Table 10).

Table 10: Annual mitigation and adaptation costs in developing nations (USD billion; Parker *et al.* 2009)

Mitigation		Adaptation		*Sources*
2010-'20	2030	2010-'20	2030	
--	92 – 97	--	27- 66	*UNFCCC*
80 -120	--	30-68	--	*McKinsey and Co.*
140		9-41	--	*EU*

Agriculture is expected to mobilize extremely large sums of conventional private and public capital finance. The FAO estimates developing countries will invest USD83 billion annually in the agricultural sector between 2005/6 through 2050 to satisfy rising global demand (Schmidhuber 2009).[37] Cumulatively, this amounts to USD9.2 trillion by mid-century: 40% (USD3.6 trillion) is dedicated to increasing (nearly doubling) output and raising productivity, while 60% (USD5.5 trillion) will be used to replace existing assets/capital stock (Schmidhuber 2009).[38] These figures reflect the modernization and industrialization of

[33] The primary drivers of tropical forest loss in Indonesia, Brasil and many countries in Africa are biofuel plantations and the expansion of low-productivity farming and grazing

[34] This may range as high as ~20% if including off-farm or bioenergy as well

[35] This figure is corroborated by the findings of the World Bank, which estimated around US$9 billion per year is available for adaptation and mitigation up to 2012, with less than US$8 billion available for mitigation (World Bank 2010) On the other hand, the *Stockholm Environment Institute* (SEI) estimates that bilateral finance institutions (BFIs) alone mobilized a similar figure in 2009 (around US$9 billion in finance for mitigation investment).

[36] As of 2010, climate finance from the UNFCCC, multilateral and bilateral sources including the CDM, GEF Trust Fund, Adaptation Fund, World Bank Climate Investment Funders and others amounted to USD8 billion annually. HAGCCF (High-Level Advisory Group on Climate Change Financing), 2010, "Report of the Secretary-General's High-Level Advisory Group on Climate Change Financing." 5 November 2009.

[37] US$210 billion gross if accounting for replacement costs of depreciating capital goods; all estimates in constant 2009 dollars.

[38] Primary agriculture accounts for USD1.2 trillion of this amount, with USD4 trillion absorbed by downstream activities (processing, transportation, storage, etc.).

the sector. Within primary agriculture, mechanization is the single largest investment (25%) along with irrigation expansion (~20%).

The global need for global climate finance, representing comparable sums, can theoretically be met in large part through developed country commitments under the Cancun Agreements to "mobilize jointly USD100 billion per year by 2020 to address the needs of developing countries" (UNFCCC 2010a). The UN High-Level Advisory Group on Climate Change Financing (HAGCCF 2010) calls such number "challenging but feasible" and recommends a systematic approach to mobilize public and private resources, bilateral and multilateral funds,[39] and new funding mechanisms. The Advisory Group identifies appropriate financial sources as:[40]

- new public instruments such as emission allowance auctions and carbon taxes that could generate USD30 billion annually with another USD20 billion from carbon pricing in the international transport sector, redirected fossil fuel subsidies and other measures (given USD20-25 tCO_2e);
- multilateral banks that have the potential to multiply investments in emission reductions with USD11 billion in net flows;
- private investment flows that may generate another USD200 billion in gross capital flows with USD10 billion in net transfers.

However, the scale of agricultural investments envisioned in this report exceeds what either public or private finance alone will likely be able to deliver alone. Therefore, financial mechanisms, donor funding and public policies should be deployed strategically through instruments that leverage private capital during the short to medium term, and exploit opportunities to create enabling conditions for investments in adaptation and mitigation (See the Box 2 case studies for examples of this approach).

Box 2: Case studies: Risk sharing and insurance mechanisms

"Safe Farming:" Kilimo Salama input insurance
Kilimo Salama, meaning "safe farming" in the Kiswahili language, is a crop insurance policy set up by UAP Insurance of Kenya, Safaricom and the Syngenta Foundation. Farmers pay an extra 5% to insure a bag of seed, fertiliser or herbicide against crop failure. MEA Fertilisers and Syngenta East Africa, two agribusinesses hoping to benefit from higher sales of their products, match the farmers' investment to meet the full 10% cost of the insurance premium. Local agents register an insurance policy with UAP by using a camera-phone to scan a bar code on each bag sold. A text message confirming the policy is then sent to the farmer's handset. Farmers are registered at their nearest weather station, which transmits data over the mobile network. If weather conditions deteriorate, a panel of experts uses an index system to determine if crops will no longer be viable. At that point payouts are made directly to the handsets of farmers in the affected areas using Safaricom's M-PESA mobile-money service. With no field surveys, no paperwork and no middlemen, transaction costs are minimal. The scheme is designed to be self-financing. Clear terms should help Kilimo Salama overcome farmers' distrust of previous insurance schemes, says James Wambugu of UAP. So should word of mouth. The trial scheme was hit by one of the worst droughts in decades, triggering compensation payments of 80% of farmers' investments. The average amount of insured seed in the area has now risen from 2kg per farmer to 4kg.

Source: Security for shillings (Insuring crops with a mobile phone); Economist 2010, 11 Mar 2010

HARITA model in Ethiopia
The Horn of Africa Risk Transfer for Adaptation (HARITA) is an innovative climate change resilience project launched by Oxfam America, Swiss Re, the Relief Society of Togray (REST), International Resource Institute for Climate and Society, Nyala Insurance, among others. Between November 2007 and December 2009, a pilot climate risk management package was designed for poor farmers in the village of Adi Ha consisting of a mix of risk reduction, drought insurance, and credit. The approach

[39] HAGCCF 2010; paragraph 1.e of the final report.
[40] These figures are acknowledged as highly sensitive to assumptions about carbon price and financial definitions

consists of three main components:

- *Risk Reduction/minimizing vulnerability:* farmers participating in the HARITA are learning how to use compost, which is critical for rebuilding soil nutrient and improving soil moisture retention. They are also building small-scale water harvesting structures and planting trees and grasses to promote soil and water conservation.
- *Risk transfer/weather Index insurance*: HARITA proposes to introduce micro-insurance to strengthen Ethiopia's Productive Safety Net Program (PSNP) by addressing the non-chronic, "unpredictable" needs not covered under the program
- *Prudent risk taking/credit:* Supporting poor producers in making optimal production decisions even in the face of uncertainty, for the purposes of livelihood diversification, technology adoption and entrance into more profitable lines of business.

HARITA is also innovative in the sense that it allows very vulnerable farmers to pay their premiums in the form of risk reducing labor as a result of which farmers benefit through these risk reduction measures even when there is no payout.

Sources: Oxfam America, Horn of Africa Risk Transfer for Adaptation (HARITA), Project Brief, Oxfam America, HARITA Project Report, November 2007 – December 2009

In the subsections below, we outline the most promising climate finance instruments and arrangements for the agricultural sector. The first subsection (7.1) defines conventional financing instruments for the agricultural sector, along with their applications, risks, availability and precedents. The second subsection (7.2) assesses climate finance options market-oriented or regulatory/policy reform approaches. The third subsection (7.3) categorizes existing climate financing sources and channels relevant to agriculture. These inform our final recommendations in section 8.

7.1. Finance and policy instruments in agricultural sector

The majority of financial flows for agricultural investments depend, as in other sectors, on conventional financial instruments such as debt, equity and public expenditures. Most capital agricultural investments are made by the private sector (domestic and foreign), but governments play an important role in helping link, pool, and promote private flows and making direct strategic investments (Schmidhuber 2009). The relative pace of agricultural investment growth, however, has been declining during the last three decades amid low or stable world food prices. The growth rate of agricultural capital stock fell from 1.1% in 1975–1990 to 0.50% in 1991–2007, mirroring a decline in agricultural budgets among developing countries and in Official Development Assistance (ODA) provided by donor countries (Ghanem, 2009). As investment in agriculture is now rising rapidly following a series of price shocks and supply constraints, this trend may be reversing.

FAO projections suggest developing countries will need gross investments of about USD5.2 trillion in primary agriculture to meet long-term demand for agricultural products (Schmidhuber 2009), not considering climate impacts.[41] This is equivalent to about USD55 billion annually, and constitutes a gap of about USD22 billion per year relative to the average annual agricultural investments between1997–2007, (Ghanem 2009). It is not clear how these investments will be made. It is likely that most of this additional investment will flow through established channels – private debt and equity, as well as public investment – but this new investment of capital, land and labour must lead to a far more efficient and effective agricultural sector than exists today if agricultural production is to be expanded without destroying natural resources or destabilizing the climate from increased GHG emissions. To frame the discussion of specific delivery mechanisms, the available investment channels for agriculture financing are listed in Table 11 along with their relative advantages/disadvantages.

[41] USD4.0 trillion is absorbed by downstream needs such as processing, transportation, storage, etc.

Table 11: Potential financial instruments to support climate smart agriculture in developing countries

Instruments	Modalities	Advantages	Disadvantages	Application	Available	Case Study
Debt	Senior and subordinate (mezzanine) loans	Offers low-cost financing source for projects; large/small/micro	Requires revenue stream; repayment risk; difficult to find local lenders	Projects	Limited availability for agriculture	1) Global Climate Partnership Fund http://gcpf.lu/ (fund is currently not supporting agricultural activities); 2) Los Andes Private Nature Reserve, USD170,000 coffee harvest credit (Conservation International)
	Micro-finance loans to households	Offers affordable financing to low income clients; often collateral-free	Requires local presence; high monitoring costs	Projects Programmes	Not employing climate finance yet	Grameen Bank Bangladesh Spandana, India Worldwide 5.4 million agricultural insurance policy holder [42]
Equity	Direct financial investment in firm or project entity	Upfront payments; assumes project and performance risk	Difficult to find matching funding; dilutes incentives	Projects	Not employing climate finance yet	1) African Agricultural Capital (AAC) is a venture fund set up with Rockefeller Foundation 2) Danone Livelihood Fund (target volume 30 Mio Euro);
Cash payments (direct market)	Market transactions for emission credits; monetization of (future) emission reductions	Increases financial attractiveness of project; allows to leverage other sources of funding; hard currency	Requires costly monitoring and verification; dependent on carbon price fluctuations	Projects Programmes	Limited demand; available	1) World Bank BioCarbon Fund; 2) The Juma Sustainable Development Reserve, Brasil (Seeberg-Elverfeld 2010);
Loan guarantees	Financing mitigating political or credit risks in public or private sector loans	Effectively mobilizes co-financing from external sources; huge leverage potential for long-term debt finance for development.	Risk of principal loss for issuer of guarantee	Projects Programmes Policies	Very limited scope and geography; No climate finance but interested	1) USAID Development Loan Agency, IFC, KfW; 2) Agricultural input supply channels in Kenya, Malawi Uganda by Rockefeller Fnd.(WB 2007 p153); 2) Root Capital lending
Other risk sharing instrument	Weather, political and crop insurance; other risks.	Shifts investment and adoption risk away from smallholders (vulnerable)	Inappropriate use distorts markets, excessive risk taking	Projects Programmes Policies	Yes; limited geography	Index-based livestock insurance in Mongolia (World Bank 2007; p 149) and Kenya (Lybbert & Sumner 2010); Harita, Ethiopia drought insurance ,

[42] http://www.microinsurancecentre.org/UploadDocuments/Landscape%20study%20paper.pdf

						Kilimo Salama input insurance Kenya, ICICI Lombard weather insurance in Andhra Pradesh, India
Public-private initiatives	Financing and guarantee support for targeted subsidies/incentive, joint ventures, or build-operate-transfer (BOT).	Flexible model accommodates multiple instruments; proven in large-scale project investments and potential for innovative small-scale project (see MFI*);	Historically favoured large infrastructure projects; climate finance must represent sufficient revenue stream	Projects Programmes Policies	Yes; but many still grant-financed; Not employing climate finance yet	Water efficient maize for Africa (WEMA) (Lybbert & Sumner 2010); Africa Enterprise Challenge Fund
Tariffs, taxes	Attractive feed-in tariffs or tax-incentives to support policy objectives	Enables projects that would otherwise be economically unrewarding;	Tariffs and taxes may change with a new government; continuity is uncertain	Projects Programmes Policies	Not employing climate finance yet	Renewable energy feed-in tariffs in Uganda for Bagasse and biogas projects
Grants and subsidies	Financial support to projects that serve the public interest, often provided by governments	Increases the financial attractiveness of projects that might otherwise not be economically feasible; comes at no cost	Availability is limited and continuity is uncertain; unlikely to cover entire investment cost	Projects Programmes Policies	Limited use of climate finance	1) Small Grants Programme: Climate Change to NGOs; 2) China Grassland Ecology Conservation Reward and Subsidy System

* MFI: Micro-finance institute

The instruments listed above are financial tools. To be wielded effectively, they must be used within an effective program or policy framework to achieve the mitigation, adaptation and/or food security objectives in the agricultural sector. The next section lays out options to mobilize private capital within the two most promising categories of interventions allowing governments and the private sector to support sustainable (climate-smart) agricultural practices:

- Improvement of the investment climate and/or incentives (risk-return ratio, risk apportionment, liability rules, etc.) for direct investments in agricultural operations and practices.
- Regulatory and economic reforms of agriculture in developing countries

7.2. Climate financing strategies for the agricultural sector

Prioritized domestic or international actions can be matched with climate finance instruments, as well as linked to bilateral and multilateral funds. Determining the most appropriate climate financing method for the agricultural sector is unlikely to yield a single answer. Climate-specific financing can add crucial financial and political resources, and act as a convening force for agricultural investments, complementing conventional financial instruments. We believe the two most promising approaches for climate finance in the agricultural sector are i) market-oriented incentives for direct investments; and ii) regulatory and economic reforms/incentives. The latter may involve results-based payments for nationally appropriate mitigation actions (NAMAs) or REDD.

The appropriate institutional arrangements for each country will depend on i) effective agricultural practices; ii) evolution of climate policy under the UNFCCC; iii) social and political circumstances in host countries. Given these caveats, we have summarized the most promising financing options for each of the two approaches in Table 12, and elaborated on each below.

Table 12: Climate financing approaches for supporting agriculture

Market-oriented incentives for direct investments
Risk management: Designing and supporting financial instruments that reduce or redistribute risks for investments in agriculture

Monetizing agricultural/carbon/ecosystem service revenue streams: Financial instruments (e.g. bonds) monetizing revenue stream from improved agricultural productivity and/or ecosystem services

Direct purchase: Purchase or creation of sustained demand for carbon credits, potentially with a quota for credits derived from agricultural projects

Transition cost subsidies: Creation of funds and financial instruments that subsidize upfront costs for transition to improved agricultural practices

Regulatory and economic reforms
Subsidies or tariffs: Removal or modification of domestic subsidies or tariffs that encourage unsustainable agricultural activities – or disincentivize more efficient production – with international trading partners

Regulatory mandates: Implementation and enforcement of regulatory mandates for adoption of specific agricultural practices, minimum standards or processes, lowering transaction costs for adoption

Regulatory infrastructure: Investments in the regulatory infrastructure that lower the transition costs of adopting agricultural methods

Land use planning and tenure reform: Investments in land use planning and tenure reform to support sustainable land management practices, enforcement, monitoring and improved governance

Sustainability criteria: Creating, recognizing or mandating market-based sustainability criteria and labeling (within the borders of current WTO agreements)

Market-oriented incentives for direct investments

Risk management: Risk management with an appropriate level of government or public guarantees or risk-sharing, could unlock more large-scale investment in terrestrial carbon (agriculture and REDD) from institutional investors now deterred by today's political and technical uncertainties. High or unmanageable risk deters or makes it impossible for certain categories of investors to finance climate change mitigating agricultural practices. Risk sharing mechanisms, on the other hand, can be deployed by banks and multilateral institutions in coordination with governments or development agencies to unlock investment in agriculture. Financial instruments that leverage public finance to increase private investment are listed below with associated risks and precedents.

Table 13: Cases studies and risks associated with each of these instruments

	Example	Description	Results	Risks
Loan guarantees	CLUSA Mozambique	Between 1995-2005, USD11.5 million in USAID funding helped farmers better organize market products to local traders (Dorsey and Assefa 2005).	USD5.1 million leveraged from other sources (partially in form of matching grants); Farmers gained greater market access, and program copied by other donors.	- Primary risk loss of creditor capital -Requires strong domestic financial institutions - Potentially high transaction costs - May not serve most destitute farmers
	AGRA's Innovative Financing Initiative	USD17 million in loan guarantees to reduce risks of lending to smallholders	Leveraged USD160 million in loans from commercial banks in Kenya, Uganda, Tanzania, Ghana, and Mozambique (AGRA 2011)	
Insurance Products	"Kilimo Salama" (Safe Farming) microinsurance scheme in Kenya	Farmers pay extra 5% to insure seed, fertilizer, herbicide, etc. against crop failure; agribusiness match investment to meet insurance premium; Index used to determine if crops fail due to weather conditions.	Average amount of seed insured in area has risen from 2kg per farmer to 4kg; Trial of 200 farmers hit by drought, triggering compensation payments of 80% of farmers' investments. (The Economist 2010).	- Incentive to neglect crops to gain higher payouts (traditional risk) but only in non-index systems - Weather data may not be available (need 30+ years); - Farmers may be unable to afford insurance (Oxfam America 2009).
	Horn of Africa Risk Transfer for Adaptation (HARITA)	Farmers work extra days for payments to earn insurance certificate protecting against rainfall deficit.	Approach "multiplies the value of [donor] money by two" by paying insurance premium through labour fr risk reduction measures (Oxfam America 2009).	
Providing seller price guarantees	World Bank Prototype Carbon Fund (PCF)	PCF has generally agreed to buy specified minimum amount of Emission Reductions (ERs) from a given project at a specified cost.	Project developers can either sell additional ERs on same terms and contract price as all other ERs purchased by the World Bank; or could sell additional ERs at market price	- Risk price floor too low (due to financial or political constraints): households unable to meet subsistence needs; - Per hectare subsidy: small growers will receive less financial assistance; per household subsidy: large growers might receive insufficient funds.
	Mexico's Coffee Stabilization Fund (*Fondo de Estabilizción del Café,* FEC)	Voluntary program, guarantees participating coffee growers set price for crop through USD80 million permanent fund.	Study by Ávalos-Sartorio and Blackman (2009) found in study region that the program did not significantly improve the ability of small growers to meet their	

			subsistence needs	
Lenders/investor price guarantees	European compliance Buyer for land-fill /natural gas mitigation project	Minimum absolute or market index price with variable options to buy or sell post 2012	Ongoing carbon market practice; track-record of successfully completed sales	- Negotiation leverage may put sellers at disadvantage - inappropriate distribution of risks

In most transactions where public finance has been placed at risk, it has rarely been lost due to the relatively low rate of default in such initiatives. As such, these instruments leverage private capital investments worth many times the value of the ultimate public expenditure. The key requirements are: understanding performance risks, targeting specific agricultural measures, and managing transaction costs to ensure that public funds are preserved and deployed efficiently.

Another emerging financing model (in the context of social programs) is paying performance premiums to implementing organizations of government programs (usually private or civil society groups). This model repays implementing entities for budgeted program costs plus an agreed-upon rate of return if performance benchmarks are met. Success means the full value of the money plus a rate of return is disbursed. Failure means that program costs are not reimbursed. This puts both capital and interest payments at risk. It has the advantage of imposing accountability, MRV and market rigor on programs traditionally executed by government agencies which sometimes lack the capacity to carry them out. For agricultural climate measures, an international partner could back a bond for a developing country's development agency or an NGO program to meet overall, mutually agreed upon performance metrics (not necessarily on a per ton of carbon basis) in a project or program. Entities can potentially attract private finance based on this government guarantee. However, this approach is more risky then the models above and is only feasible where risks are manageable, the rate of return is high and/or there is philanthropic funding.

Monetizing agricultural/carbon/ecosystem service revenue streams

Fixed income instruments linked to climate-related assets are a promising option for agricultural mitigation. Traditionally, climate investment has focused on higher risk private and public equity or debt. Fixed-income instruments monetize revenue or credits from climate-related projects allowing institutional investors to finance ecosystem services – as well as programs meeting specific performance standards – at a lower risk level than either equity or debt investors in projects. Several so-called green bonds or fixed income products have been issued since 2007 by the World Bank and the European Investment Bank. Investors include the State of California, Swedish national pension funds, UN pension funds, and others – institutions who have not traditionally invested in bonds from these organizations.

Two basic bond structures relevant to agriculture are described below:

- *Bond where fraction of the interest/coupon is project off-take*: In this model, bonds are issued at competitive rates but discounted slightly and combined with a percentage of amortized revenue from climate-related projects. For example, the World Bank may issue a USD100 million bond and pay back bond holders with 3% interest plus carbon credits (or other revenue stream enabled by the climate finance) from some project (a difference of 2% from market rate). The carbon credit risk is assumed by the bond holder but only for the difference in the interest. This is an attractive investment for many institutional investors, and has been successfully issued by other projects in the past.
- *Bond based on the income stream from a project*: In the case of agriculture, this amortized revenue stream could be i) a share of higher productivity above some benchmark baseline; or ii) a share of cost savings after the implementation of mitigation activities; or iii) a share of some credit for carbon/ecosystems service. The bonds are based on existing financial instruments and, while MRV and implement challenges exist, appear promising. It is also possible for other types of

financing to be leveraged through these revenue streams that do strictly qualify as bonds but provide upfront financing.

These models represent a key opportunity to expand the base of climate investors to fixed-income investors. As of 2008, pension funds alone had USD25 trillion under management (Reichelt 2010). To appeal to institutional investors, bonds should have i) standardized criteria and/or project eligibility (as far as possible); ii) minimum financial characteristics (size, rating, structure); iii) rigorous governance and due diligence process for project finance (Reichelt 2010). This standardization and flexibility will attract a much broader range of investors (pension funds, endowments, asset managers and sovereign wealth funds) with different risk profiles from high-yield to high-grade products (Reichelt 2010). Ultimately, government credit can support financial instruments that turn the cash or credit flow from mitigation and adaptation activities into investments attractive to larger investors interested in fixed-income. World Bank Green Bonds[43] and energy efficiency bonds[44] issued by US states illustrate structures and terms for such programs although a unique set of arrangements will likely be needed for the agricultural sector.

Direct purchase

Global carbon markets represent a potential source of finance for improved agriculture in the future. Upfront finance is needed invest in inputs or more efficient technology that will subsequently reduce emissions or sequester GHG. Carbon finance can bridge the time gap between implementation costs and realizing these benefits/revenues. The ability of carbon finance to provide bridge financing is contingent upon investors or donors offering upfront payments against credits delivered during the first two to five years, the most critical period to overcome initial cost hurdles for farmers.

Transition cost subsidies

An industry or government-financed fund to reimburse transactions costs for adopting climate change mitigating activities could address a major barrier preventing large-scale implementation of agricultural mitigation and adaptation. Models are being developed that draw on industry taxes or public finance to create a way for individual businesses to cover the upfront capital costs of certification, improving agricultural methods or other program costs. This could remove a major obstacle for adoption of improved practices in the agricultural sector while creating suitable MRV systems. NGOs such as WWF[45] and others are pursuing these initiatives.

Regulatory and economic reforms

The massive scale of agricultural subsidies, market interventions and trade barriers in the agricultural sector will limit the effectiveness of any market-based agricultural climate finance schemes that do not consider how these issues shape incentives for famers and agri-businesses. We have outlined the primary challenges and opportunities – often one and the same – relevant to supporting regulatory and economic reforms. Incentive-based payments for agriculture are unlikely to address such obstacles. It is possible that financing from developed countries could also address specific reforms and/or work in tandem to implement market-based approaches that also support structural reforms in the agricultural sector. Solutions to create this enabling environment for large-scale performance-based payments will be highly country-specific and, in some cases, a systematic process of policy reforms.

Subsidies or tariffs

Subsidies and tariffs still profoundly shape global prices and trade in agricultural commodities. Any interventions in the agricultural sector – including investments in climate mitigation and adaptation – should consider whether support will disrupt (or enable) a competitive marketplace. Subsidies in Organisation for Economic Co-operation and Development (OECD) countries – such as the USD3.9 billion spent on cotton in the US or EUR16 billion spent on the dairy industry by the EU – depress global prices and destroy export markets for developing world producers unable to compete with exports sold at prices

---

[43] http://treasury.worldbank.org/cmd/htm/WorldBankGreenBonds.html
[44] http://www.commerce.wa.gov/site/862/default.aspx
[45] http://wwf.panda.org/what_we_do/footprint/agriculture/

below the cost of production. The USD3.9 billion spent on US cotton subsidies, for example, has lowered global prices as much as 26% and diverted USD300 million from West and Central Africa, a prime growing region (OECD 2007). Similarly, agricultural tariffs, averaging 60% in OECD countries, raise trade barriers undermining other efforts to spur agricultural improvements through ODA or other means.

Opportunities to pair investments in agricultural mitigation and adaptation with subsidy modifications can multiply their effectiveness if implemented in conjunction with mandates or support for agricultural mitigation activities. While a politically difficult strategy (reforming the international trade in agricultural products has been the subject of failed talks in the Doha round of the World Trade Organization negotiations, as well as in the agricultural text for the Cancun Agreements under the UNFCCC), political opportunities to alter or adjust the current tariff/subsidy system may appear if climate considerations can be introduced into the domestic policy discussion or in international negotiations.

Sustainability criteria/labeling for agricultural practices
Demand-side measures – either regulatory or market-oriented standards - can reduce the demand for unsustainably grown, harvested or produced products, or increase premiums paid for sustainable products. Agricultural certification organizations such as Rainforest Alliance, UTZ certified, Fair Trade and others are well established, and growing to meet the demand for certified agricultural commodity supplies. Labeling or sustainability criteria (usually market-led or government sanctioned) have the advantage of remaining more flexible and attractive to producers, particularly if it increases prices. Regulated standards are also relatively straight forward for legislatures to define and pass.

Few labeling schemes, however, have explicitly integrated climate standards. Implementation is challenging and sometimes impossible in developing countries if practices are not economically viable or if enforcement capacity is weak. Governments also run the risk of selecting inappropriate standards or criteria. Political pragmatism means that developing countries, especially those with impoverished smallholders, are unlikely to adopt burdensome criteria. The record for such interventions – either at raising prices or achieving rapid adoption – is mixed and it remains to be seen if such policies would work in the context of mitigation and/or adaptation measures.

Regulatory infrastructure (lowering transition costs of adopting agricultural methods)
Regulatory or bureaucratic barriers may prevent the adoption of GHG mitigation activities, or lower rewards for doing so. Public reforms that effectively reduce the cost of achieving this transition – possibly in conjunction with a market 'pull' factor from higher commodity prices or recoverable funds for the transition expenditures (see category above) - could accelerate or multiply the effectiveness of climate programs in the agricultural sector.

Land use planning and tenure reform
Governments can probably achieve the most comprehensive mitigation and adaptation benefits by adopting long-delayed land use planning and land tenure reforms in the context of climate policies for the agricultural sector. While not a direct market-based approach *per se,* these measures are often a pre-requisite for large-scale agricultural programs in many countries and are an underlying element of sustained and permanent emission reductions from agriculture in some regions. The political and technical complexity of this approach makes it a difficult, but appealing, option for supporting more sustainable agriculture.

7.3. Climate finance sources and policy instruments

Domestic and/or international finance instruments, as well as bilateral and multilateral sources, can be linked to agriculture sector finance. The two primary results-based approaches defined by the UNFCCC – are REDD and NAMAs. Agriculture, as the primary driver of deforestation in many countries, is considered a critical part of REDD strategies, and at least half of the 44 NAMAs submitted to the UNFCCC involve the agricultural sector (FAO 2010d). These are described in more detail below:

- REDD: The 2010 Cancun Agreements established a REDD mechanism, including conservation, sustainable management and enhancement of forest carbon stocks (all activities combined are referred to as REDD+), which encourage developing countries to contribute to mitigation actions in the forest sector through the full scope of forest-related REDD activities. Agriculture, although not explicitly included in this decision except through agroforestry, is expected to play a major role in countries' REDD strategy to address major drivers of deforestation. REDD readiness activities include i) a national REDD strategy; ii) national and, if appropriate, sub- national reference (emission) levels, iii) a MRV system that is national and, if appropriate, sub national; and iv) a system for providing information on how the safeguards referred to are being addressed and respected throughout the implementation of REDD activities
- NAMAs: Developing countries have agreed to take voluntary nationally appropriate mitigation actions to reduce BAU emissions by 2020 under the Copenhagen Accord and Cancun Agreements. In the context of the Cancun Agreements, the Conference of the Parties to the UNFCCC (COP) "[took] note" of all NAMAs to be implemented by developing country Parties. A registry will record the transfer of funds and resources to carry out these actions, as well as match available funding with countries wishing to implement actions. The COP also decided developed country Parties "shall" provide enhanced support for the preparation and implementation of NAMAs. A more detailed discussion of agricultural NAMAs is included in Annex 9.4.

Results-based payments for REDD and NAMAs can be delivered through markets or public funds. Funds are likely to support market-based mechanisms by reducing transaction costs, creating enabling conditions and supporting pilot projects. The Green Climate Fund established in accordance with the Cancun Agreements is likely to contain a window for REDD and may see additional dedicated finance for the agricultural sector. The exact approach – market of fund – is evolving through UNFCCC and domestic political negotiations, as well as through the small but vibrant voluntary market.

Table 14: Mitigation sectoral/policy/aggregated activities approach (market-based)

	REDD	NAMAs
Mechanism	REDD is supported by incentive mechanisms to encourage developing countries to reduce emissions from deforestation and forest degradation; as well as conservation, sustainable management of forests and enhancement of forest carbon stocks.	NAMAs are voluntary commitments made by developing countries to reduce GHG emissions. These are submitted to the UNFCCC and available for international climate financing per terms in the Cancun Agreements.
Agricultural Practices	Terrestrial carbon activities; e.g. tree-based farming practices, agroforestry, improved agricultural practices, etc.	Unrestricted: e.g. sustainable land management and efficiency, livestock, soil and agricultural practices, cropland and livestock management, agroforestry, crop intensification and improvement.
Barriers	Not explicitly crediting non-tree agriculture	Still undefined financing and implementation modalities

Market-based approaches

The role of markets – emission-related or otherwise –is still a matter of debate as an incentive mechanism for the agricultural sector under the UNFCCC. Increased private sector finance for climate mitigation is considered a vital element of mobilizing USD100 billion annually for climate actions in developing countries by 2020 committed to under the Cancun Agreements. The High-level Advisory Group on Climate Change Financing sees international private investment flows as "essential for the transition to a low-carbon and climate-resilient future" and able to generate around USD100 billion to USD200 billion of gross private capital flows at a carbon price of USD20-USD25 (HAGCCF 2010). To understand the possible private sector financing approaches, it is helpful to categorize them by their relationship to "markets" representing pools of capital, investment and trade:[46]

- Carbon market: national or sub-national cap and trade systems to meet compliance GHG emission targets, as well as voluntary credit transactions to generate and sell offsets used for mitigation.
- Carbon market-linked: mechanisms that raise money indirectly through carbon markets such as auctioning allowances that are redirected into mitigation or adaptation
- Market-linked: taxes, levies or other tariffs on economic sectors or financial transactions outside a GHG emissions market
- Non-market instruments: other financing sources including ODA, philanthropy and public sector transfers that do not fall under the categories above.
- Private sector investment flows: Foreign direct investment, representing USD170 billion or 10% of investment in developing countries, as well as other funds from the private sector.

Important carbon market-based GHG mitigation options in the agricultural sector are i) compliance markets; ii) voluntary market transactions between project developers, buyers and/or brokers; domestic cap-and-trade systems. These are summarized in Table 15 which explains the main features of carbon-market approaches under the Kyoto Protocol and voluntary standards. An inventory of agricultural mitigation projects under these standards is available in Annex 9.3.

CDM

The CDM allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol to acquire emission reductions from mitigation projects in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, which can be counted towards meeting Kyoto targets. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction or limitation targets. The Cancun Agreements mandate operational reforms to expand and streamline CDM activities.

The Kyoto Protocol treats agriculture differently in Annex I (or developed) countries and developing countries. Developed countries have the option of using net "direct human-induced" changes in GHG emissions and removals by sinks to meet their emission reduction targets.[47] By contrast, in the CDM, the mitigation crediting mechanism for developing countries, limits the eligibility of carbon sequestration to afforestation and reforestation while excluding the primary mitigation opportunities (especially for smallholders) to enhance soil carbon stocks through cropland or rangeland management.

Table 15: Mitigation project approach (market-based) (UNFCCC, Ecosystem Marketplace, 2010)

	Clean Development Mechanism (CDM)	Voluntary carbon market	CDM PoAs
Mechanism	The CDM was authorized under the Kyoto Protocol to generate saleable certified emission reductions (CERs) in developing countries, to meet GHG targets in Annex I countries.	The voluntary carbon market represents the transaction of emission reduction credits by entities purchasing offsets outside of a compliance GHG target. Independent standards typically certify credits traded in over-the-	CDM Programme of activities (PoAs) are a modality under the CDM to register an unlimited number of projects and local, regional or national policies/standards as associated project activities provided that

[46] Categories modified from Parker (2009)

[47] These countries are obligated to report certain agricultural emissions (mainly CH4 and NO2 emissions from human-induced biological processes) while CO2 removal or emission from cropland management is optional (Article 3.4).47 Only a few countries have elected to do so (FAO 2010b). Those 'net changes' must be "measured as verifiable changes in carbon stocks in each commitment period" (Kyoto Protocol). Forest carbon stocks by developed countries are treated separately (Article 3.3 KP; Article 3.4 KP).

			counter or exchange transactions.	approved baseline and monitoring methodologies are used.
Agricultural Practices		Manure management, urea offset, afforestation/ reforestation and bioenergy.	Voluntary market mechanisms credit, *inter alia*, agroforestry, nitrogen-, farm energy-, crop-, land use-, livestock-, and soil management.	Limited to CDM methodologies; e.g. reducing nitrous oxide emissions, reducing methane
Value (*million USD)*	'08	Primary: 6,511 Secondary: 26,277	728	*N/A*
	'09	Primary: 2,678 Secondary: 17,543	387	*N/A*
Barriers		Procedural/eligibility limitations; A/R offset cap for Annex I targets; temporary credits; EU-ETS exclusion of A/R credits; soil carbon sequestration not eligible	Low prices and variable credit quality Small size of market (<1% compliance); uncertain current and future demand; lack of standardization	CDM restrictions on soil carbon; additionality and crediting constraints; challenging economics

Compliance markets have also imposed restrictive rules on crediting land use activities, deterring investments in agricultural projects. The EU Emissions Trading Scheme has banned trading of forest and non-CDM agricultural credits through 2020 (future inclusions depend on stringency of global GHG targets).[48] Similarly, CDM rules and methodologies only permit temporary credits for removals from forestry activities (temporary or long-term CERs) and onerous accounting rules for forestry and the exclusion of soil carbon projects. Implicitly, this means that countries with low emissions and high sequestration potential – that is, most poor agrarian nations – are poorly positioned to participate in these markets.

To enable projects with a high replication potential that are implemented over a longer period of time, typically several years to over a decade, Parties to the Kyoto Protocol created the concept of Programme of Activities (PoA) under the CDM. In contrast to conventional CDM, where the pooling of individual abatement activities is restricted to a one-off 'bundling' of similar projects, a PoA creates an umbrella structure that supports the inclusion of multiple and unlimited bundles of subprojects over time. Adding projects requires only a 'quick check' by a validator, as opposed to the more detailed and lengthy validation and registration procedure of the regular CDM project-approval cycle. Agricultural activities eligible under the CDM can be included under this structure to achieve large-scale implementation. As of 2010, the PoA project pipeline included 98 projects of which two were in agriculture, two in biomass energy, 22 in methane avoidance (the single biggest category along with household energy efficiency), and two in reforestation.

Voluntary markets

Voluntary markets account for less than 0.3% of the value of regulated markets (USD 387 million compared to approximately USD 144 billion, respectively, in 2009) yet they constitute a large share of total agricultural offset demand (Ecosystem Marketplace, 2009). Offset standards explicitly encourage agricultural mitigation, and may permit ex-ante crediting (issuing credits prior to validated sequestration),

[48] Depends on the progress towards and results of the international agreement on climate change (Articles 8 and 9 of Decision 406/29/EC and Article 28 of Directive 2009/29/EC). As part of the report the Commission is required to assess different modalities for including land use, land use change and forestry in the EU's reduction commitment. URL: http://ec.europa.eu/clima/policies/effort/framework_en.htm

flexible eligibility and accounting rules and lower up-front costs important for land use activities relying on accumulation of carbon stocks) attractive for agricultural mitigation projects. The voluntary market is predominately unregulated - encompassing all transactions of emission reduction credits among entities outside of compliance GHG cap-and-trade systems. Sales are predominately "over-the-counter" between buyers and sellers (or brokers) or brokered on exchanges.

Table 16: Voluntary Carbon Market – Traded volumes and values, 2009, via the voluntary offset market (Bloomberg New Energy Finance, Ecosystem Marketplace, World Bank, 2010)

	Volume ($MtCO_2e$)			Eligible activities†		
	2008	2009	% all '09	A/R	REDD	Ag
Voluntary Carbon Standard	24.0	16.4	35	Yes	Yes	Yes
Plan Vivo	NA	NA	0.2	N/A	N/A	N/A
Carbon Fix	NA	NA	0.6	N/A	N/A	N/A
Climate Action Reserve	5.3	14.5	31	Yes	Yes	Yes
American Carbon Registry	4.3	1.8	4	Yes	Yes	Yes
Chicago Climate Exchange (CCX)*	1.4	5.5	12	Yes	Yes	Yes
Gold Standard	6	3.2	7	No	No	No
Climate Conservation and Biodiversity Standard (CCB)**	0.5	0.6	3	N/A	N/A	N/A

† A/R is afforestation and reforestation. Agriculture includes a range of practices varying according to each standard.
* CCX is no longer trading.
**CCB is a performance certification focused on co-benefits and does not issue carbon credits.

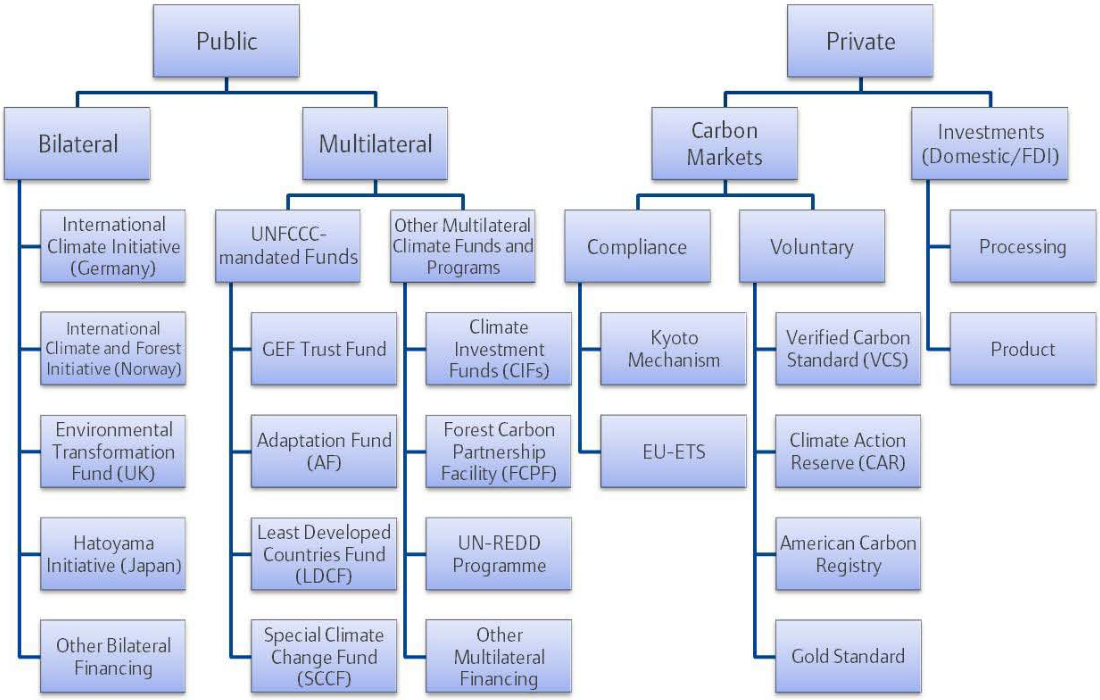
Agricultural activities accepted under voluntary standards include methane capture (4%), agricultural soil management (3%), agroforestry (1%), and afforestation/reforestation (10%) or forest management (3%) accounting for 21.3% of OTC trades in 2009 (about 9.4 million VERs).[49] Despite this, they have had a limited impact in leveraging private capital given that the future of the voluntary market is clouded by financial volatility and political uncertainty. Transaction values have dropped 47% in 2009 (USD387.4 million), and traded volumes declined 26% (93.7 $MtCO_2e$). The eligibility of agricultural activities under different standards is reviewed below.

Funds

The primary climate funds that support mitigation action in agriculture were reviewed (see Figure 19), and the most relevant for agriculture described in more detail in Annex 9.2). The success of future mechanisms depends on financing mechanisms implemented in a coherent and coordinated way. This depends on harmonizing planning processes for climate mechanisms, as well those of other non-climate related programs for food security, land management and economic development. Such cross-sectoral processes need to be manageable for developing countries now facing multiple financing and planning requirements due to the proliferation of climate funds and mechanisms.

Figure 19: Overview of existing public and private financing sources for agricultural mitigation and adaptation (a full list of fund characteristics is available in Annex 9.2).

[49] Agricultural OTC trades 2009 (Hamilton et al. 2010) Hamilton et al. 2010 Building Bridges:State of the Voluntary Carbon Markets 2010, Ecosystem Marketplace, Bloomberg New Energy Finance



Additional mechanisms

Private-sector supply-chain investments.

Private-sector investments in supply-chain GHG management reflect companies' willingness to invest in improvements of internal or suppliers' practices and facilities. These investments by individual firms in agricultural GHG abatement are small but growing. They have not been well quantified across sectors. There are multiple examples of investments by multinational firms (e.g. Group Danone, General Mills, Nestle, Unilever and Cadbury) intended to lower emissions in their supply chain, as well as sector-wide efforts such as the Sustainable Agriculture Initiative Platform to share mitigation opportunities. However, like the regulatory market, this sector is expected to provide some growth and innovation but struggles to achieve scale comparable to economy-wide (or even sectoral) compliance targets. It is important to note that none of these initiatives have yet resulted in globally significant agricultural mitigation activities.

8. Engagement: Climate and agriculture

An opportunity is emerging for public climate funds to influence large-scale private sector agricultural investments contributing to GHG mitigation and poverty alleviation. The rising demand for agricultural production will accelerate this rate of investment, and broaden the opportunities for climate finance to strategically affect the nature of these investments. We suggest a strategy that focuses on lifting investment barriers and increasing incentives for sustainable agricultural intensification, while laying the groundwork for results-based (including carbon market) approaches in the future. The most promising climate financing options for agricultural practices that meet GHG mitigation, productivity and food security objectives are:

- Reducing climate-smart agriculture investment barriers
- Addressing risks related to mitigation and adaptation investments
- Harnessing carbon crediting and trading
- Strengthening public sector capacities

Two primary financing approaches have been identified to support these options: market-oriented incentives for direct investments and results-based payments for regulatory and economic reforms/incentives. The potential sources of funding are diverse (existing climate funds, private sector investments, or ODA) and may be delivered through a number of channels such as NAMAs, REDD, or private sector supply chains. The agricultural practices and policies, however, must be country specific. As outlined in the report, there are a number of widely accepted, no-regret mitigation options exist for immediate implementation: preventing land-use changes, encouraging crop rotations with legumes to enhance soil nutrient status and carbon sequestration on smallholder farms, agroforestry and the development of low energy and water efficient irrigation systems are among the most attractive options.

8.1. Reducing sustainable agriculture investment barriers

Sustainable agriculture transition fund model
Transition funds are designed to subsidize the costs for farmer and agricultural processers to adopt sustainable practices usually connected to industry-wide environmental and social standards. The assumption is that improved productivity and efficiency gains will offset higher costs related to meeting these standards and subsidies can be phased-out over time. Supplies of global agricultural commodities, many of which involve extensive networks of smallholder out-growers, are extremely price-sensitive and difficult to influence through standards with low premiums or significant upfront costs. A transition fund removes this barrier to adoption by providing finance that lowers producers' initial investments in auditing, quality control, and improved practices enabling it to achieve certification and adopt sustainable practices.

This transition fund model could be used to foster the adoption of agricultural mitigation and adaptation practices among smallholder producer associations and agribusinesses, and influence the decisions of domestic and foreign investors. Beneficiaries of this fund would receive performance payments (with upfront financing possible) using a predefined MRV system and respective climate benefit and livelihood indicators and benchmarks. Aid for Trade (AfT) initiatives aiming to reduce the costs for trading (Cali and Te Velde, 2011) could also be employed to introduce market driven sustainability standards including carbon standards. This model appears most promising for cash crops where quality premia are paid and additional environmental and social costs can be partly or entirely compensated. Agricultural producers would commit to not engage directly or indirectly in deforestation or forest degradation.

The beef industry in Brazil is one widely known example for domestic investment for related policies cited in this report. The Brazilian government linked preferential government loans to the enforcement of land use plans and avoiding expansion of production into forested areas. MRV systems also monitor performance and enforce policies. Other suitable sectors may include cocoa management in West Africa, tobacco production in East Africa or palm oil, soy, and sugar/ethanol agribusinesses globally.

Agricultural technology fund model
Agricultural research is mainly funded by the public sector in developing countries. A lack of private sector engagement at the research stage means innovations often lack the investment capital to commercialize and apply these innovations at scale. A technology fund could fill this void by attracting private sector capital to inform and invest in agricultural mitigation and adaptation innovations designed to meet multiple social and environmental objectives. These include irrigation technology (to reduce rainfall vulnerability); seed multiplication technology; precision farming techniques; more efficient fertilizer application, particular in emerging economies; and simple cost-effective carbon monitoring systems managed by local private sector. Effective examples of this approach can be found among the micro-irrigation system entrepreneurs in India. A systematic overview of agricultural innovations and diffusion pathways is provided in the World Bank's Enhancing Agricultural Innovation study.[50]

The perceived risks of transition and technology funds are that the grants or soft loans interfere with private agricultural funds, public money is deployed for impractical ideas or there is weak competition. However, these risks can be addressed through fund management. Potential partners for the development of transition funds are environmental protection agencies, private sector agribusinesses and funds as well as smallholder producer associations and NGOs supporting agricultural development. Technology funds require a close link with public-private agricultural innovation cluster that already influence the research agenda. Farmers and researchers need to engage in participatory research. Investors need to understand financing gaps, investment risks and technology futures that are worthwhile to finance.

The Africa Enterprise Challenge Fund is a promising example of how a fund vehicle can deploy limited public funds efficiently to mobilize private low-carbon agricultural capital at scale. The fund is now targeting emission reductions related to renewable energy but additional windows to support the implementation of carbon standards, investments that capture soil carbon or reduce livestock related emissions could be added.

Box 3: Africa Enterprise Challenge Fund[51]

The Africa Enterprise Challenge Fund (AECF) provides grants and interest free loans to businesses who wish to implement innovative, commercial viable, high impact projects in Africa. Competitions serve to ensure that viable business ideas that can be risky but provide the strongest impact on climate and rural employment will benefit from the fund. The AECF supports businesses working in agriculture, financial services, renewable energy and technologies for adapting to climate change. It also supports initiatives in media and information services where they relate to these sectors. The AECF is funded by DFID, the Consultative Group to Assist the Poor, the International Fund for Agricultural Development and the Netherlands Ministry of Foreign Affairs.

8.2. Addressing risks related to mitigation and adaptation investments

Farmers, particularly the rural poor, face market volatility and harvest risks with little or no insurance against input loss and crop failure. As a result, farmers reduce inputs to minimize financial risk triggering declines in soil carbon stocks and productivity, while increasing their vulnerability to disruptions. By helping farmers manage these risks through simple but accessible loan guarantees and insurance options, private sector investment can flow into improved agriculture at limited public expense.

[50] http://siteresources.worldbank.org/INTARD/Resources/Enhancing_Ag_Innovation.pdf
[51] http://www.aecfafrica.org/

Subsidizing soil carbon sequestration: We recommend a NAMA-based financing mechanism specifically for sustainable agricultural intensification targeting small farms. Soil carbon sequestration activities in particular yield multiple benefits for smallholders. Public funding could be used to establish a national policy framework and MRV system using soil carbon models to estimate soil sequestration benefits and efficiency accounting for intensity-based emission reductions. Public climate finance should also underwrite some risks for related private sector investment options such as loan guarantees for input and irrigation technology investments. Loan guarantees are already widely offered, while a climate finance component could be integrated into existing programs. Considering that the design, capacity building and implementation of such programs will take time, it is important to support, in parallel, individual projects that will inform a NAMA design. A national registry of the investments and emission reductions as required under the Cancun Agreements that will serve to monitor the efficiency and to reward performance. Examples of this approach include loan guarantees or support programs being considered by the USAID Development Credit Agency and KfW.

Risk insurance mechanisms: A second important element to reduce climate-related agricultural production risks are insurance strategies. Schemes that are available at low transaction costs will encourage smallholder farmers to increase production intensity because inputs are insured against failure. Hence farmers will increase inputs, which will increase food production and farm income. To understand the scaling potential, public leverage options and related risk, a detailed analysis of existing schemes is required. Successful input insurance systems that employ smart mobile phone technology to address the challenge to reduce transaction costs (see Kilimo Salama model) are presented in this report. Weather index based insurance mechanisms have also been tested successfully in a number of countries.[52] The Harita system in Ethiopia is linking the weather index based insurance with the government food for work programme which is in particular useful for regions with frequent drought events.[53] There are risks however: insurance is ineffective if drought events are too frequent; in this case government safety nets providing alternatives to farming may be the most effective adaptation strategy.

8.3. Harnessing carbon crediting and trading

Carbon market financing appears to be a promising long-term strategy to support agricultural improvements. The most important factor for a market-driven offset strategy is robust demand for carbon credits (either through direct purchase programs, or inclusion of agricultural credits in an emission trading scheme permitting offsets). Demand-side measures that can be financed include:

- issuance of a limited purchase order and creating floor pricing for carbon credits generated by a specific party or government
- procuring agricultural credits through public tenders (following the ERUPT/CERUPT example of the Dutch government in the late 1990/2000s)
- creating a direct purchasing facility to buy, sell and guarantee credits generated by appropriate standards

At the moment, a carbon market does not appear to be a short to medium-term option for supporting improved agricultural policies and practices on large scales as discussed in section 7.2. Carbon market approaches are most appropriate under favorable conditions for private investment including:

- a policy framework to ensure market demand (either compliance or voluntary)
- assurance of public support for enabling conditions (such as: land tenure enforcement, agricultural extension services, and other key elements)
- approved and feasible methodologies for agricultural carbon
- track record in selecting and managing projects at reasonable MRV and transaction costs, and
- proven complementary revenue streams secured
- cost effective aggregation mechanism at national or regional scale

[52] http://www.ifpri.org/publication/innovations-rural-and-agriculture-finance
[53] http://www.ukcip.org.uk/business/business-case-studies/harita/

However, the barriers to effectively deploying carbon finance (carbon credits) in today's market are:

- low demand for carbon credits in the agricultural sector;
- limited focus on productivity and smallholder benefits by projects;
- lack of protocols for MRV;
- little political support for new market mechanisms, particularly if these affect food production or prices;
- high initial risks and low returns initially given early project costs and slow accumulation of carbon and productivity benefit over years or decades.

The future applications of this market are more promising. Laying the foundations for MRV and market finance benefits both future carbon-market approaches and immediate climate finance efforts. We recommend strategic purchases of agricultural carbon credits and/or direct finance of strategic projects in cases where efforts provide the scientific and institutional foundation for broader activities. This will support the development of viable agricultural carbon projects and contribute to beneficial agricultural research that might be scaled through other means.

Immediate applications include project-based carbon crediting mechanisms such as the CDM. These are suitable for agricultural emission reduction options in the energy sector (methane emissions from animal waste or biomass residue fuel-switch programs). CDM Programme of Activities or standardized baselines can contribute to reduce transaction costs. It is important that the CDM is reformed and continues beyond 2012. For more advanced developing countries, domestic carbon trading systems may also offer a politically acceptable, cost-effective means to reduce emissions and stimulate low carbon development in the agricultural sector. The Panda Standard (see case study below) is designed as a voluntary carbon standard for China, supported by the government, and may eventually be used for compliance carbon trading.

Box 4: Panda Standard[54] and evolving carbon trading systems in China[55]

The Panda Standard is the first voluntary carbon standard in China with a focus on agriculture and forestry. It was announced in December 2010 and the first transaction took place in March 2011. It aims to compliment China's regulatory efforts to increase carbon efficiency targets and to advance its objective to reduce rural poverty. In addition China will set up carbon trading systems in five provinces (Guangdong, Hubei, Liaoning, Shaanxi and Yunnan) to develop standards and mechanisms for market-based carbon trading mechanisms and to support the development of green economies.

8.4. Strengthening public sector capacities

Public sector support for national climate-smart agricultural initiatives: International climate finance can be used to support countries that have a demonstrated commitment to establish the infrastructure and capacity to monitor agricultural emissions, along with policies and measures to reduce agricultural emissions. Financial support could be provided for an agricultural readiness process, strengthening of existing agricultural monitoring and evaluation capacity. This would ultimately lead to national agricultural GHG monitoring systems including national reference emission levels and related capacity building support. Financing could be linked to milestones related to the MRV system development and reporting accuracy. Performance payments for emission reductions achieved would provide incentives not only to set-up monitoring systems but also to adopt agricultural mitigation activities. The fast-start financing committed under the Cancun Agreements could provide suitable financing pathways such as NAMAs or bilateral initiatives. Any agricultural climate investment program would need to be developed tailoring different climate financing mechanisms to tackle specific investment barriers and risks.

[54] http://www.pandastandard.org/
[55] http://www.chinadaily.com.cn/china/2010-08/19/content_11174407.htm

Work cited

ACIL Tasman, 2009. Agriculture and GHG mitigation policy: options in addition to the CPRS. Prepared for the Victorian Department of Primary Industries NSW Department of Industry and Investment. Melbourne, Australia.

AGRA 2010, Innovative Financing for African Agriculture. www.agra-alliance.org

Angelsen, A. 2010. Policies for reduced deforestation and their impact on agricultural production. PNAS, Vol. 107, No. 46, 19639–19644

AWG-LCA, 2009, Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention, Draft conclusions proposed by the Chair, Addendum, Draft decision -/CP.15, Cooperative sectoral approaches and sector-specific actions in agriculture, URL: http://unfccc.int/resource/docs/2009/awglca8/eng/l07a09.pdf

Babkova, E. 2010. Part I. Food Crisis Looming? Center for Strategic and International Studies. Sep 28, 2010. URL: http://csis.org/blog/part-i-food-crisis-looming.

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

Balmford, A., R.E. Green and J.P.W. Scharlemann 2005. "Sparing land for nature: exploring the potential impact of changes in agricultural yield on the area needed for crop production". Global Change Biology 11 (10): 1594-1605.

Bruinsma, J. 2009, *The Resource Outlook to 2050. By how much do land, water use and crop yield need to increase by 2050?* Technical paper from the Expert Meeting on How to Feed the World in 2050, FAO Rome.

Burney, J. A., Davis, S. J., Lobell, D. B. 2010. "Greenhouse Gas Mitigation by agricultural Intensification," PNAS. URL: http://www.pnas.org/content/early/2010/06/14/0914216107.abstract

Burton, I. And B. Lim. 2005. Achieving Adequate Adaptation in Agriculture. Climate Change, 70(2005): 191-200

CAADP 2010. URL: http://www.nepad-caadp.net/about-caadp.php

Cali, M. and Te Velde C.D. 2011. Does Aid for Trade Really Improve Trade Performance? World Development Vol. 39, No. 5, pp. 725–740.

Canadell, Raupach and Houghton. 2009. Anthropogenic CO2 emissions in Africa. Biogeociences 6:463-468

Coalition on Agricultural Greenhouse Gases (C-AGG), 2010, Agriculture in the UNFCCC: Post-Cancun/COP16 Perspectives on Agricultural Issues within the UNFCCC. Draft memo. December 2010.

CSM 2008, "The Monitor's View: Price Shock in Global Food," 7 April 2008. The Christian Science Monitor.

Deutsche Bank Group 2009, Investing in Agriculture: Far-Reaching Challenge, Significant Opportunity An Asset Management Perspective June 2009 Deutsche Bank Group.

DeFries, R. and Rosenzweig, C. 2010. Toward a whole-landscape approach for sustainable land use in the tropics. PNAS, Vol. 107, No. 46, 19627–19632

Dioné, J. 2010. Presentation Agriculture and Rural Development Day 2010, Director of Food Security and Sustainable Development Division of the United Nations Economic Commission for Africa (ECA),Cancun Mexico.

ECA (Economic Commission for Africa) 2009, Economic Report on Africa 2009: Developing African Agriculture Through Regional Value Chains Economic Commission for Africa. Addis Ababa, Ethiopia.

EPRI 2010. Brasil's Emerging Sectoral Framework for Reducing Emissions from Deforestation and Degradation and the Potential to Deliver Greenhouse Gas Emissions Reductions from Avoided Deforestation in the Amazon's Xingu River Basin. Palo Alto.

European Commission 2011, Communication from the Commission to the European Parliament, the Council, the Europena Economic and Social Committee and the Committee of the Regions: A Roadmap for moving to a competitive low carbon economy in 2050 Brussels, {SEC(2011) 287 final}.

FAO 2005, The UN Food and Agriculture Organization Committee on Food Security. Report of 31st Session

FAO 2008. Climate Change Adaptation and Mitigation in the Agricultural Sector, available at: ftp://ftp.fao.org/docrep/fao/meeting/013/ai782e.pdf

FAO 2009c. Harvesting agriculture's multiple benefits: Mitigation, adaptation, development and food security. Policy Brief, Food and Agriculture Organization of the United Nations, Rome.

FAO 2010a "No food crisis seen, but greater market stability needed: FAO Assistant-Director General on current food situation." 7 September 2010, Rome. URL: http://www.fao.org/news/story/tr/item/45178/icode/en/

FAO 2010b Towards a Work Progamme on Agriculture: A submission to the AWG-LCA by the Food and Agriculture Organization of the United Nations URL: http://unfccc.int/resource/docs/2010/smsn/igo/081.pdf

FAO 2010c "Climate-Smart" Agriculture Policies, Practices and Financing for Food Security, Adaptation and Mitigation", 2010.

FAO 2010d "Agriculture, Food Security and Climate Change in Post-Copenhagen Processes: An FAO Information Note," FAO.

Foresight 2011, "The Future of Food and Farming: Challenges and choice for global sustainability." Government Office for Science, London, UK.

Frankhauser, S., and Ward, J., 2010, "Regional Implications of the AGF recommendations: Africa." Climate & Development Knowledge Network. November 2010.

Ghanem, H.2009, "World Food Security and Investment in Agriculture," Internatoinal Economic Bulletin, Weekly Economic Commentary and analysis from the Global Think Tank. URL: http://www.carnegieendowment.org/ieb/?fa=show&id=23850.

Govaerts, B., Verhulst, N., Castellanos-Navarrete, A., Sayre, K.D., Dixon, J., and Dendooven, L. 2009. Conservation Agriculture and Soil Carbon Sequestration: Between Myth and Farmer Reality. Critical Reviews in Plant Science, 28: 97-122.

Grieg-Gran, M., 2010, Beyond forestry: why agriculture is key to the success of REDD+, iied briefing, iied.

HAGCCF (High-Level Advisory Group on Climate Change Financing), 2010, "Report of the Secretary-General's High-Level Advisory Group on Climate Change Financing." 5 November 2009. URL: http://www.un.org/wcm/webdav/site/climatechange/shared/Documents/AGF_reports/AGF%20Report.pdf

iisd 2009. "Expanding Agriculture's Role in a Post-2012 Climate Change Regime." International Institute for Sustainable Development (iisd), March 2009. URL: http://www.iisd.org/pdf/2009/agriculture_post_2012.pdf

IPCC 2007, Fourth Assessment Report Intergovernmental Panel on Climate Change, URL: http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html

IPCC 2007(b). Climate Change 2007: Synthesis Report. Intergovernmental Panel on Climate Change (IPCC), Valencia, Spain

Kahrla, F., Lia, Y., Suc, Y., Tennigkeit, T., Wilkes, A., Xua, J., 2010. *Greenhouse gas emissions from nitrogen fertilizer use in China.* Environmental Science & Policy 13:8, p 688-694.

Lal, R. 2011. Sequestering carbon in soils of agro-ecosystems. Food Policy 36, 533-539.

Larson, D.F., Dinar, A., Frisbie, J.A., 2011 "Agriculture and the Clean Development Mechanism," Policy Research Working Paper 5621. The World Bank, Development Research Group, April 2011. URL: http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2011/04/04/000158349_20110404091922/Rendered/PDF/WPS5621.pdf

Lobell et al. 2008. Science. Prioritizing climate change adaptation needs for food security in 2030. February 2008

Luo, Z., Wang, E., and O.J. Sun. 2010. Can no-tillage stimulate carbon sequestration in agricultural soils? A meta-analysis of paired experiments. Agriculture, Ecosystems and Environment, 139(2010): 224-231.

Lybbert, T. and Sumner, D. 2010. Agricultural Technologies for Climate Change Adaptation in Developing Countries: Policy Options for Innovation and Technology Diffusion. International Center for Trade and Sustainable Development.

Martino, D. 2009. Mitigation in Agriculture: Main Findings of IPCC AR4. Presented to AWG-LCA In-Session Workshop: Opportunities and Challenges for Mitigation in the Agricultural Sector. Bonn, Germany. 4 April 2009.

Milchunas, D. and Lauenroth, W. 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. Ecological Monographs 63:327–366.

Moorhead, A., 2009, "Climate, agriculture and food security: A strategy for change." Consultative Group on International Agricultural Research (CGIAR) December 2009.

Nair, C.T.S. and Rutt, R., 2009, "Creating forestry jobs to boost the economy and build a green future," article developed from background paper "Impacts of Global Economic Turbulence on the Forest Sector" at the nineteenth session of the FAO Committee on Forestry, Rome, 20 March 2009.

Nelson, G.C., Rosegrant, M.W., Palazzo, A., Gray, I., Ingersoll, C., Robertson, R., Tokgoz, S., Zhu, T., Sulser, T.B., Ringler, C., Msangi, S., and You, L., 2010a, Food Security, Farming, and Climate Change to 2050: Scenarios, Results, Policy Option. International Food Policy and Research Institute, Washington DC.

Nelson, G.C., Rosegrant, M.W., Koo, J., Robertson, R., Sulser, T., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R., Ewing, M., and Lee, D. 2010b. The Costs of Agricultural Adaptation to Climate Change. Discussion Paper 4: Development and Climate Change. World Bank.

Nepstad, D., B. S. Soares, F. Merry, A. Lima, P. Moutinho, J. Carter, M. Bowman, A. Cattaneo, H. Rodrigues, S. Schwartzman, D. G. McGrath, C. M. Stickler, R. Lubowski, P. Piris-Cabezas, S. Rivero, A. Alencar, O. Almeida, and O. Stella. 2009. The End of Deforestation in the Brasilian Amazon. Science 326 (5958):1350-1351.

New, M., D. Liverman, H. Schroder, and K. Anderson, 2011, Four degrees and beyond: the potential for a global temperature increase of four degrees and its implications. Phil Trans R Soc A January 13, 2011 369:6-19

NRC, 2001, “Climate Change Science: An Analysis of Some Key Questions.” Committee on the Science of Climate Change, Division on Earth and Life Studies, National Research Council. Washington, DC., National Academy Press. URL: http://books.nap.edu/openbook/0309075742/html/ index.html.

Nwanze, K.F., 2009, “Agriculture and Rural Development Day 2009 Keynote Statement.” Copenhagen, 12 Dec 2009.

OECD 2007, “Agricultural policies in non-OECD countries: Monitoring and Evaluation.” Organization for Economic Co-operation and Development; Paris, France.

Olofsson, J. and T. Hickler, 2008, Effects of human land use on the global carbon cycle during the last 6,000 years. Vegetation History and Archaeobotany 17:605–15.

Padgham, J., 2009. “Agricultural Development Under a Changing Climate: Opportunities and Challenges for Adaptation.” Joint Departmental Discussion Paper – Issue 1. Agricultural and Rural Development and Environment Departments. August 2009.

Parry et al., 2004, Effects of climate change on global food production under SRES emissions and socio-economic scenarios. Global Environ. Chang., 14, 53-67.

Parker, C., Brown, J., Pickering, J., Roynestad, E., Mardas, N., and Mitchell, A. W., 2009, The Little Climate Finance Book. Global Canopy Fouyndation. Oxford. December 2009.

Paustian, K., C.V. Cole, D. Sauerbeck and N. Sampson,1998, CO_2 mitigation by agriculture: An overview. Climatic Change 40:135–62

Perez, C., Roncoli, C., Neely, C., and J.L. Steiner. 2007. Can carbon sequestration markets benefit low-income producers in semi-arid Africa? Potentials and challenges. Agricultural Systems 94(2007): 2-12

Pingali, P. 2007. Agricultural Growth and Economic Development: a view through the globalization lens. Agricultural Economics 37: 1-12

Popp, A., Lotze-Campen, H. & Bodirsky, B. 2010. Food consumption, diet shifts and associated non-CO2 greenhouse gases from agricultural production. Global Environmental Change 20, 451-462.

Project Catalyst, 2009, “Scaling up climate finance”.

Raupach, M.R. Marland, G. Ciais, P. Le Que, C., Canadell, J.G., Klepper, G. and Field, C.B., 2007, "Global and regional drivers of accelerating CO2 emissions," 10288–10293 _ PNAS _ June 12, 2007 _ vol. 104 _ no. 24

Schmidhuber, J. Bruinsma, J. Boedeker, G., 2009. "Capital requirements for agriculture in developing countries to 2050." Food and Agriculture Organization of the United Nations; Economic and Social Development Department. Rome, Italy. ftp://ftp.fao.org/docrep/fao/012/ak974e/ak974e00.pdf

Seeberg-Elverfeldt,C., 2010. Carbon Finance Possibilities for Agriculture, Forestry and Other Land Use Projects in a Smallholder Context. FAO, Rome, Italy.

Seeberg-Elverfeldt, C. and M. Tapio-Bistrom. 2010, "Global Survey of agricultural mitigation projects." FAO August 2010, Rome, Italy.

Sharma, S., 2010, "Agriculture in the climate talks: Tianjin, October 18, 2010." Institute for Agriculture and Trade Policy. URL: http://www.iatp.org/iatp/commentaries.cfm?refid=107749

Sheeran, J., 2010, "Statement by Ms. Josette Sheeran, Executive Director, United Nations World Food Programme, (Delivered by Sheila Sisulu, Deputy Executive Director), New York, 8 March 2010

Smith, P., D. Martino, Z. Cai, D. Gwary, H.H Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, 2007, Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Smith, P., D. Martino, Z. Cai, D. Gwary, H.H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, R.J. Scholes, O. Sirotenko, M. Howden, T. McAllister, G. Pan, V. Romanenkov, U. Schneider, S. Towprayoon, M. Wattenbach, and J.U. Smith, 2007a, Greenhouse gas mitigation in agriculture. Philosophical Transactions of the Royal Society, B., 363. doi:10.1098/rstb.2007.2184.

Smith, P. and Martino, D., 2007, Agriculture. In: Climate Change 2007 (IPCC, 4th Assessment Report);

Stehfest, E., Bouwman, L., van Vuuren, D., den Elzen, M., Eickhout, B. & Kabat, P. 2009. Climate benefits of changing diet. Climatic Change 95, 83-102.

TCG 2009, "Tools for Setting Reference Emission Levels A review of existing tools that can be used to set a benchmark for rewarding reduced emissions and increased sequestration of greenhouse gasses in the terrestrial system." Policy Briefs II, Discussion Draft June 2009.

Thornton, P.T. Jones, P.G., Ericksen, P.J., Challinor, A.J., 2011, Agriculture and food systems in sub-Saharan Africa in a 4°C+ world doi: 10.1098/rsta.2010.0246 Phil. Trans. R. Soc. A 13 January 2011 vol. 369 no. 1934 117-136.

Towprayoon, 2007, Policy and technological constraints to implementation of greenhouse gas mitigation options in agriculture. Agriculture, Ecosystems & Environment, 118(1-4): 6-28.

U.S. EPA, 2006a, Global Mitigation of Non-CO2 Greenhouse Gases. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 2006b, Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990–2020. U.S. Environmental Protection Agency, Washington, DC.

UNFCCC 1992, United Nations Framework Convention on Climate Change, United Nations. FCCC/INFORMAL/84 GE.05-62220 (E) 200705. URL: http://unfccc.int/resource/docs/convkp/conveng.pdf

UNFCCC 1998, Kyoto Protocol to the United Nations Framework Convention on Climate Change. URL: http://unfccc.int/resource/docs/convkp/kpeng.pdf.

UNFCCC, 2007. Bali Action Plan. Decision 1/CP.13 United Nationas Framework Convention on Climate Change, Bali, Indonesia. FCCC/CP/2007/6/Add.1.

UNFCCC 2010a Outcome of the work of the Ad Hoc Working Group on long-term Cooperative Action under the Convention. Draft decision/CP16. United Nations Framework Convention on Climate Change, Cancun Mexico.

Vermeulen, S.J., Aggarwal, P.K., Ainslie, A., Angelone, C., Campbell, B.M., Challinor, A.J., Hansen, J., Ingram, J.S.I., Jarvis, A., Kristjanson, P., Lau, C., Thornton, P.K, and Wollenberg, E., 2010, Agriculture, Food Security and Climate Change: Outlook for Knowledge, Tools and Action. CCAFS Report 3. Copenhagen, Denmark: CGIAR-ESSP Program on Climate Change, Agriculture and Food Security.

Vitousek, P.M., H.A. Mooney, J. Lubchenco and J.M. Melillo, 1997, Human domination of earth's ecosystems. Science 277: 494–9.

Vlek, P.L.G., G. Rodriquez-Kuhl and R. Sommer, 2004, Energy use and CO2 productoin in tropical agriculture and means and strategies for reduction or mitigation. Environment, Development and Sustainability, 6(1-2): 213-233.

Vuren, D.P. van, et al., 2009, Outlook on agricultural change and its drivers. IN: McIntyre, B.D., Herren, H.R., Wakhungu, J. and Watson, R.T., Agriculture at a Crossroads. Washington, DC: Island Press: 255-305

World Bank, 2007, World Development Report 2008: Agriculture for Development. Washington DC.

World Bank, 2009, The Global Agriculture and Food Security Program (GAFSP) Questions and Answers. URL: http://siteresources.worldbank.org/NEWS/Resources/GAFSPQuestionsAnswers_ext042210.pdf

World Bank, 2009b, World Development Report 2010: Development and Climate Change, Washington DC.

World Bank, 2010, Rising Global Interest in Farmland: Can it Yield Sustainable and Equitable Benefits. 7 September 2010.

9. Annexes

9.1. Stakeholders

A selected list of interviewees includes Misha Wolsgaard-Iversen (CGIAR), Dr. Joan Kagwanja (Alliance for a Green Revolution in Africa), Dr. Harun M. Warui (Kenya Agricultural Research Institute, Gerald Nelson (IFPRI). Genito Maure (University of Cape Town), Dr. Lindiwe Majee Sibanda (FANRPAN) and Maria M. Mulinidi (Alliance for a Green Revolution in Africa) and a number of government officials and negotiators from developing countries who spoke on condition of anonymity given the political sensitivity of the subject.

9.2. Funds

Table 17: Agriculture-relevant funds with a focus on climate change adaptation[56]

Funds	Description	Approved projects	Fund size million (USD)
UN Adaptation Fund (AF)	The AF was established under the Kyoto protocol to finance concrete adaptation projects and programmes in developing countries that are party to the Kyoto protocol	2	197
Least Developed Countries Fund (LDCF)	The LDCF assists the 49 least developed countries under the UNFCCC to prepare and implementing national adaptation programmes of action (NAPAs)[57]	92 (including NAPA preparation)	262
Special Climate Change Fund (SCCF)	The SCCF finance and implement activities that increase resilience of national development sectors to the impacts of climate change in non-Annex I countries; significant agricultural component.[58]	30	149
Pilot Program for Climate Resilience (PPCR)	WB initiative to pilot and demonstrate approaches for integration of climate risk and resilience into development policies and planning with 9 country programs and 2 regional programs. All 9 country programs mention agriculture as a component.	9 pilot countries 2 pilot regions	1,036

Table 18: Agriculture-relevant funds with a focus on climate change mitigation

Funds	Description	Approved projects	Fund size million (USD)
Global Environment Facility (GEF)	The GEF receives funding from multiple donor countries and provides grants and concessional loans to cover the "incremental costs" associated with	2644[60]	GEF-5 (2010-2014): USD 4.35

[57] Decision 5/CMP.7. NAPAs provide a process for LDCs to identify priority activities that address their urgent and immediate needs to adapt to climate change—those for which further delay would increase vulnerability and costs.
[58] Decision 7/CP.7, Funding under the Convention, paragraph 1 (c)

Trust Fund	transforming a project with national benefits into one with global environmental benefits. Projects and funding for agriculture relatively low between 2006 and 2010 but future potential.[59]		billion
EU Global Climate Change Alliance (GCCA)	The Global Climate Change Alliance (GCCA) aims at supporting the poorest and most vulnerable countries with respect to their capacity to adapt to the effects of climate change. Only 2 agricultural related between 2008 and 2009 although other projects deal with related aspects (food security, forestry, land use) for mitigation and adaptation.[61]	18	~205 (EUR 141.2 million)
BioCarbon Fund	The BioCarbon Fund provides carbon finance for projects that sequester or conserve greenhouse gases in forests, agro- and other ecosystems.	15	N/A
Forest Investment Program (FIP)	The Forest Investment Program (FIP) is a targeted program of the Strategic Climate Fund (SCF) within the Climate Investment Funds (CIF). It was established to catalyze policies and measures and mobilize funds to facilitate REDD and promote improved sustainable management of forests.	8 pilot countries in the FIP	620
UN-REDD Programme Fund	The UN-REDD Programme was launched in September 2008 to assist developing countries prepare and implement national REDD+ strategies. Currently it has 29 partner countries spanning Africa, Asia-Pacific and Latin America, of which 12 are receiving support to National Programme activities.	12 supported countries	112
Forest Carbon Partnership Facility (FCPF)	Partnership created by the World Bank to support developing countries in their REDD efforts, activities and policy development. There are 37 developing countries in the partnership. There are two separate funds in the FCPF, a readiness fund (for REDD readiness) and a carbon fund (for performance based payments).	13 countries have been awarded formulation grants[62]	221

9.3. Project & programme inventory

There are few high quality global surveys of agricultural mitigation and adaptation projects. The two most extensive global surveys are the i) UNEP Risoe CDM/JI pipeline and ii) FAO agriculture, forestry and other land use (AFOLU) projects database.[63] Regional assessments are also available.[64] We have reviewed and presented a summary of the findings below. The UNEP Risoe database follows the CDM classification of project activities, which underestimates the amount of agriculture related projects because methane capture or projects using agricultural residues are considered as energy projects. In the FAO database,

[60] As of January, 2011
[59] Selection whether projects are solely or partly focusing on agriculture, based on project outlines in GEF reports; 4th replenishment period.
[61] In 2010, the beneficiary countries are: Belize, Mozambique, Nepal, the Pacific region plus the Solomon Islands, Ethiopia, The Gambia and Sierra Leone.
[62] As of November, 2010
[63] (Varming et al. 2010; Seeberg-Elverfeldt, C. and Tapio-Bistrom, M., 2010)
[64] World Agrogorestry Centre (ICRAF) inventory (Chomba and Minang 2009)

listed projects highlight that many sustainable agricultural land management practices have mitigation and adaptation benefits. However, in most of the projects the benefits are not quantified against a baseline or reference scenario and projects are not additional because they are funded already for other purposes. Nevertheless, the FAO database shows that there are a number of effective climate- smart technologies that are available to be scaled.

UNEP Risoe CDM/JI pipeline

A survey of agricultural projects in the CDM/JI pipeline found agriculture represents 17% (964 projects) of the 5,824 recorded projects, and is expected to reduce 582 mtCO2e by 2020 (or a 7% share) (Larson *et al.* 2011). Agricultural projects in this survey are defined according to FAO guidelines as "a project that uses agricultural systems or residuals/outputs from agricultural processes to directly or indirectly reduce greenhouse gas emissions." The cumulative mitigation of agricultural projects, when combined with all land use activities such as forestry, represents about 3% (50 MtCO2e) of the estimated 1,629 MtCO2e potential abatement believed to exist in developing counties by the IPCC. The average mitigation per project is about 604,000 tCO2e through 2020. Most of these projects are concentrated in just five countries (like the CDM at large) with China, India, Brasil, Mexico and Malaysia accounting for 79% of all agricultural projects. The results are summarized in the Table 20 below.

Table 19: CDM projects by type and expected mitigation impact by 2012 and 2020 (WORLD BANK, 2011)

Projects		Mitigation impact by 2012	Mitigation impact by 2020	Average project impact ((ktCO2e))	
Project type	number	ktCO2e	ktCO2e	2012	2020
Agriculture	964	219,507	582,081	228	604
Forests	58	16,638	69,109	287	1,192
Non-agriculture					
Hydro	1,558	482,160	1,894,491	309	1,216
Alternative energy	1,221	326,170	1,154,888	267	946
Energy Efficiency	837	332,619	1,139,571	397	1,361
Methane avoidance	340	191,296	596,638	563	1,755
Landfill gas	326	204,097	537,122	626	1,648
Assorted gases	145	340,797	904,581	2,350	6,238
Biomass energy	141	36,958	101,004	262	716
Fossil fuel switch	133	191,523	585,274	1,440	4,401
Cement	44	35,444	76,590	806	1,741
Transport	34	10,157	39,160	299	1,152
HFCs	23	476,541	1,100,353	20,719	47,841
Total	5,824	2,863,906	8,780,862	492	1,508
Agriculture	964	219,507	582,081	228	604
Forests	58	16,638	69,109	287	1,192

Table 20: CDM projects expected mitigation impact by core set of activities (WORLD BANK, 2011)

Type of projects	Number of projects	Expected mitigation (ktCO2e)	
		2012	2020
Agricultural residues	615	153,768	428,634
Manure	288	52,837	119,486
Composting	60	12,883	33,861

Land use	57	16,614	69,054
Irrigation	1	18	100
Mangroves	1	24	55
Total	1,022	236,145	651,189

FAO database: AFOLU projects

The FAO database on projects that target agriculture, forestry and other land uses (AFOLU) has recorded 497 AFOLU mitigation projects from various registries and crediting regimes. "Agriculture" is defined broadly here to encompass on-farm and off-farm activities but excludes all processing activities (including those from residues) and thus does not account for projects included in the CDM analysis above.

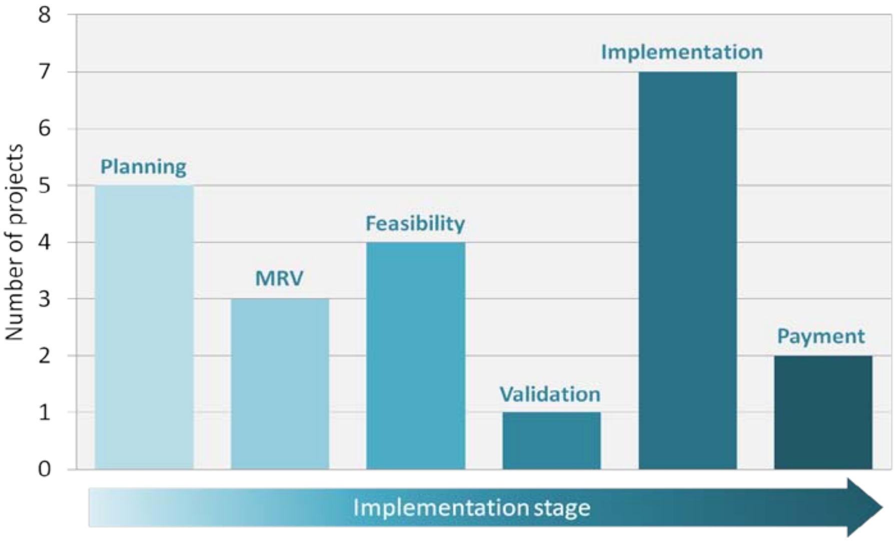
In the 2010 data, 74 (less than 10%) of projects were defined as agricultural (and only 50 adequately responded to the surveys).[65] The rate of new project creation in agriculture is slowing, affected by the same economic challenges and political uncertainty dampening the supply of other AFOLU credits.
AFOLU projects between 2007-2009 shifted toward forestry (after a peak in 2006 dominated by swine manure/methane projects) and diversified away from CDM standards toward voluntary regimes. This growth halted in 2010. As of July 2010, only 19 new AFOLU projects, mostly REDD+ and A/R, were identified compared to a total of 100 in 2009 – on track for a 60% decease.

The primary mitigation activities were off-farm land rehabilitation with benefits to farmers (30.3%); on-farm practices, agroforestry and soil management (27.6%); REDD with benefits to farmers (7.9%); others (7.9%). CSA practices employed were restoration of degraded soils, and agroforestry, along with cropland management and improved livestock management. Projects were generally at early stages of development (some consist only of proposals or project information notes) and lacked private sector involvement – most are sponsored by international and domestic NGOs, universities, and research institutions (See Figure 20). A summary description of the projects follows (Varming *et al. 2010*):

- Geographic distribution: Latin America and Caribbean (14), Asia (5), Africa (2), Eastern Europe (1).
- Area: average size is 8,000 ha to 300,000 ha (with two largest projects included)
- Project duration: 2-50 year (17 average)
- Number households: 20 – 150,000 (20,000 average)
- Categories: annual crops and/or grazing (11), Perennial corps (5), grazling (3), and other (3)

[65] The projects listed are therefore all directly related to land use and livestock keeping, and include carbon sequestration from agriculture and forestry activities, as well as manure treatment from livestock. Processing activities such as slaughter, milling or sawmilling are not included, nor are projects involving agricultural residues such as rice husk or bagass.

Figure 20: Implementation stages of registered agricultural project with mitigation component (FAO 2010)



9.4. NAMA and sectoral approaches

NAMAs have been submitted by all major developing country emitters. Of the more than 27 agricultural submissions by developing countries, seven are non-sector specific and 11 involve mitigation actions in the agricultural sector (FAO 2010d). Activities include i) crop residue management; ii) cropland-related mitigation practices in specific areas; iii) build capacity and conduct research to identify and develop good agricultural practices for reducing GHG emissions at the farm level; iv) develop carbon projects in forestry and agriculture; v) restoration of grasslands, fodder crop production, introduction of combined irrigation and fertilization techniques to increase the efficiency of fertilizer application and methane capture in livestock and chicken farms. Two countries have issues specific agricultural mitigation targets but noted these are voluntary domestic reductions and may include the Clean Development Mechanism. Four countries submitted quantitative agricultural reduction targets.

NAMAs represent voluntary GHG emission reduction goals by developing countries that are to be realized through technology transfer and financial support from developed countries. These initiatives will likely form the basis for future projects and programs as fast-start and adaptation financing flows to developing countries. NAMA submissions by developing counties relevant to agriculture are summarized below in Table 21.

Table 21: Agricultural NAMA submissions to the UNFCCC (13 Jan 2011)

Country	Mode	Activity	Implementation
Brasil	GHG cuts & sinks	Cropland and livestock management	Integrated crop-livestock system (range of estimated reduction:18 to 22 million tons of CO2 eq in 2020
			No-till farming (range of estimated reduction: 16-20 million tons eq in 2020
			Implementation of agroforestry practices and systems on 261,840 square km of agricultural land for livelihood improvement and carbon sequestration

Central African Republic	N/A	Land and livestock management	"Increase of forage seed and their popularisation in following regions: Ouham, Ouham-Pende et Nana –Mambere"
	GHG sinks	Crop intensification and improvement	"Intensification of the production of improved agricultural seeds with farmers
Chad Republic	GHG sinks	Crop intensification and improvement	"Multiplication of forage seeds and their popularisation with farmers. Manufacturing of compost and fertilizer"
Republic of Congo	Capacity & sinks	Crop improvement and extension	"Choosing and popularizing of agricultural species better adapted to climate change. Capacity building of farmers population with regard to improved techniques and crops better adjusted to global warming"
Eritrea	GHG sinks	Sustainable land management	Implement projects and programmes which enhance soil carbon stocks in agricultural soils
	N/A	Sustainable land planning	Develop and elaborate appropriate and integrated plans which are supportive of both adaptation and mitigation actions for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas in Eritrea affected by drought and desertification, as well as floods
Ethiopia	GHG cuts & sinks	Cropland management and agroforestry	Application of compost on 8000 square km of agricultural land of rural local communities for increased carbon retention by the soil
			Implementation of agroforestry practices and systems on 261,840 square km of agricultural land for livelihood improvement and carbon sequestration
Gabon	GHG sinks	Agroforestry	Mention of "agroforestry" as an action domain "with proper funding 100,000 ha is targeted and with application of diverse international mechanisms 1900,000 ha is targeted."
Ghana	GHG cuts & sinks	Sustainable land management	Uncontrolled burning (promote spot and zero burning practices); Improved land preparation (promote minimum tillage ; incentivise use of bio-fuels for mechanised agriculture; Use of nitrogen-based fertilizers (promote the use of organic fertilizers ; promote integrated use of plant nutrients)
	GHG cuts	Crop switching	Predominant cultivation of rice in low lands (promote the cultivation of high yielding upland rice cultivation
	GHG cuts & sinks	Post-harvest practices	burning of crop residues (promote the recycling of crop residues)
	GHG cuts & sinks		High post-harvest losses (improve storage facilities and promote the use of post-harvest technologies
Ivory Coast	N/A	N/A	" Durable development of agricultural operations."
Jordan	GHG cuts & sinks	Cropland and live stock management	i) Growing perennial forages in Badia region; ii) Best management practices in irrigated farming fertilization applications)
	GHG cuts	Methane capture	Use of methane emitted from livestock and chicken farming production and slaughter houses

Macedonia	GHG cuts	Enabling conditions for GHG emission reduction	i) Completion of institutional and legal reforms in irrigation sector; ii) increasing institutional and individual capacity for applying international funds iii) development of systems to apply "good agricultural practices" 5) financial incentives for mitigation technologies.
		Mitigation technologies	i) Installation of methane recovery and flaring systems at selected farms; ii) Research support program for development of new mitigation technologies and transfer of existing ones; iii) Program of introduction of practices that use the agriculture potential for renewable energy and carbon sequestration; iv) programmatic CDM projects
	Capacity	Carbon finance capacity building	National and local training and capacity strengthening for i) training for CDM potential in agriculture; ii) training for preparation of CDM documentation
		Mitigation technologies and capacity building	Training of farmers/decision makers in i) GHG mitigation issues (upgrade to current curricula and syllabuses); ii) Training of farmers for adopting new technologies; iii) familiarization of public and institutions with the problems of climate mitigation
Madagascar	N/A	Crop improvement and fertilization	i) Increase forage seeds and ensure their popularization; ii) Intensify the production of enhanced agricultural seeds; iii) Manufacture compost and fertilizers in accordance with the quality levels applicable to rural environment in agricultural investment zones"
Mauretania	N/A	Efficiency	Policies with regard to agriculture: i) promote public transportation; ii) utilize butane gas as a replacement of the use of wood products; iii) Use of energy -efficient lamps
Mongolia	GHG sinks	Livestock management	Limit the increase of the total number of livestock by increasing the productivity of each type of animal, especially cattle.
Morocco	GHG cuts & sinks	Cropland management	"Increase efficiency of agricultural land;" potential reduction 2025 $KtCO_2e$/year
Papua New Guinea	GHG cuts	N/A	High-level policy objectives for GHG reductions in agriculture sector of 15-27 $MtCO_2e$/year relative to BAU projections of 31 - 58 Mt CO2/year by 2030 (estimates in 2010 of 25-38 $MtCO_2e$/year)
Peru	GHG cuts & sinks	Livestock, soil and agricultural practices	Ministry of Agriculture will coordinate NAMAs implemented for GHG mitigation: 1) livestock management; 2) agricultural residue management; 3) soil and agricultural system improvement
Sierra Leone	GHG sinks	Sustainable land management and agroforestry	Introducing conservation farming and promoting the use of other sustainable agricultural practices e.g. Agroforestry
	GHG cuts	Bio energy	Developing agricultural waste incineration programmes for energy production
Togo	GHG cuts	Efficiency	"i) Reduction of energy consumption by use of common transportation; ii) use of gas as a replacement to fuel; iii) Replacing non-energy efficient lamps with energy-efficient ones"

Tunisia	GHG cuts & sinks	Sustainable land management and efficiency	i) Expand "biological farming" to 500,000 hectares by 2014; ii) Upgrade farms to "international standards" and promote water-saving irrigation on ≥ 200,000 hectares vs. 120,000 hectares in 2009; iii) Support brackish water desalinization of treated wastewater for agriculture using recycling and efficient technologies