Agriculture and Climate Change Policy Brief

Main Issues for UNFCCC and Beyond

Meridian Institute
Connecting People to Solve Problems

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Contents

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Bruce Campbell, Consultative Group on International Agricultural Research (CGIAR) Research Program on Climate Change, Agriculture and Food Security

Wendy Mann, Food and Agriculture Organization of the United Nations (retired)

Ricardo Meléndez-Ortiz, International Centre for Trade and Sustainable Development

Charlotte Streck, Climate Focus (lead author)

Timm Tennigkeit, UNIQUE

Sonja Vermeulen, CGIAR Research Program on Climate Change, Agriculture and Food Security

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Acronyms and Abbreviations

CDM	clean development mechanism
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COP	Conference of Parties to the UNFCCC
CTCN	Climate Technology Centre and Network
FAO	Food and Agriculture Organization of the United Nations
GCF	Green Climate Fund
GDP	gross domestic product
GHG	greenhouse gas
Gt	gigaton
IPCC	Intergovernmental Panel on Climate Change
LULUCF	land use, land-use change and forestry
MRV	measurement, reporting, and verification
NAMAs	nationally appropriate mitigation actions
NAPAs	national adaptation programs of action
ODA	official development assistance
REDD+	reducing emissions from deforestation; reducing emissions from forest degradation; conservation of forest carbon stocks; sustainable management of forests; enhancement of forest carbon stocks
TEC	Technology Executive Committee
UNFCCC	United Nations Framework Convention on Climate Change
WTO	World Trade Organization

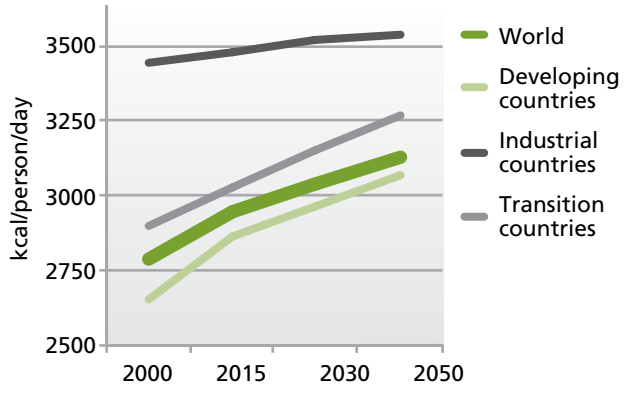
1. Introduction

This summary is a condensed version of the June 2011 *Agriculture and Climate Change: A Scoping Report*[i] developed by a team of expert authors, in consultation with UN Framework Convention on Climate Change (UNFCCC) negotiators and other key stakeholders, and facilitated by Meridian Institute. The aim of that report was to provide independent, objective analysis on many complex issues related to agriculture and climate change. This summary provides key points for policymakers, focusing on the unique aspects of agriculture when considered in the context of climate change. It recommends actions that can be taken when considering agriculture's multiple objectives, from providing adequate food for growing populations to protecting the environment, and ensuring resilience to future climatic change. Finally, it briefly describes needs related to finance, technology, and capacity building; options for measuring mitigation and adaptation activities; and trade dimensions.

2. Why is Agriculture Special?

Agriculture is essential for food security and income generation. It also affects critical ecosystem services. The impacts of long-term climatic changes will have significant repercussions for agriculture,[2] requiring adaptation of agricultural systems over time. And finally, agriculture has significant potential to contribute to greenhouse gas (GHG) mitigation.

Figure 1. Per capita food Consumption



By 2050, people will be eating 60 percent more food, increasing the demand for, and prices of, agricultural products. Source: FAO, 2006[1]

[i] The full report can be found at: http://www.climate-agriculture.org/en/The_Report.aspx

These multiple contributions and unique features suggest **that agriculture would benefit from distinct treatment in the context of the UN Framework Convention on Climate Change** (UNFCCC or Convention) **and from a unified approach rather than separate treatment in UNFCCC negotiating streams**, such as adaptation, mitigation, finance, technology, capacity building, or reducing emissions from deforestation (REDD+[ii]).[iii]

Factors that make agriculture special

Contribution to basic needs of people. The increase of the world's population to 9 billion people by 2050,[3] the rise in caloric intake[4] and increasing demand for commodities will put new pressure on land in the coming decades. Agriculture is the number one provider of livelihoods in many developing countries—contributing on average 29 percent of gross domestic product (GDP) and 65 percent of employment.[5]

Highly site- and context-specific. Different economic and climatic conditions, ecosystems, cultures, and customs need site-specific agricultural systems and practices. Defining global indices for climate vulnerability, or expressing mitigation potential in marginal abatement cost curves, is particularly challenging for this sector.

Complex interactions among adaptation, food security, mitigation, and trade. Climate change is expected to exacerbate traditional vulnerabilities, and the geographic distribution of its impacts will likely alter food production and prices in different regions leading to changes in global trade flows. Some mitigation actions in agriculture could also affect the distribution and availability of food in

[ii] REDD+ is reducing emissions from deforestation; reducing emissions from forest degradation; conservation of forest carbon stocks; sustainable management of forests; enhancement of forest carbon stocks

[iii] As of October 2011, many country representatives—including a number of African ministers responsible for agriculture—have called for a separate agriculture work program under the UNFCCC that addresses both adaptation and mitigation.

the world market. At the same time, countries will need to balance options between production and imports to meet increased demand for food and to reduce poverty. Finally, agriculture is one of the principal drivers of deforestation in developing countries—the second largest source of global GHG emissions. All these interactions lead to difficult policy choices and the need to understand and balance trade-offs.

Adaptation measures are essential. To meet increased demand for food, agricultural production must grow, almost inevitably leading to increases in GHG emissions. With food security at stake, many see this trade-off as necessary and one that should not be altered in favor of increased mitigation.

Mitigation potential predominantly in sequestration of carbon. Studies estimate that up to 89 percent of the mitigation potential in the agricultural sector by 2030 could be achieved through soil carbon sequestration,[6] although there is still contention over how much is ultimately feasible. Worldwide agricultural production offers considerable mitigation possibilities: an estimated potential of 5.5–6 gigatons (Gt) of CO_2 equivalent (CO_2e) per year, almost equal to its current total annual emissions of 5.1–6.1 Gt CO_2e.

Despite the many challenges, the agricultural sector has great potential for synergies among the objectives of adaptation, food security, poverty reduction, and mitigation. How to maximize synergies and minimize trade-offs is an increasingly pressing challenge that a number of stakeholders, from policymakers to farmers, are being called upon to address.

Agriculture: IPCC's Fourth Assessment Report

In this report, the term "agriculture," includes the activities and practices in the agriculture section of Working Group III's contribution to the IPCC's Fourth Assessment Report:[7] cropland management; grazing land management/pasture improvement; management of agricultural organic soils; restoration of degraded lands; livestock management; manure/biosolid management; and bioenergy production. These practices can result in the following GHG emissions:

- CH_4 from enteric fermentation
- CH_4 from rice production
- N_2O emissions from soils
- N_2O and CH_4 from manure management
- N_2O and CH_4 from biomass burning
- CO_2 emissions and removals in agricultural soils

3. Agricultural Production, Food Security, and Climate Change

Policy objectives for agriculture are multifaceted in most countries, and many developing countries will prioritize food security.[iv] For this reason, there is benefit in a robust exchange between international deliberations on food security and climate change. This exchange could increase the likelihood that climate change actions ensure the availability and accessibility of food, and that food security interventions take full account of climate change impacts and options.

Food Production and Climate Change Adaptation

Adaptation policies should increase the resilience of farming and food systems to climate change impacts while maintaining or increasing food production. In Sub-Saharan Africa and Asia, 56 percent and 21 percent of crops, respectively, are expected to be negatively affected by climate change by 2050.[8] Better postharvest storage and distribution of food can ameliorate the gap between good and poor years. Easterling et al.[9] describe a range of adaptation options in agriculture:

- Use of different varieties or species

[iv] The globally accepted definition of food security, agreed at the 1996 World Food Summit, is that "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

- New cropping practices; for example, timing of planting
- Greater use of water conservation and management technologies
- Diversification of on-farm activities
- Enhancement of agrobiodiversity
- Adapted livestock and pasture management
- Improved management of pests, diseases, and weeds
- Better use of short-term and seasonal climate forecasting to reduce production risks

Adaptation measures will be locally specific, and should be considered throughout the food chain. Many of the projected impacts of climate change are amplifications of the challenges that climate variability already imposes on agriculture. Thus, because farmers have generations of experience in managing climatic risks, interventions can build on current practices and technologies. However, these interventions should be coupled with new strategies that build preparedness for long-term climatic shifts.

Investments in infrastructure, extension services, and research are critical.[10] New understandings of agriculture, such as appraisals of how trends in retail and consumption patterns affect food security, could effectively help direct investments, for example, in irrigation or rural infrastructure. The most successful interventions will be those that support the multiple ways in which food systems contribute to livelihoods, incomes, food security and, in some countries, overall GDP.

Food Production and Climate Change Mitigation

Mitigation in agriculture should be achieved without compromising food security. Increasing food production will often lead to more agricultural emissions. However, substantial mitigation can be achieved, including, in some cases, absolute reductions in GHG emissions, through greater efficiency in production as well as removals through sequestration in agricultural soils and biomass.

Many options can simultaneously increase food productivity and reduce emissions per unit of output. The potential for synergies between actions that promote both mitigation and food security are particularly high for specific practices, including: adopting improved crop varieties, breeding livestock to increase sustainable productivity of meat or milk while improving animal welfare, avoiding bare fallow land and changing crop rotations to incorporate food-producing cover crops and legumes, adopting precision fertilizer management, improving forage quality and quantity on pastures, expanding energy-efficient and precision irrigation, as well as water conservation techniques, and implementing agroforestry that does not take significant amounts of land out of food production.

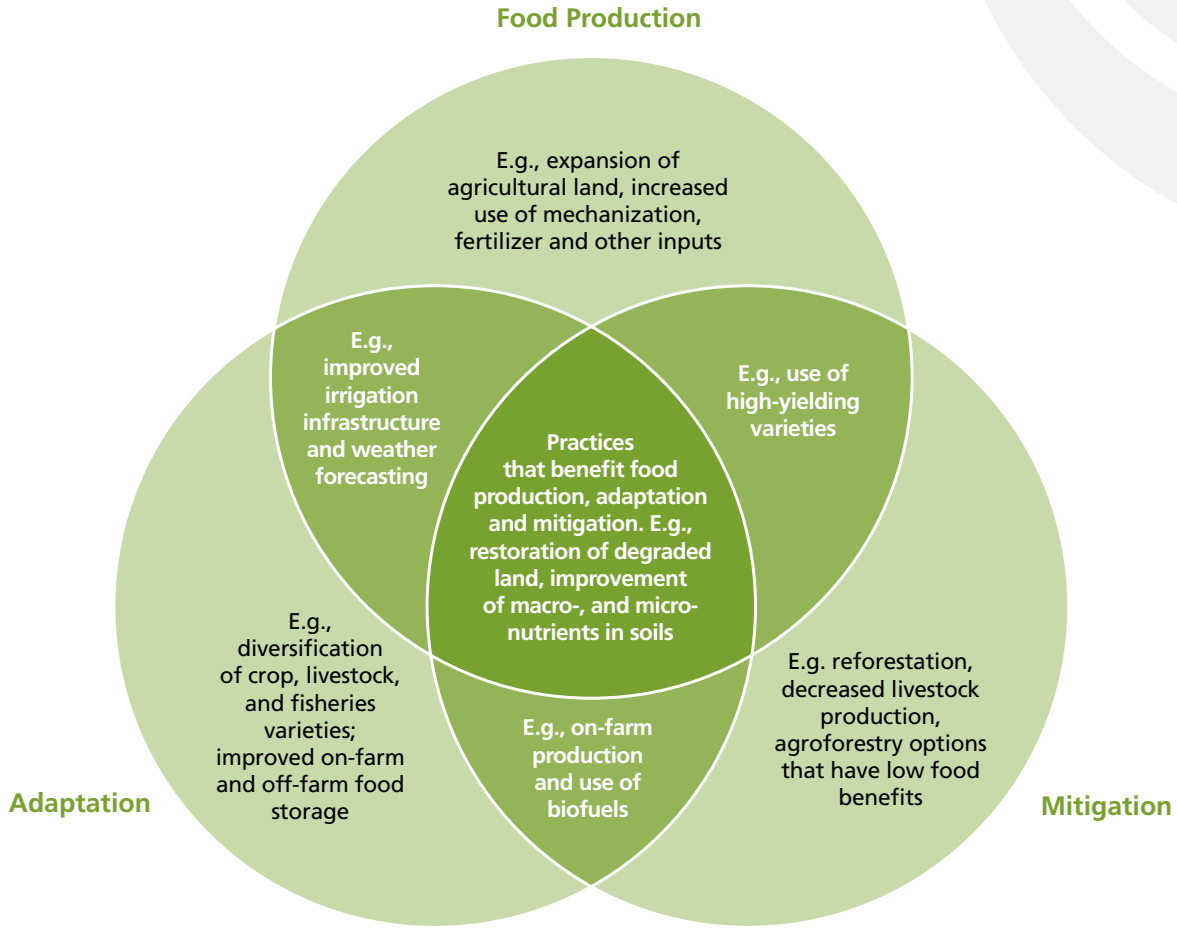
Mitigation options in agriculture need to be locally appropriate and placed within a holistic approach to land management. For example, there may not be a net mitigation effect if greater on-farm efficiency displaces emissions to other parts of the landscape or food chain. Some of the biggest mitigation potential may lie in reducing the expansion of agriculture into forests[11] which suggests a need for close coordination among incentive mechanisms for forest protection, such as those for REDD+, with improved agricultural practice.

Synergies and Trade-Offs: Food Production, Adaptation, and Mitigation

Agriculture offers a wealth of opportunities to deliver simultaneously on food production, adaptation, and mitigation. Figure 2 shows a few possible trade-offs and synergies among these three objectives.

These opportunities can also benefit wider environmental services, farming incomes, and food security. Many of these options use low-tech good practices that are already available and affordable. These opportunities include activities such as soil and shade management and increasing the diversity of crop rotations.[12]

Figure 2. Trade-offs and Synergies among Food Production, Adaptation, and Mitigation



Interactions are complex, may involve trade-offs, and need to be tailored to specific contexts. Some mitigation actions can have negative impacts on food security and the adaptive capacity of farming systems; for example, the removal of crop residues for small-scale biogas systems can reduce the availability of feed and deplete soil organic matter. Some adaptation strategies employed by farmers may also increase GHG emissions. These trade-offs point to the critical need to look across different land uses at a larger scale (e.g., landscape, watershed, agroecological region).

A wealth of **recent recommendations suggest an integrated approach to land management for the multiple dimensions of agriculture** (e.g., affordable food, jobs, environmental services) and stewardship of nutrients, energy, and water cycles at the levels of landscapes and farms. Terms such as "sustainable agriculture," "conservation agriculture," "organic agriculture," "eco-efficient agriculture," and "agro-ecology"[13] may differ in specifics, but all advocate this holistic approach.

> *A more recent term that is inclusive of climate change is "climate-smart agriculture," which seeks to maximize benefits and minimize negative trade-offs across the multiple objectives that agriculture is being called on to address: food security, development, climate change adaptation, and mitigation. Key elements include increasing productivity and the resilience of agricultural systems, reducing GHG emissions or enhancing sequestration, and managing interfaces with other land uses.*

Finally, **appropriate incentives, governance, institutions, and funding mechanisms will be needed to deliver multiple objectives**. A mix of instruments and governance arrangements that include positive incentives, safeguards, and regulations will be needed. Enabling means such as finance, technology, capacity building and measurement of results are all important to achieving the various objectives expected from agriculture.

4. Early Action Opportunities in Agriculture

While international negotiations continue within the UNFCCC, **countries can lead with "early action" that increases capacity, confidence, and knowledge to achieve multiple objectives in agriculture.** There is no blueprint for early action and the specific contexts of countries and communities need to shape the activities chosen. Some countries may prioritize adaptation (due to country-specific vulnerabilities), food security (due to chronic food deficits), or productivity increases (required for livelihoods and economic growth), while others may focus on contributing to mitigation. Several possible early action policies and measures are suggested below that countries may wish to pursue.

Building an Evidence Base: Informing Country-Specific Actions

Countries are often obliged to take urgent and difficult policy decisions based on insufficient evidence. Narrowing knowledge and data gaps through the collection, analysis, and modeling of information can inform policies and strategies with the best possible scientific evidence. Reliable information can help countries make strategic choices that maximize benefits and minimize trade-offs related to adaptation, mitigation, and food security. Options for collecting and analyzing information and data could include:

- Assessment of adaptation and food security needs, and the mitigation potential of agriculture
- Identification of practices with synergies among food security, adaptation, and mitigation
- Analysis of household-level and institutional constraints that need to be addressed in managing trade-offs
- Development of weather, crop, and pest/disease forecasting and mechanisms for data collection as well as delivery of relevant information to farmers
- Strengthening national agriculture research systems and mainstreaming climate change into existing agricultural research programs

Designing National Policies to Enable Adoption of Practices

Policies to address constraints (e.g., lack of secure land tenure, transaction costs, lack of capital to innovate) to adoption of climate-smart practices will be needed. Such policies could include both incentives and regulatory measures such as:

- Identification of barriers to the uptake of climate-smart practices by farmers—such as risk aversion, lack of collateral, or land tenure issues—and how to address them
- Identification of policy options and incentives that enable adoption of climate-smart practices, and possible measures to ensure implementation

Designing Coherent and Coordinated National Policies

Countries will have to address competition for land (and other natural resources) driven by increasing demands for food, fuel, and carbon storage. Integrated approaches for land-use planning are in their infancy, but are of increasing relevance as countries look for ways to meet multiple goals, such as to increase food and bioenergy production while reducing deforestation. Better aligned policies could help overcome policy fragmentation

and encourage more coordinated action required for synergy building and management of difficult trade-offs.[14] Concrete steps might include:

- Reviewing existing national policies and frameworks related to agricultural sector development, poverty reduction, food security, and climate change (mitigation, adaptation, bioenergy and REDD+) to see how they can be better integrated
- Building the capacity of policy makers and planners to formulate and coordinate coherent agriculture-related policies across multiple policy areas, and across multiple ministries, including the use of integrated land-use planning, landscape and ecosystem approaches, and scenario simulation for different policy choices

Developing Supportive National Institutional Arrangements

Agriculture involves multiple objectives that cut across separate institutions at national and international levels. Developing innovative institutional arrangements that facilitate communication and integration across entities and with key stakeholders can contribute to improved coordination and integration of capacity across institutions. Options for developing supportive national arrangements could include:

- Reviewing existing institutions and analyzing the potential for greater integration
- Strengthening agricultural extension and research systems to help link farmers with information, inputs, and incentive and payment schemes
- Creating, designating, or integrating national and regional knowledge networks or platforms for the dissemination of climate-smart agricultural practices and technologies

Accessing Financing and Investment

Early action can improve understanding of the feasibility of agricultural programs, costs of measuring results, and effectiveness of different financing options. Such knowledge can help inform the creation of future mechanisms, such as the Green Climate Fund (GCF), promote agriculture's eligibility for climate financing, and ensure its specificities are taken into account for effective allocation of resources.

Multiple sources of finance, and coordination among them, will be necessary to mobilize the scale and effectiveness of finance required to meet the challenges of agricultural production and climate change. Countries should integrate domestic and international sources of public finance for mitigation, adaptation, food security, and development and achieve synergies with private sector investments—while taking into account stakeholders, such as smallholder farmers, with limited capital and capacity.

Early actions that will help countries mobilize finance could include:

- Strengthening or formulating national policies on investment and financing that ensure access to financing for agriculture, including prioritizing agriculture sector development
- Identifying financing streams that might be optimally combined to give greater flexibility and provide needed resource levels for relevant activities in the agriculture sector
- Strengthening national financial institutions, including, where relevant, national funds, that reward synergies across agricultural adaptation and mitigation and food security
- Exploring the possibility of new business models for adaptation and mitigation
- Conducting cost-benefit analysis of candidate financing delivery mechanisms and related policies that reach farmers (payments for ecosystem services, index insurance, safety nets)
- Designing financing that addresses delayed returns on investment and addresses the loss of income over the short term
- Improving national systems for data collection and monitoring, including GHG emissions

National Strategies and Implementation Frameworks

Countries could develop strategies for agricultural transformation. The strategy could be stand-alone, or integrated into existing agriculture sector, food security, REDD+ or economic development frameworks. Such strategies could draw on work undertaken to build an evidence base of best practices as well as barriers to their adoption; policies to overcome these barriers and promote integrated approaches; institution-strengthening to enable greater coordination across entities dealing with food security, development, and climate change; and formal and innovative ways of linking finance and agriculture.

Building a national strategy might also include:

- Costing, prioritizing, and sequencing implementation of promising agricultural practices and policies
- Identifying the potential and modalities for synergies across agricultural adaptation, mitigation, and food security in the agriculture sector
- Identifying other enabling conditions (e.g., capacity building, technology transfer)
- Monitoring and measuring results
- Drawing on broad stakeholder consultation

Demonstration Activities

Demonstration activities could provide opportunities for learning by doing. Activities would be highly dependent on country contexts, thus it is difficult to identify a generic list of options. Categorization or typologies of activities may also not be useful because holistic or integrative approaches are needed to capture synergies across different policy areas and institutions.

5. Finance, Technology, and Capacity Building

Finance, technology, and capacity are essential to enable effective adaptation and to motivate emission reductions from the agricultural sector. Adopting new agricultural practices requires access to new technologies; modification of existing ones; and additional capacity at the farm, policy, and scientific levels to implement such measures.

Finance

Population growth, higher incomes leading to demand for more resource-intensive foods, and surging bioenergy demand are likely to lead to an increase in demand for agricultural products in the foreseeable future.

Significant new investments will be required to meet projected agricultural demand. The Food and Agriculture Organization of the United Nations (FAO) estimates investment needs of US$9.2 trillion by midcentury (US$210 billion annually from 2005 – 2050).[15] Asia accounts for the largest part of global investment needs (57 percent); China and India alone account for some 40 percent. Latin America would absorb about 20 percent and Sub-Saharan Africa and the Near East and North Africa region account for the remaining 23 percent.[16]

The majority of agricultural capital needs is likely to be covered by private domestic sources.[17] About 70 percent of agricultural finance comes from the private sector.[v] Capital flowing into the farmland and agricultural infrastructure is expected to grow two to three times beyond the current level (US$28 – 42 billion annually) within five years, and as high as US$150 billion beyond 2015.[18]

Public sector finance is smaller, but still an important component of agricultural finance. Public spending on agriculture can be as low as 4 percent

[v] The most recent FAO estimates are that about 30 percent of total agricultural investments come from the public sector, while private investment accounts for 70 percent. Schmidthuber *et al. 2009.*

in agriculture-based countries with a high share of agricultural GDP.[19] However, the public sector plays a role in financing agricultural research and development[20] and also in helping to link, pool, and promote private investment flows.[21] In addition, the share of agriculture in official development assistance (ODA) was about 6 percent in 2009, and rising.[22] FAO estimates that in developing countries through 2050, about US$60 billion of the US$210 billion estimated to be needed annually may be provided by public sources, both foreign and domestic, for rural infrastructure, knowledge generation, support services, and ensuring access to food and markets.[23]

Public funds should be used strategically to remove investment barriers and facilitate private investment. Although international climate finance is likely to be scaled up in the future, it is unlikely to address the full investment needs for adaptation and mitigation in developing countries. Public funds should therefore focus on creating an appropriate investment environment for, and leveraging, private capital.

Financing for Agriculture under the Convention

New and emerging mechanisms under the UNFCCC and its Kyoto Protocol, such as an expanded clean development mechanism (CDM) and funding for national adaptation programmes of action (NAPAs) and nationally appropriate mitigation actions (NAMAs), may help countries, in the short term, access financing for mitigation and adaptation. Under the 2010 Cancun Agreements, developed countries committed to provide new and additional resources approaching US$30 billion for the period 2010–2012 and to mobilize US$100 billion annually by 2020.[24]

However, agriculture will compete with other sectors for limited funds. There is significant uncertainty about how the precise finance channels and mechanisms could evolve. The current incentive frameworks do not appear to take into account the special characteristics of the agricultural sector, and, therefore, may fail to provide appropriate support and incentives. Thus, it is important to engage in the development of new mechanisms and the reform of existing ones. For agricultural adaptation and mitigation activities, the following climate financing channels are relevant:

The Global Environment Facility (GEF) Trust Fund. The GEF operates the current financial mechanism of the Convention and is one of the largest sources of grant-based finance for mitigation. For the period 2010–2014, a total of US$4.25 billion has been pledged, of which about US$1.35 billion is expected to be delivered to mitigation projects.[25]

UNFCCC and Kyoto Protocol linked funds. The GEF also operates two other funds under the Convention: the Special Climate Change Fund, which focuses mainly on adaptation, and the Least Developed Countries Fund, for preparing and implementing NAPAs. Both funds provide adaptation funding for agriculture-related projects. Under the Kyoto Protocol, the Adaptation Fund supports projects and programs in developing countries and is financed through a 2 percent levy on the share of proceeds from CDM project activities. Most of the projects accepted and proposed for funding to date have agriculture as a component.[26]

The Green Climate Fund. The Cancun Agreements established the GCF as a new financial mechanism under the Convention, expected to scale up finance. However, it remains unclear where its resources will come from and how much time it will take to begin operations and then start receiving and channelling funds to developing countries.

A reformed Clean Development Mechanism. The current CDM excludes opportunities to enhance soil carbon stocks through cropland or rangeland management. However, its scope may increase in the context of a review of the Kyoto Protocol.

Developing-Country NAMAs. Although there is no clear definition of the term yet, NAMAs are generally interpreted as voluntary mitigation actions by developing countries. So far, NAMAs appear to comprise a diverse set of activities, from capacity building to conventional command-and-control regulations and include sectoral and nonsectoral emissions trading schemes.

Reduced emissions from deforestation and forest degradation (REDD+). Support for REDD+ is likely to finance a range of activities including spatial and land-use planning, land tenure, and tackling drivers of deforestation, including agriculture.

Technology Development and Transfer

Technology development and diffusion can support a change in agricultural practices toward more sustainable activities. Concerns about mitigation and adaptation to climate change are generating new research and innovation priorities in agriculture. In the context of agriculture, "technologies" includes new varieties and practices, such as soil management, water harvesting, irrigation, fertilizer application, and ploughing. Table 1 shows examples of technology needs identified by developing countries.[27]

Impediments to the diffusion of technologies need to be identified and overcome. The most binding constraints often occur at the adoption stage. Poorly functioning input and output markets, weak local institutions and infrastructure, or inadequate extension systems, or missing credit and insurance markets can prevent smallholders from accessing and using new technologies and practices.[28]

Technology Development and Transfer under the Convention

In the Cancun Agreements, Parties decided to create a Technology Mechanism to accelerate the development and transfer of climate-friendly technologies, especially to developing countries, to support action on climate mitigation and adaptation.[29] The Technology Mechanism will consists of two bodies: (1) the Technology Executive Committee (TEC) which will make recommendations on technological needs; and (2) the Climate Technology Centre and Network (CTCN), the operational arm that will provide services to developing countries and facilitate a network of national, regional, sectoral, and international technology centers.

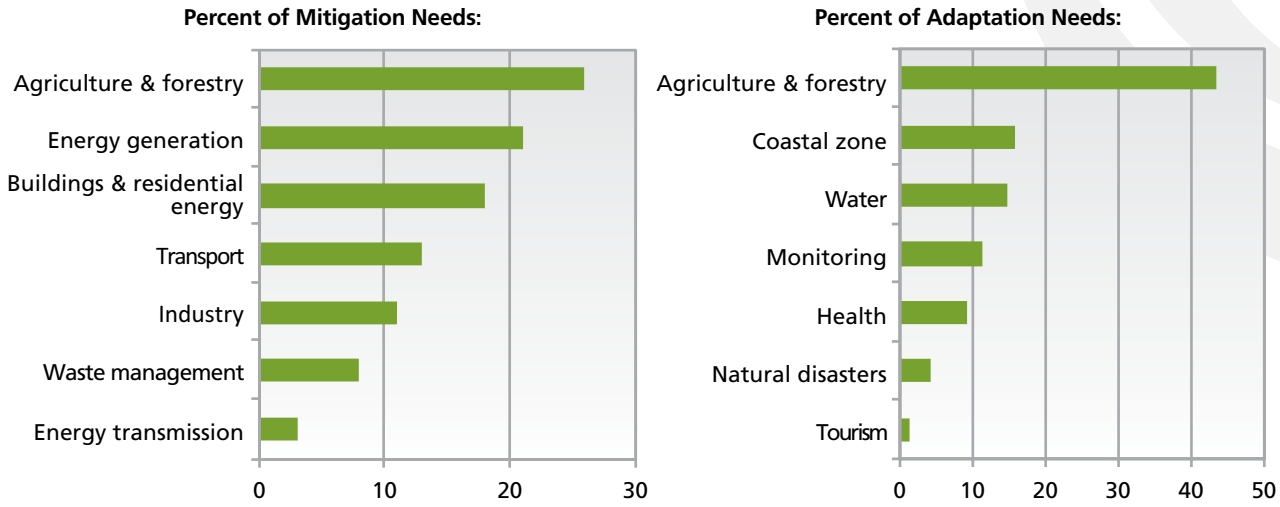
There is ample scope for including agriculture in the Technology Mechanism's priorities and activities. The specifics on how the TEC and CTCN should operate, what their priorities should

Table 1. Technology Needs Identified by Developing Countries

Examples of Technology Needs for Mitigation in Agriculture	Examples of Technology Needs for Adaptation in Agriculture
• Crop waste gasification • Improved cultivation methods • Production/management of soil nutrients • Rational application of fertilizer • Drip irrigation • Biodigesters (manure management) • Solar (photovoltaic) and wind water pumps • Solar energy for processing agricultural products • Modification of livestock feed	• Tolerant/resistant crop varieties • Efficient water use and improved irrigation systems • Low-density planting, adjustment of sowing dates and crop rotation • Improved drainage • Integrated pest management • Sustainable grazing and herd management • Heat-tolerant livestock breeds • Networks of early warning systems

Source: UNFCCC 2009[27]

Figure 3. Needs Identified by Developing Countries



According to 70 Technology Needs Assessments by developing countries, agriculture and forestry were the most important sectors identified for both mitigation and adaptation. Source: UNFCCC 2009

be or how their activities are funded are yet to be determined and no specific sectors are mentioned in the mandate of the mechanism. However, they could play a key role in promoting innovation and technology diffusion. In this regard, the national Technology Needs Assessments (TNAs) undertaken by developing countries are a valuable source of information (see Figure 3).[30]

Harnessing the potential of the Technology Mechanism to support the development and deployment of technology for agriculture will require the active engagement of negotiators. This engagement could be aided by mapping possible options and points of intervention in current discussions about the operationalization and institutional set-up of the mechanism.

Capacity Building and Institutional Strengthening

Weak institutional structures, unavailability of finance and insurance, insecurity of land tenure, limited access to markets and basic services, and the absence of capable local research institutions are barriers to the deployment and uptake of agricultural practices and technologies. Capacity building and institutional strengthening are essential to enable farmers, communities, institutions, and other entities to make effective use of available knowledge, resources, and technologies to successfully respond to the challenges facing agriculture, particularly in a changing climate.

The foundation for building adaptive capacity in agriculture for climate change is better knowledge. Relevant knowledge includes the likely impacts of, and vulnerabilities to, climate change and weather events at local scales. Creative ways of improving knowledge management may include: regional knowledge management networks; enhanced use of cell phones for receiving relevant weather forecasts; and farmer field schools that involve farmer-to-farmer exchanges.

Institutional, financial, and technical support will also be required. This support includes creating legal and policy frameworks that ensure access and provide secure tenure to resources and land, protect water-use rights, allow brokering of long-term contractual arrangements, and support commercial out-grower schemes and farmer cooperatives.[31] Investments in agricultural infrastructure to expand farmers' access to markets are also essential. Farmers also need access to, and awareness of, opportunities for financial support, including

credit and insurance markets. Once they have access to such finance, they need the capacity to use it efficiently and allocate it equitably within the community to enhance stakeholder trust, and sense of ownership.[32]

The capacity and coordination of national and local institutions, such as agricultural ministries and research institutes, must also be enhanced. Increasing the capacities of policy-makers to better align policies across multiple policy areas and coordinate horizontally across national government entities and vertically from local to national levels could help produce multiple win solutions. An exchange of information and training among research institutions and policy-makers and among policy makers of developing and/or developed countries can be a tool for policy and program development that supports the above-mentioned needs.[33]

Agricultural research and extension services need greater capacity to enable responses to climate change and, in particular, to provide support to small-scale farmers. Improving agricultural extension requires adequate funding, staffing levels, and expertise in climate and agricultural science relevant to the local context, as well as in trade, economics, and political science. Developing such capacities could lead to better coherence among poverty alleviation, market orientation, food security, and climate change goals being pursued in rural development.[34] Support to farmers might include improved climate and weather services, innovative extensions systems, and learning-by-doing programs.

6. Performance and Benefits Measurement

Measuring the performance of activities in the agriculture sector can be beneficial to countries. Table 2 offers several examples of such benefits, including: generating knowledge, supporting learning, tracking progress, and ensuring accountability.

Measuring Adaptation

Assessing progress toward adaptation is essential to identify and prioritize the most effective actions.[35] However**, measurement of adaptation benefits is complex and there is no consensus on indicators, frameworks, or methods**. Under the UNFCCC,

Table 2. Benefits from Measuring Performance

Generating knowledge	• Identify and share best practices among countries • Create and share knowledge on the impacts of interventions • Increase understanding of context-specific outcomes and impacts
Supporting learning	• Help identify new potential mitigation and adaptation actions • Enhance action by providing an opportunity for expert inputs • Create credibility and trust in collective action • Enable comparisons among countries and sectors
Tracking progress	• Enable transparent party-specific and collective-action progress • Inform implementation status of specific actions
Ensuring accountability	• Ensure support is provided • Link developing-country actions to support • Assess compliance with domestic or international targets • Ensure effectiveness of program or project expenditures

reporting on vulnerability and adaptation is required in national communications, in relation to NAPAs, and in the operations of the Adaptation Fund. Donors and international organizations often use results-based frameworks[36] to track progress and to ensure accountability for the use of funds. However, despite their wide use, little systematic analysis of these practices has been conducted.

Better coordination among different sources of funding and national agencies, and a single-impact monitoring framework would increase efficiency. For most countries, funding for adaptation in the agricultural sector is likely to derive from several sources, including national, bilateral, or multilateral funding, each with its own specific monitoring and reporting requirements. Coordinated monitoring and reporting can be facilitated by inter-ministerial coordination and by integration of adaptation actions into national and sectoral development plans.

Countries would benefit from guidance from international institutions to develop internationally comparable, standardized national reporting systems. Such guidance would lower costs and enable comparison for learning and improving the effectiveness of adaptation activities over time. An internationally comparable system, which accounts for wide differences among country adaptation needs and options, could also potentially increase the efficiency of adaptation funding.

Finally, adaptation measurement and reporting systems could increase accountability through greater participation of local stakeholders in defining how measurement and reporting systems can meet diverse stakeholders' information and learning needs.[37]

Measurement, Reporting, and Verification (MRV) for Mitigation in Agriculture

Approaches to measure mitigation impacts in agriculture already exist in IPCC inventory guidelines. IPCC Guidelines and Good Practice Guidance for Uncertainty Management and for land use, land-use change and forestry (LULUCF) provide internationally agreed methods for estimating and reporting on carbon stock changes and GHG emissions from agriculture and other land uses at the national level and performing uncertainty assessments, and offers quality assurance and quality control procedures.

Although IPCC guidelines were developed for national GHG inventory reporting, they also inform approaches at the project or program level. For many of the agricultural NAMAs submitted by developing countries, GHG emissions can be quantified using existing IPCC guidelines. Others may require different approaches. In either case, existing protocols can provide guidance on practical methods for estimating GHG emissions.

GHG estimates are hampered by inherent variability, a lack of available data, and limited capacities for measurement. Almost all countries have a wide range of uncertainty in their agriculture and land- use GHG inventory.[38] Even developed countries that have elected to account for cropland and grazing land emissions in the Kyoto Protocol have uncertainties ranging between 13 and 100 percent.[39]

More investment in agricultural monitoring and evaluation capacity and research activities to improve GHG data availability is required. Both developing and developed countries need to continuously improve estimates of agricultural emissions.

Emerging Issues Relevant to the Convention

The Cancun Agreements[40] suggest that, for developing countries, both domestic and internationally supported mitigation actions need to be measured in accordance with guidelines to be developed under the Convention. These guidelines will have implications for the ability of agricultural activities to be accounted for, and to access finance.

MRV guidelines for mitigation actions need to take into account capacities while encouraging continuous improvement in data. Given the lack of sufficient GHG data in the agriculture sector, and large variability in capacities for measurement, requirements imposed by MRV guidelines may affect access to mitigation finance as well as scaled-up adoption of agricultural mitigation options.

Improved measurement will require increased availability of data and investment in targeted research on agricultural GHG emissions. There are a number of initiatives[41] to help developing countries establish national inventory systems, improve their national inventory estimates, and enhance research on agricultural emission factors. Developed countries are also continuously improving their emission estimates and methods for agricultural emissions measurement. Finally, research on cost-effective approaches will be key for smallholders to scale-up adoption of mitigation practices.

Given the need for increased food production in the future, MRV guidelines could consider efficiency-accounting approaches that incentivize increased food output while reducing the intensity of GHG emissions per unit output. Current IPCC guidelines are not fully compatible with such an accounting approach, and standards for life-cycle analysis for many food products still need to be developed. However, considering the need to further food production to meet current and future food security goals, efficiency accounting may be more suited to reflecting emissions while allowing for growth in food production.

Development of safeguard measures or screening tools that ensure synergies among adaptation, ecosystem services, and socio-economic goals can help promote co-benefits. Screening tools and safeguards could be used to guide international support and national agricultural agencies' decision-making processes. The agricultural sector could review lessons learned from REDD+, where social and environmental issues have been addressed in international negotiations and in multilateral processes,[42] and develop agriculture-specific safeguards.

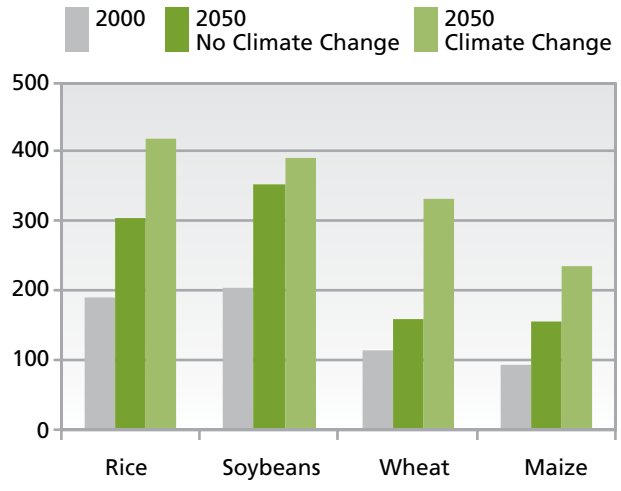
7. Trade

Climate change will affect comparative advantages in agriculture, and trade patterns are likely to alter as a result of changing yields and prices. Yet the complexities of the interface between trade and climate change have not been comprehensively dealt with—let alone resolved.

Climate change will alter crop yields and animal productivity and ultimately affect the trade flows of agricultural products. Figure 4 compares world prices in 2000 to two scenarios for 2050 (at constant US$2000 /ton), first without considering climate change and then under a scenario that includes the impacts of climate change.[43] In the absence of climate change, prices are expected to increase significantly as population and income growth surpass agricultural production. Climate change will further exacerbate this trend. For example, in 2050, wheat prices would be about twice as high in the scenario without climate change, and maize prices more than 50 percent higher than in 2000.

Developing countries' agricultural imports are expected to double due to climate change impacts on prices and production. This doubling would be mirrored by a similar increase in developed-country exports. These changes will affect individual countries differently. For example,

Figure 4. World Prices Predicted for 2050, with and without Climate Change



Source: FAO 2010[44]

whereas South Asia was a net exporter of cereals in 2000, it is projected to become a net importer under a no climate change scenario in 2050.

From a food accessibility and availability perspective, agricultural trade offers the potential to balance productivity losses and offset shifts in production patterns. Improved market access for exports could enhance capacities to respond to climate-change-induced productivity declines. This improved access needs to be combined with increased investment in agricultural infrastructure and production, particularly in developing countries where farm productivity has remained low, and measures in all countries to reduce trade-distorting policies such as implicit and explicit taxation or export subsidies.

Concerns have been expressed regarding how measures to reduce agricultural emissions could affect trade performance or accessibility and availability of food. In particular, countries that rely on agricultural imports have raised concerns regarding the consequences of mitigation measures taken by their trading partners. Similarly, countries considering emission reductions in agriculture are concerned about losing competitiveness vis-à-vis foreign providers as a result of more stringent domestic environmental regulations. Unless these countries manage to reduce their emissions without affecting production, they will have to make difficult trade-offs between mitigation and export revenues.

Finally, some climate change mitigation measures may affect trade patterns or pose challenges to existing trade agreements. For example, depending on how they are designed, carbon standards and labeling, subsidies, border tax/carbon adjustments, or free allowances in the agricultural sector could be considered discriminatory or challenged under World Trade Organization (WTO) rules.

Treatment of Trade under the UNFCCC

The Convention (Article 3.5) and Cancun Agreements, drawing from the WTO's Global Agreement on Tariffs and Trade (GATT) Article XX, state that "measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade."[45] The extent to which the UNFCCC goes beyond such language is a matter for negotiation among Parties.

Overall, good-faith climate-change policies are unlikely to breach existing multilateral trade rules, because they would not be discriminatory or because, if they are, they may be covered by the general exception under GATT Article XX.[46] That said, ensuring a supportive role of trade policy in addressing climate change and avoiding perverse interaction between existing trade and climate change frameworks could be explored, both within and outside established negotiation tracks. **Several potential options within and outside the UNFCCC are proposed in Table 3.**

Table 3. Options for Climate Change-Related Trade Measures under the UNFCCC process

Create norms on trade and climate change. For example, by agreeing on principles for the use of trade measures for climate change, which could be taken into consideration by WTO dispute procedures if a conflict arises.
Call on the WTO to address a set of critical issues at the interface between trade and climate change, encouraging the establishment of a formal discussion within the multilateral trading system.
Explore selected trade- and climate-change-related issues in the context of a work program on agriculture under the Subsidiary Body of Scientific and Technical Advice. This program could range from simple exchange of information, to methodological and conceptual aspects (e.g. design of carbon standards and regulations), to broader political concerns around the potential trade impact of policies and measures to address climate change.
Create a dedicated forum outside the formal negotiating process. This forum could follow the model provided under paragraph 93 of the Ad-hoc Working Group on Long-term Cooperative Action text of the Cancun Agreements, but with a specific focus on trade.

Other options may also be available within the WTO. For example, a dialogue process could be initiated to examine emerging policies designed to combat climate change, identify possible areas of conflict, and consider ways in which WTO rules may need to be clarified and possibly amended. Alternately, a time-limited moratorium on the use of WTO dispute settlement procedures or on the application of trade-related measures (such as border adjustments) in the context of climate change legislation could be considered while UNFCCC and WTO negotiations are underway.[47]

8. Conclusions

The impacts of climate change on agriculture have severe repercussions on economic activity, livelihoods, and food production, particularly in agriculture-dependant societies in the developing world. The resilience of agriculture to such impacts is of paramount importance to affected countries. At the same time, the agricultural sector holds significant climate change mitigation potential, through reductions of GHG emissions, enhancement of sequestration, and as a main driver of forest-related emissions. The following points reflect the main conclusions of this report:

Transformation of agriculture to meet growing demand for food provides opportunities to build synergies and manage trade-offs across the multiple objectives of food security and climate change adaptation and mitigation. Because of growing global food needs, a carbon-neutral agricultural sector may be very difficult to achieve. Thus, it may be more appropriate to focus policy interventions on meeting food security equitably by enhancing climate resilience of production and distribution systems without commensurate increases in emissions. Integrated approaches (e.g., landscape, ecosystem, and value-chain approaches) are likely to be useful in balancing multiple goals in land-use and food systems.

Lower emissions options that do not compromise development and food security goals are possible. Agriculture offers a wealth of opportunities to deliver simultaneously on improving agricultural resilience to climate change, increasing food production, and lowering emissions. Many of these opportunities use practices, technologies, and systems that are already available and affordable, but need to be tailored to specific contexts and may require incentives from climate finance to ensure adoption. Some interventions also benefit wider environmental services, farming incomes, and agriculture-based economies.

Integrated approaches will help consolidate multiple goals within broader efforts to manage land. For example, agriculture is one of the main drivers of deforestation. Curbing expansion of agriculture into forested areas will require actively addressing the complexity surrounding competing land uses, driven by increasing demands for food, fuel, carbon storage, livelihoods, economic growth, as well as the protection of forests and biodiversity.

Early action can build confidence, capacity and knowledge. Early action allows countries to take the lead in preparing for near and long-term agricultural adaptation and mitigation actions, and link these closely with national food security and broader economic development efforts, while negotiations continue in the context of the Convention. It may also provide experiences that can help shape enabling mechanisms that enhance national-level action.

Finance, technology and capacity building are essential to motivate large- scale adaptation efforts and emission reductions from the agricultural sector. Incentive frameworks under the Convention do not currently provide adequate support. Technology deployment, institutional strengthening, increased capacity building, and dedicated financial support can promote more sustainable and climate-friendly agricultural practices. The newly established Technology

Mechanism may ostensibly respond to needs identified by developing countries as set forth in National Technology Needs Assessments, of which a significant portion, thus far, relate to agriculture and forestry.

Strengthening existing agricultural monitoring and evaluation systems is essential to implementing effective climate response measures and for performance and benefit measurements. For measurement of adaptation actions, results-based frameworks and multidimensional and cross-sectoral approaches are emerging as common practice. A single adaptation monitoring framework would increase monitoring efficiency at country level. Regarding mitigation, there is a general need to improve methods and data availability for measurement, reporting, and verification of emission reductions. Where country-specific data are unavailable, IPCC emission factors can be used to highlight hotspots for targeted mitigation efforts. Finally, efficiency accounting that considers emissions per unit of output are evolving that could more directly incentivize activities that support food security.

Finally, from a food accessibility and availability perspective, agricultural trade offers the potential to balance productivity losses and offset shifts in production patterns. Climate change will affect comparative advantages in agriculture and may drive up food prices. Trade, combined with increased investment in agricultural production and local food security systems, can ensure a supply of food to world markets by counterbalancing climate-induced production decreases in certain regions. Ensuring a supportive role of trade policy in addressing climate change and avoiding perverse interaction between existing trade and climate change regulative frameworks needs to be explored at the most effective venues, including the Convention and the multilateral trading system, both within and outside of established negotiation tracks.

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Meridian Institute
1920 L Street NW, Suite 500
Washington, DC 20036 USA
Phone: +1 202-354-6440
Fax: +1 202-354-6441
www.merid.org

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