IISDREPORT

IISD Food Security and Climate Change Initiative

Encouraging a Triple Dividend in Agriculture: Increased food security, improved adaptive capacity and reduced emissions

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Preface

A critical challenge facing the world is how to feed an expected population of around 9 billion by 2050, while simultaneously reducing greenhouse gas (GHG) emissions and adapting to climate change.

The agricultural sector plays a critical role in food security, poverty reduction and economic growth—especially in developing countries, where agriculture is fundamental to sustainable development. Agricultural systems are very sensitive to changes in climatic conditions and will have to adapt if they are to ensure provision of adequate food for an increasing population. The sector is a large emitter of GHGs, responsible for around 14 per cent of global emissions, and has significant potential to sequester atmospheric carbon dioxide and reduce GHG emissions. In this respect, actions in the agricultural sector within the international climate change regime potentially can strengthen adaptive capacity and reduce GHG emissions while improving food security and enhancing rural livelihoods.

With the support of Canada's International Development Research Centre, the International Institute for Sustainable Development (IISD) launched the Food Security and Climate Change Initiative to help promote the triple dividend within the context of the United Nations Framework Convention on Climate Change (UNFCCC). IISD's research, policy and practice aims to inform the inclusion of agriculture in a future international climate change agreement in a way that encourages the triple dividend.

The series of policy reports focus on the following themes:

Agriculture and the UNFCCC Negotiations

- *Agriculture in an International Climate Change Agreement*
- *Agriculture and Climate Change: Post-Durban Issues for Negotiators*

Achieving the Triple Dividend: Perspectives on linking adaptation and mitigation in practice

- *Encouraging a Triple Dividend: Increased Food Security, Improved Adaptive Capacity and Reduced Emissions*
- *Integrating Mitigation and Adaptation in the Agricultural Sector*

Critical Issues for Agriculture Moving Forward

- *Addressing Financing for Agriculture: Ensuring a Triple Dividend for Smallholders*
- *Agriculture and Trade*

The papers are written by a team of researchers from IISD's Climate Change and Energy team. We extend thanks to our Expert Advisory Group—comprised of Mohammed Asaduzzaman, Marcelo Theoto Rocha, Brian Mantlana, Isabel Proulx, Alexandra Conliffe and Marie Boehm—whose input and direction improved the papers. The opinions and ideas expressed in these papers are those of the authors alone and do not necessarily reflect the views of those consulted.

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1.0 Introduction

Agriculture is a unique sector in the negotiations because mitigation and adaptation actions are closely linked to food security, which is a basic need for the world's population. The 1996 World Food Summit agreed 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" (World Food Summit, 1996). A successful climate change and agriculture agreement could encourage actions that put food security at the forefront, and encourage both mitigation and adaptation actions. Another important benefit is enhancement of rural life through increased incomes and improved livelihoods.

Effectively including agriculture in an international climate change agreement is important for developing countries, whose agricultural systems are most likely to be negatively impacted by climate change, and that will experience the bulk of increased food demand. But this is not exclusively an issue for developing countries. Dealing effectively with agricultural mitigation and adaptation is also important in developed countries, which will also need to adapt to a changing climate and reduce emissions in the sector. The agricultural sector is usually the second-largest source of GHG emissions in developed countries, trailing only the energy sector. GHG emissions from food production occur in all countries, and global food security can be enhanced through improved mitigation and adaptation actions in both developing and developed countries.

The stage is being set to make agriculture a success story at the seventeenth Conference of the Parties (COP 17) of the UNFCCC in Durban, South Africa in December 2011. Agriculture is discussed under "Cooperative sectoral approaches and sector-specific actions" through the Ad Hoc Working Group on Long-term Cooperative Action under the Convention. Good progress has been made over the past two years toward a common understanding on key issues, but other issues remain outstanding. As such, the negotiating text is bracketed or undecided and open to future negotiation. Agriculture is also discussed under adaptation, although the reference to agriculture and food security is in a footnote in the adaptation section of the Cancun Agreements, which many countries believe downplays the importance of the issue. Despite this uncertainty over the issue of how to include agriculture in the international climate regime, most countries agree that agriculture is an important element of climate change mitigation and adaptation.

This paper examines the triple dividend, and why it is important for an international agreement to contribute to mitigation, adaptation and food security goals. The paper examines the trade-offs and synergies between these three goals and critical issues that will need to be considered by negotiators in shaping an effective agricultural agreement.

2.0 The Elements of the Triple Dividend

An important pillar of the triple dividend is **food security**. One of the most critical challenges facing the world is how to feed an expected population of around nine billion by 2050, with most growth occurring in developing countries (UN, 2010). The Food and Agriculture Organization (FAO, 2009) has estimated that the world will need to produce at least 70 per cent more food in light of the growing impacts of climate change, and expected dietary shifts (including increased consumption of animal products).

Adaptation is of critical importance because changing climatic conditions will affect agricultural productivity, impacting crop growth and livestock performance. Negative impacts (such as volatility in production and prices because of extreme weather events) are likely to outweigh positive impacts (such as new land at high altitudes becoming suitable for cultivation). Hoffman (2011) reports that agricultural production potential in the temperate zones of North

America, Europe and Asia is likely to increase, benefiting from higher mean temperatures and longer growing seasons. Agricultural productivity in the other regions, which include most of the developing countries, is expected to decline. The Intergovernmental Panel on Climate Change (IPCC, 2007) predicts that yields from rain-fed farming in some African countries could fall by up to 50 per cent by 2020, and by up to 30 per cent in some central and South Asian countries by 2050. These changes in agricultural productivity are likely to impact agricultural trade patterns. Exports from temperate zones are likely to increase, whereas non-temperate zones will need to import more. While there are uncertainties in these predictions, many countries will be negatively impacted by climate change, and levels of agricultural production could drop or fail to keep pace with the increases in population. The extent to which adaptation occurs, such as through the development of crops and production methods adapted to new conditions, will critically influence how climate change impacts food security. Investments in research and development are especially important to improve resilience (for example, through suitable stress tolerant varieties and cropping systems) in developing countries in non-temperate zones.

Emphasis on the third pillar, **mitigation**, is needed because agriculture is a large emitter of GHGs. The Food and Agriculture Organization (FAO, 2011) reports that agriculture directly accounts for 14 per cent of global GHG emissions each year and indirectly contributes to emissions through changes in land use, especially deforestation for agricultural expansion, which accounts for an additional 17 per cent of total GHG emissions. Developing countries have experienced the most rapid increase in emissions in the agricultural sector (approximately 35 per cent between 1990 and 1998) and are responsible for three-quarters of global agricultural emissions. Developed countries collectively have shown a decrease of 12 per cent in agricultural emissions over the same period (Wright, 2010).

BOX 1: GREENHOUSE GAS EMISSIONS IN THE AGRICULTURAL SECTOR

Agricultural systems emit carbon dioxide, as well as the more powerful greenhouse gases methane and nitrous oxide. Agriculture contributes approximately 50 per cent and 60 per cent of total methane and nitrous oxide emissions, respectively. Countries report on these emissions under the UNFCCC and Kyoto Protocol (the latter being developed country compliance reporting on meeting GHG emission targets). The IPCC Guidelines for National Greenhouse Gas Inventories Reporting include two categories related to sources and sinks in the agricultural sector:

1. Agricultural emissions: methane and nitrous oxide
   - Enteric fermentation—methane is a waste product of digestion by ruminants.
   - Animal waste—methane is released from stored manure.
   - Rice cultivation—anaerobic decomposition in flooded fields produces methane.
   - Agricultural soils—directly through volatilization of gases from fields (and fertilizers) and indirectly through other pathways.
   - Prescribed burning of savannas—produces methane and nitrous oxide.
   - Field burning of agricultural residues—produces methane and nitrous oxide.
2. Land-use Change/Forestry
   - Forest and Grassland Conversion—carbon dioxide releases (which could be a result of conversion to agriculture, along with other land uses)
   - Carbon dioxide emissions and removals from soil

Agricultural emissions also occur from fertilizer production, farm machinery and irrigation usage, which are reported as energy emissions.

Source: Smith, et al. (2007); IPCC (1996)

Agriculture can play a critical mitigation role by shifting farming practices to encourage large-scale carbon sinks on agricultural land—through such actions as soil carbon sequestration and agroforestry—as well as through emissions reductions. The IPCC reports that the agricultural sector has the potential to contribute significantly to GHG emissions reductions, with potential ranges from 5 to 20 per cent of total CO_2 emissions by 2030 (Smith et al., 2007). On a global scale, grassland management, agroforestry, integrated conservation agriculture technologies, and reduced methane and nitrous oxide emissions from animal production have emerged as the strategies with the highest potentials for GHG mitigation in agriculture. Larson, Dinar and Frisbie (2011) note these actions arise because of the large areas suitable for these land uses, the high carbon density in agroforestry systems and the increased carbon sequestration capacity under conservation systems. Other promising options include improved fertilizer and soil nitrogen management, management changes in the cultivation of wetland rice and reducing waste.

Mitigation action in the agricultural sector can help achieve the goal of the UNFCCC, but the reductions of GHG emissions have to take place at the same time that food production increases and climate resiliency is enhanced—presenting a challenge that differentiates mitigation in the agricultural sector from mitigation in other sectors.

3.0 Generating the Triple Dividend

Options exist to generate the triple dividend, but attaining climate change goals will mean feeding a larger global population while delivering a steep reduction in GHG emissions. Producing more food to feed a growing population will require intensifying current production (i.e., increasing yield per unit of land) or expanding the area cultivated, both of which are likely to increase GHG emissions. There are positive and negative effects of both increasing agricultural productivity and bringing new land into cultivation. Improved food security is the obvious positive effect. Negative environmental effects can result from increasing the amount of land under cultivation, such as loss of watersheds and biodiversity, in addition to increased GHG emissions. In regard to intensification, the IPCC reported that increasing inputs to improve productivity might lead to soil depletion through acidification or salinization, and that soil carbon sequestration offers an immediate mitigation potential but is time-limited and has a saturation level (Smith, et al., 2007). Increased soil carbon sequestration often results in increased nitrous oxide emissions, which somewhat negates the expected mitigation benefits (Zaehle, et al., 2011).

A critical question that has not been fully answered is: can sustainable farming methods that reduce GHG emissions feed a growing population? A few studies indicate that an organic style of agriculture, as a proxy of low-emissions agriculture, can feed the world if a change in diets and land use is accepted (Wright, 2011). A Meridian Institute report (Campbell, et al., 2011) concluded that agriculture could meet ever–growing demand for food while also contributing meaningfully to mitigation if governments and farmers undertake what they refer to as climate-smart agriculture actions, and its study stressed the importance of open global trade to help food security. The Royal Society (2010) determined that the growth in production must be achieved for the most part without the cultivation of additional land: and large-scale sustainable intensification is needed, with substantially lower reliance on fossil fuels.

The Foresight Project (2010) concluded that agricultural production would need to increase on existing land to keep emissions in check and that the application of existing knowledge and technology could increase average yields two- to threefold in many parts of Africa, and twofold in the Russian Federation. Sub-Saharan Africa has seen fewer productivity gains than the rest of the world, and there is significant potential for productivity increases. But there are real challenges, including millions of smallholder farmers whose production is critical for food security in the region and require support to adapt to climate change and mitigate agricultural emissions.

Effective strategies can increase production and enhance food security, while improving resiliency and mitigating emissions (See Box 2 for a discussion of a project that generates the triple dividend). The restoration of carbon pools in soil on degraded land can sequester carbon and help to reverse declining soil fertility, translating into higher yields and greater resilience through improved water retention capacity and soil nutrient content. Vågen, Lal and Singh (2005) reported that soils are degraded on 20 to 25 per cent of the land area in Sub-Saharan Africa, contributing to stagnant agricultural productivity. Management and restoration of degraded crop and grassland to increase soil carbon gains—through such management practices as conservation tillage, tree planting and agroforestry, and residue management—have been estimated to have a mitigation potential of 4 to 9 per cent of Africa's annual CO_2 emissions (Batjes, 2004).

BOX 2: GENERATING THE TRIPLE DIVIDEND: KENYA AGRICULTURAL CARBON PROJECT

The Kenya Agricultural Carbon Project, supported by the BioCarbon Fund and SCC-VI Agroforestry, is an example of an initiative that generates the triple dividend. This first project in Africa to sell soil carbon credits on the voluntary market has benefited 60,000 smallholder farmers on 45,000 hectares. These farmers have improved farming practices through integrated water management, sustainable intensification, integrated soil fertility management, improved weather information, agroforestry, and better land-use planning. The project has contributed to the triple dividend:

- Mitigation—carbon uptake through soil sequestration and agroforestry; the project is estimated to generate a total of 1.2 million tonnes (Mt) of CO_2e with a direct benefit to communities of US$350,000.
- Adaptation—increased variety of food crops, and better water harvesting and retention.
- Food Security—increased crop yields through productivity-enhancing practices and technologies.

Lessons from the project indicate that revenues to farmers from increased productivity are the most important economic outcome of the project, with income from the carbon market considered an additional incentive. Financial benefits from carbon revenues are expected to be only a small proportion of the benefits of increased crop yields, and the carbon revenues will not deliver substantial cash benefits to individual farmers. Monitoring carbon is very costly, and grant funding supports the costs associated with monitoring in the project.

Sources: Kenya Agricultural Carbon Project (2011); Wekesa (2011).

Sustainable intensification—through such techniques as drip-feed irrigation, water harvesting, low- or zero-till agriculture, agroforestry, intercropping, and the use of organic manures—can reduce carbon, boost yields and reduce pressures on land and water. A study of 286 sustainable agriculture projects in 57 countries found an average yield increase of 79 per cent, with potential carbon sequestered amounting to an average of 0.35 tonnes of carbon per hectare^{-1} per year^{-1} (Pretty et al., 2006). Another study of 40 sustainable intensification projects in 20 African countries found that average yields more than doubled over a period of 3 to 10 years (Pretty et al., 2011). These studies showed that carbon content of soils improved i) where legumes and shrubs were used; ii) through increased return of organic residues to the soil; and iii) where plowing or soil tillage were abandoned. There are off-the-shelf, low-cost technologies that can help lower GHG emissions and build resilience; some can even reduce costs of production. An example is the use of irrigation in wetland agriculture. The International Rice Research Institute has developed the Alternate Wet and Dry (AWD) method that uses very simple technology to reduce the need for irrigation by about 25–30 per cent. The use of this technology results in energy savings and lower GHG emissions, enhanced resilience to drought, and lower irrigation costs of irrigation, which in turn reduce the costs of production and price of food. Another example is the simple Leaf Colour Chart (LCC) that farmers can use to easily determine if urea fertilizer needs to be applied. The LCC can reduce application of urea by about 30 per cent, reducing costs of input and lowering emissions of nitrous oxide. The point is that simple, readily available, technologies can lower costs of production, while providing adaptation and mitigation benefits.

Livestock also plays an important role in mitigation and adaptation. In regard to mitigation, globally the sector is estimated to account for 65 per cent of human-related nitrous oxide and 37 per cent of methane emissions (Steinfeld, et al., 2006). Technical and management options—such as different animal feeding systems, manure management and management of feed crop production—can reduce GHG emissions from livestock and generate potential co-benefits such as greater productivity, renewable energy, reduced water and air pollution, and soil fertility improvements. But cost implications, lack of technical knowledge (e.g., on feed management) and the development of systems that work in pastoralist systems are challenges in many developing countries.

Significant advances have been made to increase the productivity of livestock production, particularly in developed countries. For example, Verge et al. (2008) calculated that GHG emissions per kilogram of live weight beef cattle in Canada were estimated to have decreased from 13.9 to 10.4 kg CO_2e from 1991 to 2006. The reductions occurred through displacement of high roughage diets by high-energy feeds that reduced enteric methane emissions and reductions in the total crop area to meet the feed requirements of the beef population. However, total emissions increased because of the growth of the animal population.

4.0 Critical Issues in Furthering the Triple Dividend

While the principles of an agricultural production system based on low GHG emissions and high carbon sinks are known, much more needs to be done. Limited research has been undertaken to examine if low-carbon agricultural production can feed a growing global population, and work is needed to understand the trade-offs and synergies between climate change mitigation, adaptation and food security. These linkages vary, depending on numerous factors, including population density, soils, climate, land availability, crop and soil management, and dietary preferences (i.e., increased consumption of animal products).

Research and development are vital to increasing agricultural productivity, to identifying intensification practices that improve GHG emissions efficiency, and to improving the knowledge base on the linkages and interactions between mitigation, adaptation and food security in the agricultural sector. Important research is being undertaken by several organizations, including the Global Research Alliance on Agricultural Greenhouse Gases, and the agriculture and climate change platform of the Global Donor Platform for Rural Development. Under the Consultative Group on International Agricultural Research (CGIAR), the International Food Policy Research Institute (IFPRI) has undertaken policy research on climate change and agriculture (see Box 3); and the Climate Change, Agriculture and Food Security (CCFAS) initiative released a report that sets out critical leverage points for action, and provides examples of policies and programs that are tackling food security in the context of climate change.[1]

[1] See http://ccafs.cgiar.org/; http://www.globalresearchalliance.org/; and http://www.donorplatform.org/activities/climate-change for more information.

BOX 3: LESSONS LEARNED: AGRICULTURAL MANAGEMENT FOR CLIMATE CHANGE ADAPTATION, GREENHOUSE GAS MITIGATION, AND AGRICULTURAL PRODUCTIVITY IN KENYA

A 2011 report published by the International Food Policy Research Institute (IFPRI) presented the results of a study that examined agricultural management practices in Kenya that provide triple-win benefits. The study examined the household-level management practices of 710 farm households from July 2009 to February 2010, spanning seven districts and a range of agro-ecological zones including arid, semi-arid, temperate and humid areas. The main findings of the study were:

- *Changes in agricultural practices are primarily motivated by livelihoods and productivity concerns:* Few farmers are aware of the linkages between mitigation, adaptation and productivity. Capacity building and awareness raising is needed at the local level to encourage triple-win agricultural measures.
- *While farmers are aware of and implementing adaptation measures, they are less aware of agricultural management activities that generate mitigation co-benefits:* Farmers have undertaken a range of actions to adapt to perceived climate changes. While the majority of farmers surveyed were aware of the mitigation benefits of agroforestry, they were unaware of broader measures to reduce the impact of agriculture on climate change.
- *Triple-win climate agricultural production methods are location-specific:* While the study found that soil nutrient management and improved livestock feeding practices produce triple-win benefits in each area studied, other practices—including changing crop varieties—produced mixed results depending on location.
- *A range of policy interventions are required to implement approaches at the farm level that encourage adaptation, mitigation and improved agricultural productivity:* The study recommends several policy interventions; including capacity building at the national level, better coordination between ministries; identification and dissemination of locally-appropriate practices and measures; greater access to information through extension services; and the possibility for innovative financing of mitigation measures.

Source: Bryan et al., 2011.

However, many policy, scientific and technical questions remain unanswered or require further exploration, including in such areas as:

Sustainable intensification

A significant amount of work has been done to examine methods to produce food more efficiently and sustainably while mitigating climate change, including developing new crop varieties and improving soil science and soil management technologies that conserve soil moisture and water resources. The uptake of options to promote the triple dividend (such as low-tillage, soil carbon sequestration, drip-feed irrigation, inter-cropping and agroforestry) in agriculture is not always straightforward or easy. These technologies, while important for achieving the triple win, can be knowledge-intensive, have high start-up costs (and long payback periods through increased productivity), and require substantial time and labour inputs that farmers may not be willing to commit. In addition, promoting such agricultural practices may require a substantial improvement in the agricultural extension service in many countries and training for the extension workers.

Research is needed to examine why seemingly effective technologies are not taken up. What programs, policies and investments can best help to address the issues of cost, the need for upfront investment, knowledge and capacity, and overcome resistance to change? Of course, continued research and development is needed on resilient crops and adaptive techniques to help farmers cope with a changing climate.

Scaling up successful initiatives

Positive outcomes have been generated at the project level, but a challenge is scaling-up successful projects to create positive outcomes on a larger scale. The challenges to scaling up agricultural practices that generate a triple dividend are similar to those faced in traditional development projects, which have struggled for decades to increase agricultural productivity at the smallholder level.

Research is needed to examine why successful projects have not been replicated or scaled up and where efforts should be directed; that is, what actions achieve the greatest food security, adaptation and mitigation benefits? It will also be important to understand how various strategies impact producers in the food supply chain in different contexts and locations. Who will be the winners and losers, and how will vulnerable regions and small producers fare?

Methodological issues around GHG inventories in the agriculture sector

Methodological issues around inventories include difficulties in establishing a baseline due to the lack of information in some countries, a high level of uncertainty in GHG emissions estimates, and a lack of information for assessments—especially for methane and nitrous oxide that present large variations across landscapes and regions.

Progress has been made in estimating soil carbon sequestration, but estimates of nitrous oxide and methane require further work, including the interaction of carbon and nitrous oxide. Another issue is the large number of farmers and the range of geographic and climatic conditions and production practices, meaning that there is a need for methodologies that effectively deal with the complex interplay of these and other factors.

Soil carbon sequestration

Soil carbon sequestration (enhanced sinks) is estimated to provide 89 per cent of the mitigation potential in the agricultural sector (Smith, et al., 2007). While this potential does exist, soil carbon sequestration is very complex, diverse and volatile; and the transition to low-carbon farming systems will be knowledge intensive and require upfront costs. To keep the land at least as productive as before, other agronomic practices will be required, which will require extension services and experimental plots.

An important need is a closer examination of the challenges in soil carbon sequestration and the costs associated with measurement and monitoring. Research is required on monitoring methodologies, especially methodologies that have applicability to areas with large numbers of small-scale farmers.

Financing the triple dividend

There is expectation that reaching agreement on a climate change agreement will stimulate investment in agricultural practices that bring mitigation, adaptation and food security benefits. These is some expectation that the carbon market will generate significant funding for agricultural activities in developing countries, and the potential of soil carbon sequestration projects is often highlighted. Offsets based on soil carbon could have high costs related to monitoring, the need to aggregate emissions from many smallholders, issues of permanence, and the need for capacity building. Grant funding may be the best option in some instances to encourage such improved agricultural practices, or the income from the sale of carbon credits may need to be viewed as secondary to income from increased productivity.

More research is needed before carbon credits from soil are judged to be viable, to provide clarity on the upfront costs, the expected returns to farmers (including smallholder farmers in developing countries), and the likelihood of the carbon market generating large flows of financing to developing countries.

5.0 Concluding comments

Ensuring food security for around nine billion people by 2050 will require a significant shift toward sustainable production systems that improve the productivity of large- and small-scale farmers in developing and developed countries. Changes in agricultural practices could have significant positive or negative effects in regard to achieving food security, adaptation and mitigation goals. An international agreement on climate change could help to influence a more positive shift—such as reduced emissions and increased soil carbon sinks that help to enhance resiliency and improve food security. An international agreement on climate change and agriculture could help to drive sustainable intensification policies by encouraging investment in R&D, helping to spread best practices, making food production central in development, improving the evidence base, and improving measurement, reporting and verification to assess progress, and eventually moving to a land-based approach that discourages expansion of new land for agriculture. An agreement on agriculture under the UNFCCC that includes a programme of work on agriculture is an important step in reducing emissions, enhancing resiliency and improving food security—the triple dividend.

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