Methodology Guidebook

for the Assessment of Investment and Financial Flows to Address Climate Change

5 Assessment of I&FF for Adaptation in the Agriculture Sector

5.1 Introduction

Agriculture accounts for the major share of human use of land and is a major source of greenhouse gas emissions. Lands used for agricultural production, consisting of cropland, managed grassland and permanent crops, including agro-forestry and bio-energy crops, occupy about 40 per cent of the earth's land surface (United Nations Food and Agriculture Organization, FAOSTAT, 2007). According to the IPCC, agriculture releases to the atmosphere significant amounts of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), thus adding up to around 10 to 12 per cent of total global anthropogenic emissions of greenhouse gases.

Agricultural activities generate a large share of the world's anthropogenic non CO_2 emissions, accounting in 2005 for about 41 per cent of N_2O and about 47 per cent of CH_4 (IPCC, 2007). The largest sources of non CO_2 emissions in the sector are N_2O emissions from soils and CH_4 from enteric fermentation, while biomass burning, rice production, and manure management account for the rest. CO_2 emissions from agricultural soils are not normally estimated separately, as they are included in the land use, land use change and forestry sector; the US Environmental Protection Agency has estimated that net CO_2 emission from agricultural soils amounted in 2000 to less than 1 per cent of global anthropogenic CO_2 emissions.

In its Fourth Assessment Report the IPCC states that "CO_2 is released largely from microbial decay or burning of plant litter and soil organic matter. CH_4 is produced when organic materials decompose in oxygen-deprived conditions, notably from fermentative digestion by ruminant livestock, from stored manures, and from rice grown under flooded conditions. N_2O is generated by the microbial transformation of nitrogen in soils and manures, and is often enhanced where available nitrogen (N) exceeds plant requirements, especially under wet conditions." [1]

Agricultural greenhouse gas emissions are projected to increase in coming decades, as a consequence of increased demand for agricultural products and as diets change with increasing affluence in many developing countries. Albeit growing at a lower rate than in the past, world population will continue to rise, and expected GDP growth will allow increases in per capita caloric intake and promote shifts in diet preferences.[2]

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[1] Smith, P., D. Martino, Z. Cai, D. Gwary, 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.

[2] Food and Agriculture Organization (FAO). 2002. World Agriculture: Towards 2015/2030. Rome, Italy.

The IPCC identifies three broad mechanisms through which agriculture can make a significant contribution to mitigate greenhouse gas emissions, by introducing mitigation technologies and practices:

- Reducing emissions: by more efficient management of carbon and nitrogen flows in agricultural ecosystems.
- Enhancing removals: by recovering carbon lost by agricultural ecosystems through improved management, and withdrawing atmospheric CO2.
- displacing emissions: by using crops and residues from agricultural lands as a source of fuel, contributing to biomass feedstocks for energy use.

A large proportion of the mitigation potential of agriculture arises from soil carbon sequestration, while modest mitigation potential is also available from reductions in methane and nitrous oxide emissions in some agricultural systems. However, there is no universally applicable list of mitigation practices; practices need to be evaluated for individual agricultural systems and settings.

Mitigation measures for the agriculture sector are generally of two types: 1) field-level measures, and 2) research, education, assistance, infrastructure, and institutional measures. Field-level measures[3] include:

- **Cropland management**. Mitigation practices in cropland management include:
    - Agronomy: Improved agronomic practices that increase yields and generate higher inputs of carbon residue can lead to increased soil carbon storage, including improving crop varieties; featuring perennials in crop rotations; making greater use of temporary cover crops (between successive crops or between rows of plantations); avoiding bare fallows.
    - Nutrient management: Nitrogen applied in fertilizers, manures, biosolids, and other N sources is not always used efficiently by crops. Consequently, improving N use efficiency can reduce N2O emissions and indirectly reduce GHG emissions from N fertilizer manufacture. Improved practices include improving nitrogen-use efficiency by reducing leaching and volatilization, reducing offsite N2O emissions; adjusting fertilizer application to crop needs (synchronization); using slow-release fertilizers; applying N when crop uptake is guaranteed; placing N in soil (e.g. banding) to enhance accessibility; avoiding N applications in excess of crop demands.
    - Tillage/residue management: Advances in weed control methods and farm machinery now allow many crops to be grown with minimal tillage (reduced tillage) or without tillage (no-till), also by managing tillage and residues.

[3] Based on the IPCC: Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, and FAO, Climate Change Adaptation and Mitigation in the Food and Agriculture Sector, FAO, Rome, 2008.

- Water management: Expanding the area (where water reserves allow) that receive supplementary water through irrigation or using more effective irrigation measures can enhance carbon storage in soils through enhanced yields and residue returns.

- Rice management: Methane emissions during the growing season can be reduced by various practices. For example, draining wetland rice once or several times during the growing season reduces CH4 emissions; rice cultivars with low exudation rates could offer an important methane mitigation option; in the off-rice season, methane emissions can be reduced by improved water management, especially by keeping the soil as dry as possible and avoiding water logging; methane emissions can be reduced by adjusting the timing of organic residue additions or by producing biogas for use as fuel for energy production.

- Agro-forestry: The production of livestock or food crops on land that also grows trees for timber, firewood, or other tree products.

- Land cover change: To allow or encourage the reversion of cropland to another land cover, typically one similar to the native vegetation.

- **Grazing:**

  - Grazing intensity: The intensity and timing of grazing can influence the removal, growth, carbon allocation, and flora of grasslands, thereby affecting the amount of carbon accrual in soils.

  - Increased productivity: (including fertilization): Carbon storage in grazing lands can be improved by a variety of measures that promote productivity. Examples: alleviating nutrient deficiencies by fertilizer or organic amendments increases plant litter returns and, hence, soil carbon storage.

  - Nutrient management: Practices that tailor nutrient additions to plant uptake.

  - Fire management: Reducing the intensity or frequency of on-site biomass burning.

  - Species introduction: Introducing grass species with higher productivity, or carbon allocation to deeper roots, to increase soil carbon.

- **Management of organic/peaty soils**. Emissions from drained organic soils can be reduced to some extent by practices such as avoiding row crops and tubers, avoiding deep ploughing, and maintaining a shallower water table.

- **Restoration of degraded lands.** Re-vegetation (e.g., planting trees or grasses); improving fertility by nutrient amendments; applying organic substrates such as manures, biosolids, and composts; reducing tillage and retaining crop residues; and conserving water.

- **Livestock management.**

  - Improved feeding practices: Feeding more concentrates, normally replacing forages or higher quality forages (those with higher protein content).

- Specific agents and dietary additives: A wide range of specific agents, mostly aimed at suppressing methanogenesis, has been proposed as dietary additives.
- Longer-term management changes and animal breeding: Increasing productivity through breeding and better management practices, reducing lifetime emissions, breeding dairy cattle for lifetime efficiency.

- **Manure management**. Methane emissions from manure stored in lagoons or tanks can be reduced by cooling, use of solid covers, mechanically separating solids from slurry, or by capturing and burning the CH4 emitted. Examples: preventing methane emissions from manure heaps and tanks; producing biogas; composting manure.

- **Bioenergy**. Agricultural crops and residues as sources of feedstocks for energy to displace fossil fuels. A wide range of materials have been proposed for use, including grain, crop residue, cellulosic crops (e.g., switchgrass, sugarcane), and various tree species.

Research, education, assistance, infrastructure, and institutional measures include:

- **Research**. Resources can be allocated to agronomic and engineering research on improved mitigation strategies, including demonstration/trials and diffusion of new field-level practices.

- **Extension and training**. Public resources can be allocated to agricultural extension and training programmes to disseminate information about, and training in improved agricultural practices, and to encourage their adoption.

- **Seasonal weather forecasting**. This would include improved/expanded seasonal weather forecasting to reduce production risk and optimize resource use.

- **Infrastructure development**. Both public and private infrastructure investment may be needed in the agriculture and other sectors to support agricultural mitigation measures, including new freshwater supply infrastructure.

- **Other institutional development**. Mitigation in agriculture at the regional and national levels requires the integration of long-term mitigation strategies into agricultural development policy and planning, land-use planning and regulatory structures, and overall development policy. Public resources will be needed for such measures, as well as institutional capacity building, and improved management and governance systems.

5.2 Application of I&FF Methodology to mitigation in the Agriculture Sector

This section describes how the I&FF methodology in Chapter II would be applied to mitigation in the agriculture sector.

Step 1: Establish key parameters of assessment

5.2.1 Define detailed scope of the sector

In this step, the precise subsectors of the agriculture sector that are to be included in the I&FF assessment must be defined. The agriculture sector includes production of food crops (food for humans and fodder), animals and their products, floral crops and nursery plants, biofuel crops (e.g., maize, sorghum, switchgrass, oil palm, jatropha), and other non-food crops (e.g., oilseeds, gums and resins, sweeteners, beverage crops [e.g., coffee, tea, cacao], tobacco, fibres [e.g., cotton, silk, hemp], construction crops [e.g., bamboo, hemp], and pharmaceutical, herbal, and aromatic plants).[4]

Countries may choose to include production of some or all of the significant crop species/varieties and animal species/breeds produced domestically. Crop production can be divided into annual and perennial crops, and animal production can be divided into intensive and extensive production systems. Countries may also choose to only focus on certain agro-ecological regions, rather than the entire country, if appropriate.[5]

Which components are included should depend on national circumstances, including, for each component, its contribution to national greenhouse gas emissions present and future, and the abatement opportunities the sector and subsector provide, and its relationship to national and sectoral development plans. This choice should also depend on data availability, the structure of national government entities in which data reside, and the scope of related assessments that have been completed, especially the consideration of sector emissions in the national inventories, studies included in the National Communications, and other mitigation potential assessments that have been completed.

Linkages between the agriculture sector and other sectors should be identified and considered to avoid double-counting of I&FF, inconsistent results between sectoral assessments, and assessment of mitigation measures that would result in significant effects in other sectors. Double counting might result from considering I&FF when the overlapping sectors are both chosen for the exercise.

5.2.2 Specify assessment period and base year

This methodology recommends a 25-year assessment period and 2005 as the base year.

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[4] Many types of crops have several and at times competitive uses, as in the case of maize used also for human food and fodder.

[5] Food processing has not been included in the scope of the agriculture sector as defined in this chapter in line with the IPCC, which quantifies emissions from agriculture, as well as with the ISIC and many other classifications. Including a subsector of manufacturing in this assessment may create double accounting for costs, particularly if a country undertakes analysis of its manufacturing sector, and could lead to problems of disaggregation of statistics.

5.2.3 Identify preliminary mitigation options

A preliminary set of mitigation options must be identified for each component of the agriculture sector included in the assessment, which will inform the design of the analytical approach. Table 5-1 presents a list of general options.

The selection of field-level mitigation options should be based primarily on the sectoral scope, prior analysis of mitigation options, and the technical feasibility, economic feasibility, logistical feasibility, and sectoral acceptability of the options. Consideration should also be given to emission reductions potential as well as social, and non-GHG environmental benefits and costs of the options. To avoid having analysts spending large amounts of time analyzing options that are technically feasible but not economically feasible, the national team can use economic analyses to prioritize the mitigation measures to be considered in the assessment.

The selection of research, education, assistance, infrastructure, and institutional options should be based on these same considerations as well as on national and sectoral development plans and goals.

Given the numerous linkages between the agriculture and other sectors, there is a potential for synergies between agricultural mitigation and mitigation in other sectors. For example, agricultural mitigation measures that require irrigation practices have an impact on energy and water supply. It is not expected that countries will undertake integrated I&FF assessments (i.e., integrated across sectors), but countries should be alert to such synergies and cross sectoral effects, and discuss them qualitatively in their reports.

The agriculture sector is linked to the water management sector through agricultural demand for freshwater (for both production and processing) and the potential for agricultural contamination of water supply (e.g., through pesticide runoff), to the energy sector through agricultural biofuel production and through agricultural demand for energy, to the determinants of health in the health sector through the production of safe and secure food supplies and through agricultural demand for labour, to the waste management sector through food processing waste generation, and to ecosystem health through pollutant runoff and nitrogen loading of ground and surface waters from pesticide and fertilizer use, and from inadequate management of animal wastes in confined animal operations.

Table 5-1: Agricultural mitigation measures

Type of Measure	Mitigation measure	Examples
Field level	Cropland management	Agronomy
		Nutrient management
		Tillage/residue management
		Water management
		Rice management
		Agro-forestry
		Land cover change
	Grazing land management / pasture improvement / land cover change	Grazing intensity
		Increased productivity
		Nutrient management
		Fire management
		Species introduction
	Management of organic/peaty soils	Avoid drainage of wetlands
	Restoration of degraded lands	Erosion control, organic amendments, nutrient amendments
	Livestock management	Improved feeding practices
		Specific dietary additives
		Structural and management changes and animal breeding
	Manure/ biosolid management	Improved storage and handling
		Anaerobic digestion
		Efficient use as nutrient source
	Bio-energy	Energy crops, solid, liquid, biogas, residues
Research, education, assistance, infrastructure, and institutional	Sector-wide	Research, including demonstration/trials and diffusion of new field-level practices
		Extension and training
		Forecasting, early warning, and disaster management
		Infrastructure development
		Other institutional development, including capacity building, and improved management and governance systems)

5.1.4 Select analytical approach

Countries need to determine the analytical approach that will be used to develop baseline and mitigation scenarios, and associated streams of annual IF, FF, and O&M costs. Although there are different models[6] for assessing the amount and level of emissions associated with agricultural practices and crop/livestock decision patterns in farming, the mitigation potential of various cropping systems, and technological feasibility of various mitigation options, there are no models directly applicable to developing baseline and mitigation scenarios, and cost estimates, for I&FF assessment of agriculture mitigation. In addition, mitigation measures and their costs, appropriateness, and feasibility are highly site-specific. Therefore, simple, spreadsheet based, bottom-up approaches that rely on in-country understanding of the agriculture sector and how it is likely to evolve over time, demand projections based on national and international demand of agricultural goods produced by the country, and in-country expertise and experience with the agronomic applicability, costs, feasibility, and cultural acceptance of options, in conjunction with sectoral plans and projections for agricultural production, imports, and exports, are recommended.

Step 2: Compile Historical IF, FF, and O&M Cost Data, Subsidy Cost Data (if included explicitly), and Other Input Data for Scenarios

5.2.1 Compile historical annual IF and FF data, disaggregated by investment entity and source

The methodology recommends that countries compile 10 years of historical I&FF data, i.e., for the base year and the previous nine years. At a minimum, countries should collect at least three years of data (i.e., for the base year and two years during the previous decade). Data should be compiled for each investment type, and should be annual, be disaggregated by investment entity, and, if possible, by funding source, and also be divided into investment flows and financial flows (see Table 2-3 in Chapter II).

In the agriculture sector, investment flows would include assets such as machinery (e.g., mechanized ploughs, planters, and harvesters; milking machines), wells and irrigation equipment, buildings (e.g., animal housing, greenhouses), and food processing facilities (e.g., slaughtering facilities, sugar production facilities, canning facilities).

Investment flows would also include assets for research, education, assistance, and institutional (e.g., meteorological equipment, vehicles). Financial flows would include non-asset investments in the research, education, assistance, and institutional areas (e.g., labour costs).

The I&FF data needed will likely reside in several national locations including ministry records and plans, statistical agencies, extension agencies, research institutions and national accounts, as well as the private sector stakeholders, including farmers associations, industry records, and non-governmental organizations.

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[6] FarmSim, EPIC, PaSIm and CERES, Livestock Analysis Model (LAM), among others.

Note that sectoral and subsectoral definitions and disaggregations will vary among data sources, so assumptions may need to be made to reconcile datasets and extract needed data from aggregated and/or disaggregated categories. For example, the UN System of National Accounts (SNA) utilizes the ISIC classification system in which crop and animal production is included in Section A (Agriculture, forestry and fishing), and the processing of agricultural products is included in Section C (Manufacturing). This means, for example, that the production of cattle is in Section A, but the processing of meat and dairy products is in Section C. Even at the most disaggregated level in the ISIC system (the "Class" level), multiple agricultural activities are combined so that investment information for each activity cannot be separated without making assumptions and/or using supplementary information. For example, class 0119 (Growing of other non-perennial crops) includes both fodder crops and flowers. Table 7-2 contains the ISIC classification system for the "crop and animal production, hunting, and related service activities" division of Section A. Section C (Manufacturing) is disaggregated similarly (see webpage cited below table).

Several UN Food and Agriculture Organization (FAO) databases may be useful data sources too. FAO agricultural databases are described below under "Compile other input data for scenarios."

5.2.2 Compile historical annual O&M cost data, disaggregated by investment entity and source

Historical O&M data are also needed to provide a historical basis from which to estimate future O&M costs for new physical assets, as well as to provide data for the first year of the scenarios. (Note that in the context of agriculture, physical assets include croplands and pasture).

Annual O&M costs for the physical assets that are in operation during the historical period should be collected (or estimated) for the same years for which historical I&FF data are collected. Information about the expected lifetimes of assets such as buildings, machinery, equipment that are in operation during the historical period, and annual fluctuations in O&M costs (if any), also need to be collected.

O&M data should be collected at a level of disaggregation consistent with the I&FF data, and the O&M data for assets purchased during the historical period should be tracked separately from the O&M data for assets purchased before the historical period (see Table 2-4 in Chapter II).

O&M data are a particularly important component of agricultural baseline and mitigation costs since many field-level agricultural costs are O&M costs. Significant O&M costs are likely to include agricultural inputs, such as seeds, plants, fertilizers and other soil amendments, animal stock, and animal feed; energy usage (electricity and fuels); building and equipment maintenance and/or leasing; real estate expenses; and insurance. (Note that if the national I&FF assessment also includes energy sector mitigation, agricultural measures that include energy consumption should not duplicate, or be inconsistent with, energy sector measures.)

The O&M data that need to be collected may reside in one or more of the same locations as I&FF data (e.g., national accounts, ministry of agriculture records and plans an reporting, industry records, statistical agencies, extension agencies, research institutions), as well as in FAO sources described below. If such data are not available, countries should utilize one of the estimation approaches described in Chapter II. In-country experts may be particularly useful for supplying cost estimates.

5.2.3 Compile historical annual subsidy cost data, if subsidies are included explicitly in the assessment

There are numerous types of agricultural subsidies, including direct financial transfers (e.g., grants and low-interest loans to producers), preferential tax treatments, price supports and income guarantees, and controls over access to resources such as water. If a country chooses to include subsidies explicitly in the I&FF assessment, annual costs of subsidies for each type of investment during the historical period should be collected (or estimated) for the same years for which historical I&FF data are collected. Subsidies should be compiled separately for IF, FF, and O&M (see Table 2-5 in Chapter II).

Information on subsidies may be available from relevant government ministries or agencies, statistical agencies, research organizations, academic institutions, and private sector entities.

5.2.4 Compile other input data for scenarios

In addition to historical I&FF and O&M cost data, the characterization of the scenarios and estimation of annual costs for the scenarios will require the collection of other historical and non-historical data relevant to the sector. What data are needed will depend on the sectoral scope and analytical approach. The kinds of information that will be needed may include:

- Characterization of the agricultural production subsectors included in the analysis, including crop species/varieties, quantities produced, areas planted and harvested, yields per hectare, animal species/breeds raised, animal populations, animal product production statistics, domestic consumption and exports, agricultural inputs and other management practices, employment, and national land-use statistics. Information about the current situation, as well as projections over the assessment period, should be collected.

- Characterization of agricultural processing activities included in the scope. This would include the nature and scale of operations, energy and water usage, and employment. Information about the current situation, as well as projections over the assessment period, should be collected.

- Characterization of mitigation options, including technical feasibility, cultural acceptability, scalability, costs (capital and O&M), and economic feasibility. Possible externalities and linkages with other sectors should also be noted.

- Information about major sectoral and macroeconomic policies (both recent and expected) that could significantly affect the agriculture sector should also be collected.

These data and information may be available from the national sources mentioned above for I&FF and O&M cost data. While it is recommended to go directly to the agencies which are responsible for the reporting within the country, FAO maintains several publicly available statistical databases and information systems that contain potential useful national agricultural statistics and related information. These include:

- FAOSTAT, which contains data on crop and animal production, trade, and consumption; agricultural prices; agricultural resources (land, labour, machinery, fertilizers, agrochemicals); and food security. The FAOSTAT website is:

  http://faostat.fao.org/site/291/default.aspx

- AQUASTAT, which is an information system for the collection, analysis, and dissemination of data and information on water resources and agricultural water management by country and by region. It also includes data on dams, irrigation system investment costs, and irrigated areas. The AQUASTAT website is:

  http://www.fao.org/nr/water/aquastat/main/index.stm

Step 3: Define Baseline Scenario

This step entails describing what is likely to occur in each agricultural component without climate change (and therefore, without the implementation of mitigation policies and measures to address climate change) over the assessment period. It should reflect current sectoral and national plans, expected socioeconomic trends, and expected investments in the components. It should include a quantitative description of the socioeconomic factors that affect the components (e.g., demographic change, economic growth), as well as other relevant characteristics (e.g., domestic food consumption; domestic crop, meat, and dairy and production, or other domestic consumption statistics; imports and exports; water supply availability, land availability). The baseline scenario description should include specific information about equipment, facility, and infrastructure investments that are expected (and as is relevant) in each component, as well as research, education, assistance, and institutional investments.

Step 4: Estimate Annual IF, FF, and O&M Costs, and Subsidy Costs if included explicitly, for Baseline Scenario

5.4.1 Estimate annual IF and FF for each investment type, disaggregated by investment entity and funding source

In this step, annual IF for the baseline scenario facility and infrastructure investments, and annual FF for the baseline scenario research, education, assistance, and institutional investments, are estimated for each subsector. As discussed in Chapter II, costs should be in real terms (i.e., inflation adjusted), ideally in constant 2005 US$, should be reported in the year in which they are expected to be incurred, and should be discounted using appropriate public and private discount rates. The annual IF and FF estimates for each investment type should be disaggregated by investment entity and funding source, and also be divided into investment flows and financial flows. Typically in the agriculture sector investment decisions are in many cases made by thousands of small-scale farmers and the analysis cannot be done farm by farm. In this case a simple disaggregation by type of investment entity can facilitate the analysis without losing data quality and level of aggregation. Data sources could include model output, and/or government and private sector planning documents, or estimates might be derived from historical data.

The output of this step will be a stream of annual investment flows and/or financial flows for each investment type in each subsector for the entire assessment period, by investment entity and funding source. These data should be organized as in Table 2-3 in Chapter II.

5.4.2 Estimate annual O&M costs for each IF, disaggregated by investment entity and funding source

Annual estimates of O&M costs for assets purchased during the assessment period, and for assets purchased before the assessment period and that are expected to still be in operation, need to be collected (or derived) for each subsector. Costs should be in real terms, ideally in constant 2005 US$, should be reported in the year in which they are expected to be incurred, and should be discounted.

The annual O&M estimates for each investment type should be disaggregated by investment entity and funding source (as in Table 2-4 in Chapter II), and also be divided into O&M for assets purchased during the assessment period, and for assets purchased prior to the assessment period. Again, in this case a simple disaggregation by type of investment entity can facilitate the analysis. For those assets purchased during the assessment period that are expected to still be in operation after the last year of the assessment period, annual O&M costs for each additional year the assets will be in operation should be estimated, up to an additional five years after the last year of the assessment period. Possible data sources include those described above for IF and FF.

5.4.3 Estimate annual subsidy costs for each investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment

If a country chooses to include subsidies explicitly in the I&FF assessment, annual subsidy costs should be estimated for each relevant investment type, and for all categories of cost (IF, FF, and O&M), in the baseline scenario (see section 2.2.1 of Chapter II).

Step 5: Define Mitigation Scenario

This step entails developing a description of what is likely to occur in each relevant agriculture subsector, over the assessment period, with the implementation of mitigation measures while also considering the likely impacts of Climate Change on agricultural production. This would include comprehensive descriptions of the specific mitigation measures that would be implemented, and the implications of those measures for the evolution of each subsector.

The mitigation measures need to be defined clearly and completely so that IF, FF, and O&M costs can be estimated in the next step. This should include specific information about facility and infrastructure investments that would occur in each component, as well as non-asset investments. In-country expertise, and prior work on climate change mitigation in agriculture (e.g., National Communications, mitigation abatement cost studies, etc.) should be utilized in this step.

In determining and defining the set of mitigation measures that would be implemented, the preliminary set of the mitigation measures that were identified in Step 1 should be re-evaluated, given the analytical approach chosen in Step 1, the other input data compiled in Step 2, and the baseline analysis completed in Step 3. It is also recommended that countries undertake an initial prioritization of the mitigation measures, which will be re-evaluated later in Step 8.

As part of the re-evaluation and initial prioritization of mitigation measures, countries should assess qualitatively the environmental and socioeconomic benefits, as well as potential non-investment costs (negative externalitities), of the mitigation measures. Production tradeoffs associated with mitigation measures should be identified for several practices in which those effects are relevant.

Step 6: Estimate Annual IF, FF, and O&M Costs, and Subsidy Costs if included explicitly, for Mitigation Scenario

5.6.1 Estimate annual IF and FF for each investment type, disaggregated by investment entity and funding source

In this step, annual IF for the mitigation scenario facility and infrastructure investments, and annual FF for the mitigation scenario research, education, extension, and institutional investments, are estimated for each component. As discussed in Chapter II, costs should be in real terms (i.e., inflation adjusted), ideally in constant 2005 US$, should be reported in the year in which they are expected to be incurred, and should be discounted using appropriate public and private discount rates. The annual IF and FF estimates for each investment type should be disaggregated by investment entity and funding source, and also be divided into investment flows and financial flows. Data sources include the sources listed above.

The output of this step will be a stream of annual investment flows and/or financial flows for each investment type in each subsector for the entire assessment period, by investment entity and funding source. These data should be organized as in Table 2-3 in Chapter II.

5.6.2 Estimate annual O&M costs for each IF, disaggregated by investment entity and funding source

Annual estimates of O&M costs for assets purchased during the assessment period, and for assets purchased before the assessment period and that are expected to still be in operation, need to be collected (or derived) for each component. Costs should be in real terms, ideally in constant 2005 US$, should be reported in the year in which they are expected to be incurred, and should be discounted.

The annual O&M estimates for each investment type should be disaggregated by investment entity and funding source (as in Table 2-4 in Chapter II), and also be divided into O&M for assets purchased during the assessment period, and for assets purchased prior to the assessment period. For those assets purchased during the assessment period that are expected to still be in operation after the last year of the assessment period, annual O&M costs for each additional year the assets will be in operation should be estimated, up to an additional five years after the last year of the assessment period. Possible data sources include those described above for IF and FF.

5.6.3 Estimate annual subsidy costs for each relevant investment type and for IF, FF, and O&M costs, if subsidies are included explicitly in the assessment

If a country chooses to include subsidies explicitly in the I&FF assessment, annual subsidy costs should be estimated for each relevant investment type, and for all categories of cost (IF, FF, and O&M), in the baseline scenario (see section 2.2.1 of Chapter II).

Step 7: Calculate the Changes in IF, FF, and O&M Costs, and in Subsidy Costs if included explicitly, needed to Implement Mitigation options

The changes in IF, FF, and O&M costs that are needed to implement the Mitigation measures in each component are calculated in this step by subtracting baseline scenario costs from Mitigation costs. There are two primary objectives of this step: 1) to determine how cumulative IF, FF, and O&M costs would change; and 2) to determine how annual IF, FF, and O&M costs would change. These calculations, which should be completed for each subsector, are described in detail in Chapter II.

Step 8: Evaluate Policy Implications

The purpose of this step is to evaluate the policy implications of the results of the previous step for the sector. The analyses in the previous step estimate the magnitudes and timing of changes in IF, FF, and O&M by each investment entity and from each funding source that would be needed to implement the mitigation measures in each subsector.

It is recommended that countries first re-evaluate their initial prioritization of the mitigation measures that was undertaken in Step 5, based upon the incremental cost estimates, and determine which investment entities are responsible for the most significant (largest and/or highest priority) changes in I&FF, and the predominant sources of their funds.

Then, the policy measures that might be used to induce those entities to implement the proposed measures and change their investment patterns (eg.incentives/public programmes, etc.), and the additional sources of funds that might be utilized to meet new investment needs, should be evaluated. It will be particularly important to distinguish between public and private sources of finance, as well as between domestic and foreign sources.

Policy measures include a variety of instruments, including economic instruments (e.g., taxes), regulatory instruments (e.g., fuel portfolio standards), voluntary agreements, information dissemination and strategic planning, and research, development, and demonstration (RD&D).