VIII Assessment of Investment & Financial Flows for Adaptation in the Agriculture Sector

8.1 Introduction

Agricultural production is heavily dependent on climate and water resources, and consequently is quite sensitive to changes in climate. Moreover, most rural populations in developing countries rely primarily upon agriculture for their livelihoods. Although agricultural communities have a long history of adapting to climatic variability and extreme weather events, significant changes in climate and CO_2 concentrations are expected to affect agricultural yields and income levels, and could exacerbate existing problems relating to malnutrition and food security.

Climate change has an impact on agricultural production through a variety of mechanisms affecting, for example, crop growth, development, yields, water needs, and nutritive value. Similarly it affects animal health directly as well as through its impacts on pasture[98] availability, animal[99] carrying capacity, and productivity[100]. These mechanisms include (a) changes in temperature and precipitation, (b) increases in the atmospheric concentration of CO_2, (c) changes in the frequency and intensity of extreme events (heat stress, droughts, flooding events, fires, and wind storms), and (d) altered weed, insect and disease incidence, (e) sea level rise. Climate change also affects agriculture indirectly through its effects on other sectors. These effects include, for example, reductions in freshwater supply due to decrease in snowpack, increased evaporation from reservoirs or increased demand in other sectors; loss of productive coastal acreage due to sea level rise and salt water intrusion, and reductions in labour supply due to the spread of human diseases.

The impacts of climate change on agricultural systems are highly site-specific. The vulnerability of any particular agricultural system depends on the character, magnitude, and rate of the climatic changes expected, the agricultural and socioeconomic systems' sensitivity to the climatic changes, their ability to cope with changing conditions (i.e., to adapt). In addition, the implementation of adaptation measures will also depend on the degree of active management employed and the value of adaptive management adjustments versus their costs. Agricultural systems that are already stressed due to limited water supply, biodiversity loss, land degradation, disease susceptibility and pest infestation, and/or air pollution, are particularly sensitive to climate change and least able to adapt (and many of the existing stressors are likely to be exacerbated due to climate change). The adaptive capacity of agricultural systems also depends on economic, social, technological, informational, and institutional variables, including wealth, human capital, information and technology, material resources, infrastructure, and institutional support. Smallholder and

[98] Pasture is land with low-growing vegetation cover used for grazing of livestock as part of a farm, or in ranching or other unenclosed pastoral systems. The term encompasses both unmanaged (unimproved) and managed (improved) grazing lands.

[99] The term "animals" is used here to encompass both livestock and poultry, i.e., all animals raised for food, fibre, and /or labour.

[100] IPCC (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Perry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 976pp. Accessible at: http://www.ipcc.ch/ipccreports/assessments-reports.htm

subsistence farmers and pastoralists, are the most vulnerable groups given their limited adaptive capacity and sensitivity to changes in climate and extreme events.

Adaptation measures for the agriculture sector are generally of two types:
field-level measures,[101] and
research, education, assistance, infrastructure, and institutional measures[102].

Field-level measures[103] include, for example, those aimed at:

- Land use and enterprise change, i.e. change crop (cotton to wheat) or animal species (cattle to goats); or enterprise mix (pastures for agroforestry). In addition, current land uses, such as cropping, may turn unsustainable due to climate change. In some cases, individuals may choose to abandon agriculture altogether and migrate to a city or another country to pursue alternative employment opportunities.
- Change in variety, e.g., to include varieties of crops and breeds which are more heat, drought, and/or CO_2 tolerant.
- Change in management practices regarding crops, pastures or animals. This includes changing the timing of crop planting and/or harvesting; as well as the amounts, types and timing of soil amendments and fertilizer use. Adaptations in extensive systems include altering animal stocking rates, altering the timing of seasonal migrations, integrating crop and animal systems, using supplementary feeds, etc. Adaptations in intensive systems include altering feeding practices, changing the degree of confinement/housing, and changing the housing infrastructure. The timing of "harvesting" products (milking cows, shearing sheep, slaughtering cattle and pigs) can be altered as well.
- Restoration of soils that have been degraded by climate change, and change in moister management/irrigation. Climate change can increase crop water needs, decrease water availability, decrease soil moisture holding capacity, and increase flooding, water logging, saltwater intrusion and erosion. Adaptation may involve using irrigation (which may require investing in irrigation facilities or equipment, as well as dam construction), improved rainwater harvesting and water storage, changing drainage management regimes, changing plantings to reduce water needs (or increase water use), and/or altering tillage and residue management practices to conserve water and reduce erosion. Mechanisms aimed at salt water intrusion protection may also be needed.

[101] These measures are often referred to as "farm-level measures" in the vulnerability and adaptation literature. The term "field-level" is used here to encompass forms of agriculture that are not associated with farms, such as extensive agricultural systems, shifting cultivation, nomadic pastoralism, and home gardens and animals.

[102] These measures are adapted, with modifications, from UNFCCC (2007). *Investment and Financial Flows to Address Climate Change*, which is accessible at:
http://unfccc.int/files/cooperation_and_support/financial_mechanism/application/pdf/background_paper.pdf and
Chapter 5 of IPCC (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Perry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 976pp, which is accessible at: http://www.ipcc.ch/ipccreports/assessments-reports.htm and UNFCCC, 2007, *Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries*, which is accessible at: http://unfccc.int/resource/docs/publications/impacts.pdf

[103] For a full list of options, see B. McCarl (2007). Adaptation Options for Agriculture, Forestry and Fisheries, a report to the UNFCCC. Available from http://unfccc.int/files/cooperation_and_support/financial_mechanism/application/pdf/mccarl.pdf

- Changes in pest and disease management. Climate change is likely to exacerbate pest, disease, and weed management problems. Adaptation could involve wider use of integrated pest and pathogen management, preventative veterinary care, development and use of varieties and species resistant to pests and diseases, adjusting harvesting schedules, and expanding and/or improving quarantine capabilities, outbreak monitoring programmes, and prescribed burning practices.
- Fire management. Pastures, and to some extent croplands, are vulnerable to climate change induced increases in fire risk. Adaptive actions include salvaging dead wood, landscape planning to minimize fire damage, and adjusting fire management systems.

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

- R&D programmes funded by public and private bodies, (e.g., agronomic and engineering research on crop varieties or animal management practices that are well suited to altered climatic conditions in a particular region). R&D may also aim at developing new crop cultivars and animal breeds through selective breeding and genetic modification.
- Extension and training. Public resources can be allocated to agricultural extension and training programmes to disseminate information about, and training in, adaptation practices, and to encourage their adoption.
- Forecasting, early warning, and disaster management programmes. This would include improved/expanded seasonal weather forecasting; improved/expanded early warning systems and improved/expanded disaster management to facilitate recovery.
- Transitional assistance. Climate change may require that current land uses be changed, and may cause migration from rural to urban areas. Such responses may require, or significantly benefit from, assistance in a variety of forms, including financial support (e.g., loans and grants), marketing and insurance assistance, relocation assistance, temporary food aid and shelter, and employment assistance.
- Infrastructure development. Both public and private infrastructure investment may be needed in the agriculture and other sectors to support agricultural adaption measures. This may include alternations of, and new, food processing and transport facilities to support the production of new crop and animal varieties; altered and new freshwater supply infrastructure; and construction of coastal protection infrastructure.

8.2 Application of the I&FF Methodology to Adaptation in the Agriculture Sector

This section describes how the I&FF methodology described in Chapter II would be applied to estimate the additional financial needs relating to the implementation of key adaptation measures in the agriculture sector (or specific subsectors). In order to avoid repetition, some of the information provided in Chapter II that is relevant to all sectors is not included in this chapter. Prior and careful reading of Chapter II is therefore highly recommended before starting with this chapter in detail.

Step #1: Establish key parameters of assessment

>>> Define detailed scope of the sector

In this step, the precise components of the agriculture sector that are to be considered for I&FF assessment must be defined. The agriculture sector includes both production and processing[104] of food crops (food for humans and fodder), animals and their products, floral crops and nursery plants, biofuel crops (e.g., maize, sorghum, switchgrass),[105] 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). Crops maybe classified as perennial or annual, and both cropping systems and animal systems may be classified as an intensive or extensive production system.

Countries may choose to limit the analysis in several ways, for example:

- To include only some agricultural subsectors or even some production stages or processes within a given subsector (e.g., oilseed production or edible oil production),
- To consider some specific crops or animal species/breeds only.
- To focus on specific agroecological regions, rather than on the entire country.

Which components are included should depend on a number of factors:

- First, national circumstances will determine to a large extent the selection, e.g., taking into account the contribution of the components to present and future food supply and food security, and their contribution to the national economy and potential for economic growth.
- Secondly, crop/subsector/process vulnerability and productivity changes due to climate change (including current stressors) should be considered.

Thirdly, opportunities for effective adaptation,[106] and their relationship to national and sectoral development plans should be taken into account.

- Finally, the 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 analysis of adaptation options for the National Communications, National Adaptation Programmes of Action (NAPAs), and other adaptation assessments that have been completed.

[104] In general, production encompasses all activities up through harvest or until slaughter; processing encompasses all activities from just after harvest, or just before slaughter, until the product reaches market. With "on-farm" consumption, production is extended through both harvest and slaughter.

[105] Production of woody biofuel crops is covered in the forestry adaptation chapter (Chapter VI). However, countries may choose to also include woody crops here, especially if they choose to include agroforestry as an agriculture adaptation option, although care must be taken to avoid double counting of I&FF.

[106] It is assumed that countries have already undertaken a thorough assessment of the impacts of climate change on agriculture, and of adaptation options.

Climate change may also have favourable effects for the agricultural sector, e.g., reduced frost incidence leading to higher crop yields, and favouring the adoption of more profitable crops or varieties. While these kinds of impacts are well documented for industrialised countries, there is little evidence on their relevance and incidence for developing countries. Furthermore, even if some beneficial effects may be brought by climate change, under an adaptation scenario countries may face incremental costs (rather than net benefits) for specific types of investments or financial flows. For all of the above, it is up to country teams to select and identify climate change impacts that lead to reduced I&FF (i.e., that yield net benefits rather than net incremental costs), if any. For example, reduced frost incidence may reduce the need for farmers' compensation programmes in an adaptation scenario. Estimating the investment and financial flows impacts of such effects may or may not be of interest for the country, e.g., depending on the economic and social relevance of such programmes under a baseline scenario.

Important linkages between adaptation measures adopted in the agriculture sector and impacts in other sectors should also be noted, particularly since agriculture has significant linkages with other sectors and because I&FF assessment takes a sector by sector approach (rather than a macro analysis where these cross-sector impacts would typically be acknowledged). This implies the need to make specific efforts to avoid double-counting of I&FF (e.g., if one infrastructure investment has impacts both for agriculture and other sectors considered in the assessment), reduce the scope for inconsistent results between sectoral assessments, and to permit a full assessment of adaption measures that would result in significant damages in other sectors. Particular attention should be given to potential overlaps with the water, energy, coastal management, transport, fisheries and forestry sectors, as well as to the treatment of the inputs used to implement agriculture adaptation options. The agriculture sector is linked to the water management sector, for example through investments in infrastructure such as canals. If one adaptation measure in the agriculture sector involves such investment, care should be taken in not computing them twice (in both sectors). A convention on how to allocate such investments among sectors should be mentioned. Another key sector where overlapping may arise is the energy sector (e.g., due to biofuel production).

>>> Specify assessment period and base year

This methodology recommends using 2005 as the base year, and 2030 as the end point for the analysis. If another year must be taken as base year due to data limitations or other national circumstances (e.g., 2005 being a bad or untypical year), the assessment period should still be approximately 25 years in length. This recommendation is based on the need to take into account the long lifetimes of infrastructure.

>>> Identify preliminary adaptation options

A preliminary set of adaptation options must be identified for each agricultural component (e.g., subsector) included in the assessment. Table 8-1 presents a list of general options[107]. The selection of adaptation options should be based primarily

[107] Further examples may be found in the following sources: IPCC (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Perry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.), Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 976pp. Accessible at:

on national priorities and sector plans as well as on the results from prior analyses of adaptation options (e.g., studies conducted for the first and/or second national communications) regarding technical feasibility, logistical feasibility, and sectoral acceptability of the options.

In order to prioritize adaptation measures, consideration should also be given to key criteria such as: potential economic, social, and non-GHG environmental benefits and costs of the options (e.g., agroforestry may not only help minimise erosion but also increase yields; crop or agricultural practice changes may not only reduce vulnerability due to increased drought but also help diversify and increase income, etc.), cost effectiveness, economic importance of crops/agro-ecological systems involved and replication potential. The criteria used for prioritization should be indicated.

It is also recommended that co-benefits of adaptation measures be discussed explicitly. This does not call for detailed quantification of impacts but requires to present summary information (e.g., in a one-page box format) of the types and relative importance or magnitudes of those benefits.

The selection of research, education, assistance, infrastructure, and institutional options may also be based on national and sector development plans and goals. The adaptation options should be eventually defined at a more detailed level than those listed in Table 8-1 so that I&FF, and O&M costs can be estimated in Step 6. For example, if an expanded seasonal weather forecasting system is a selected adaptation option for improved (less vulnerable) crop production, the scope and scale of the forecasting system should be specified, including equipment and labor needs.

The result of this identification and prioritization exercise, would be a short list of mitigation options (e.g., no less than 5 and ideally no more than 10 options for the sake of tractability and in order to keep the policy discussion of the last section manageable).

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http://www.ipcc.ch/ipccreports/assessments-reports.htm.

B. McCarl (2007): Adaptation Options for Agriculture, Forestry and Fisheries, a report to the UNFCCC. Available from http://unfccc.int/files/cooperation_and_support/financial_mechanism/application/pdf/mccarl.pdf.

Table 8-1: Agricultural adaptation measures

Type of Measure	Component of Agriculture Sector	Adaptation Measure
Field-level	Crop Production (including production of human food crops, fodder, industrial crops, and biofuels)	Change crop species/varieties
		Change crop management
		Moisture management/irrigation
		Pest and disease management
		Fire management
		Land-use or enterprise choice change
	Animal Production (including both animal management and grazing land management)	Change animal species/breeds
		Change in animal management practices
		Change in pasture management practices
		Moisture management/irrigation
		Pest and disease management
		Management of natural areas
		Fire management
		Land-use or enterprise choice change
Research, education, assistance, infrastructure, and institutional programmes	Sector-wide	Research, development and demonstration (e.g., of new crops, varieties and practices)
		Extension and training
		Forecasting, early warning, and disaster management
		Transitional assistance
		Trade policy
		Infrastructure development
		Other institutional development (integration of adaptation strategies, capacity building, and improved management and governance systems)

Source: Elaboration by the authors

>>> Select analytical approach

Before defining the baseline and adaptation scenarios and estimating the associated IF, FF and O&M costs, the assessment team will need to select the analytical approach (i.e., estimation methods or models) that will be applied to this aim. Although there are numerous models for assessing the impacts of climate change on agriculture, the adaptive capacity of various cropping systems, and technological feasibility of various adaptation options[108], they will typically not be directly applicable for the study of specific scenarios and cost estimates. As a result, the assessment team will have to either elaborate and apply its own analytical approach or adapt an existing one. In view of the tight time constraints of the assessment, it would be impossible to evaluate, select and train the assessment team in a new analytical approach, and therefore the selection will necessarily be based on existing capabilities, data, and experience, in particular with regard to previous model applications.

Adaptation options and their costs, appropriateness, and feasibility are all highly site-specific issues. Given the previous experience of agriculture's adaptation to recurrent climate variability, most adaptation options are largely extensions or intensifications of existing risk-management or production-enhancement activities. As a result, the richest sources of understanding and expertise are likely to reside in the interaction between the assessment team, in-country agricultural practitioners, and other local experts.

[108] The UNFCCC *Compendium on Methods and Tools to Evaluate Impacts of, and Vulnerability and Adaptation to, Climate Change* contains an extensive list, with descriptions, of agriculture sector models for assessment of vulnerability and adaptation. This is accessible at:
http://unfccc.int/adaptation/nairobi_workprogramme/compendium_on_methods_tools/items/2674.php. Go to the link for "Sector-specific tools" at the bottom of the page for agriculture tools.

Even if there is previous experience with the application of a given model, it is unlikely that it will cover all the information and projection needs of I&FF assessment. For this reason, a simple, transparent, ad-hoc spreadsheet-based approach, relying on disaggregate in-country information and knowledge of the agriculture sector and trends are recommended. It is believed that this would prove more useful for the purpose of I&FF assessment even if this analytical path has some potential weaknesses of its own as compared to the application of an agriculture model. For example, this spreadsheet approach may show low consistency in projections and assumptions for different subsectors, as well as involve less sophisticated and accurate tools for trend/projection estimates.

In addition, consideration of 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 of high importance. Previous work on baseline development for vulnerability & adaptation (V&A) assessments (e.g., conducted in the framework of second national communication) should also be utilized. Although baselines for V&A assessments are not the same as I&FF assessment baselines,[109] as long as the sectoral scopes are similar, much of the data requirements are likely to be the same. V&A assessments do not include an adaptation scenario; however, information about adaptation options that resulted from V&A assessments (e.g., the range of temperatures that a crop variety will tolerate) should be utilized as well.

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

>>> Compile historical annual IF & 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, 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 adaptation programmes (e.g., meteorological equipment, vehicles). Financial flows would include non-asset investments, such as those involved for the development of programmes in the research and development, education, assistance, and institutional fields (e.g., to include labour costs and services).

The necessary I&FF data and information sources will likely reside in several domestic locations (e.g., teams involved in V&A assessments, and national communications, industry and ministry records and plans, statistical agencies, extension agencies, research institutions, and national accounts) and eventually with international organizations if international aid is relevant for the development of R&D and extension programmes (e.g., CGIAR). Note that the definition of the agriculture sector and its subsectors will vary among data sources, so assumptions may need to be made to reconcile datasets and

[109] Although V&A baselines have evolved from simple scenarios of population and economic growth to more comprehensive socioeconomic scenarios, they tend to be for longer periods than is used in this methodology (hence, the multiple storyline approach), and are constructed for assessing the impacts of climate change rather than the costs of adaptation measures.

extract needed data from aggregated and/or disaggregated categories. As an example of the different levels of aggregation usually encountered it is worth considering that the UN System of National Accounts (SNA) utilizes the ISIC classification system[110] 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 this reason, national communications and V&A analyses offering adaptation options cost data and sectoral sources offering the most dissagregate level of data should be given priority in order to be able to cost the adaptation options at the relevant level (i.e. investment type and programme). If dissagregate data are not available, then the team may need to resort to national accounts data and thus will have to specify the assumptions and criteria used to make cost estimates for individual adaptation measures or programmatic expenditure components.

Apart from local information sources, it is worth mentioning that 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."

[110] ISIC (the International Standard Industrial Classification of All Economic Activities) is a UN system for classifying economic data. The latest version (ISIC Rev.4) is accessible at: http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27

Table 8-2: Structure of ISIC section A: agriculture, forestry and fishing[111]

Divisions	Groups	Classes
01 - Crop and animal production, hunting and related service activities	011 - Growing of non-perennial crops	0111 - Growing of cereals (except rice), leguminous crops and oil seeds
		0112 - Growing of rice
		0113 - Growing of vegetables and melons, roots and tubers
		0114 - Growing of sugar cane
		0115 - Growing of tobacco
		0116 - Growing of fibre crops
		0119 - Growing of other non-perennial crops
	012 - Growing of perennial crops	0121 - Growing of grapes
		0122 - Growing of tropical and subtropical fruits
		0123 - Growing of citrus fruits
		0124 - Growing of pome fruits and stone fruits
		0125 - Growing of other tree and bush fruits and nuts
		0126 - Growing of oleaginous fruits
		0127 - Growing of beverage crops
		0128 - Growing of spices, aromatic, drug and pharmaceutical crops
		0129 - Growing of other perennial crops
	013 - Plant propagation	0130 - Plant propagation
	014 - Animal production	0141 - Raising of cattle and buffaloes
		0142 - Raising of horses and other equines
		0143 - Raising of camels and camelids
		0144 - Raising of sheep and goats
		0145 - Raising of swine/pigs
		0146 - Raising of poultry
		0149 - Raising of other animals
	015 – Mixed farming	0150 - Mixed farming (crops and animals)
	016 - Support activities to agriculture and post-harvest crop activities	0161 - Support activities for crop production
		0162 - Support activities for animal production
		0162 - Support activities for animal production
		0163 - Post-harvest crop activities
		0164 - Seed processing for propagation
	017 - Hunting, trapping and related service activities	0170 - Hunting, trapping and related service activities
02 - Forestry and logging	Each of these divisions is disaggregated into multiple groups and classes.	
03 - Fishing and aquaculture		

[111] United Nations Statistics Division Classification Registry, Detailed structure and explanatory notes for ISIC Rev.4, from: http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27

>>> 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. It is also worth noting that in the context of agriculture, physical assets include cropland and land for 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 adaptation 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 inputs for soil management and amendment, 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 adaption 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, agriculture ministry records and plans, industry records, statistical agencies, extension agencies, research institutions, etc.), and in FAO sources. 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.

>>> 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, reductions or exemption from trade tariffs and charges (e.g., for water access and discharge). If a country chooses to include subsidies explicitly in the I&FF assessment, annual costs of subsidies for each type of investment and cost component 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.

>>> 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 components included in the scope, including crop species/varieties cultivated, 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. Information about current environmental stressors (e.g., water shortages, land degradation), and vulnerability to climate change, should also be collected for background information.
- Characterization of agricultural processing and associated transport components included in the scope, or that might be significantly affected by adaptation such as geographic shifting of production locations on the production side of agriculture. 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. Information about current environmental stressors and projected vulnerability to climate change should also be collected.
- Characterization of adaptation options, including technical feasibility, cultural acceptability, scalability, costs (capital and O&M), and economic feasibility. Possible externalities and linkages with other sectors should be noted and a convention on how to avoid double counting should be adopted from the outset as mentioned above in section 8.2, step #1.
- 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 domestic sources mentioned above for I&FF and O&M cost data. In addition, FAO maintains several publicly available statistical databases and information systems that contain potentially useful national agricultural statistics and related information. These include:

- **FAOSTAT**[112], which contains data on crop and animal production, trade, and consumption; agricultural prices; agricultural resources (land, labour, machinery, fertilizers, agrochemicals); and food security.
- **AQUASTAT**[113], 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.

[112] http://faostat.fao.org/site/291/default.aspx
[113] 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 additional measures to adapt to 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

>>> 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. Data sources could include model output, and/or government and private sector planning documents, or estimates might be derived from historical data. This may also call for estimates or assumptions regarding the future evolution of domestic and international financial flows directed at R&D and extension programmes and their impact.

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.

>>> 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. 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.

>>> 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 Adaptation Scenario

This step entails describing what is likely to occur in each relevant agriculture component, over the assessment period, with the implementation of additional adaptation measures. It should help identify the additional adaptation measures that could be undertaken in line with the projected agriculture scenario elaborated for the Second National Communication, or in case the SNC is not available, projections from national or sector plans and projections approved by government bodies should be used. This would include comprehensive descriptions of the specific adaptation measures that could be implemented according to existing information, and the implications of those measures for the evolution of the selected subsectors and components (e.g., introduction of less water intensive crop varieties may lead to an increase in cereal production to meet anticipated demand, despite an anticipated decline in annual rainfall). The vulnerabilities that the adaptation measures are designed to reduce, and the climate changes from which vulnerabilities were assessed should be described as well even though they were part of earlier V&A analysis.

The adaptation 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 (e.g., the timing and magnitude of facility upgrades at intensive livestock operations), as well as non-asset investments (e.g., the timing, nature, and magnitude of an extension program on livestock health management). In-country expertise, and prior work on climate change adaptation (e.g., National Communications, National Adaptation Programmes of Action (NAPAs)) should be utilized in this step.

In determining and defining the set of adaptation measures that would be implemented, the preliminary set of the adaptation measures that were identified in step #1 should be re-evaluated, given the analytical approach, the other input data compiled in step #2, and the baseline analysis completed in step #3 to consider, e.g., feasibility. The initial prioritization of the adaptation measures will be re-evaluated later in step #8 in view of the results of the assessment regarding their incremental costs.

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

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

In this step, annual IF for the adaptation scenario facility and infrastructure investments, and annual FF for the adaptation scenario research, education, assistance, and institutional investments, are estimated for each of the measures and options defined in the previous step. 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 when aggregated over time, they should be discounted using the relevant public or private discount rate. 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.

The output of this step will be a stream of annual investment flows and/or financial flows for each investment and financial flow 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.

>>> 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 of the measures and options defined in the previous step. 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.

>>> 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 Adaptation options

The changes in IF, FF, and O&M costs that are needed to implement the adaptation measures in each component are calculated in this step by subtracting baseline scenario costs from adaptation 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 provided estimates of the magnitudes and timing of changes in IF, FF, and O&M by each investment entity that would be needed to implement the adaptation measures in each subsector. The respective institutions responsible for I&FF and their funding sources (domestic and foreign; public and private) are also identified for the different investment and cost types.

Firstly, the team will need to evaluate how likely would be the implementation of the measures included in the adaptation scenario. To this aim, it is recommended that countries first re-evaluate their initial prioritization of the adaptation measures that was undertaken in step #5 in the light of the incremental cost estimates (which may cast doubts on their feasibility or acceptability), and further, a cost-effectiveness analysis of the options may be in order. Further to this, the team will need to determine which investment entities are responsible for the most significant (largest and/or highest priority) changes in I&FF, and the extent to which suitable sources of funds are available or could be identified to meet incremental needs.

The team should also at this stage identify the implementation barriers (financial, informational, disincentives, etc.) faced by each adaptation option, specifying to what extent these barriers affect the individual public and private investment entities and investment types identified in the previous step.

Finally, a discussion of the policy measures that might be used to induce those entities to implement the proposed measures and change their investment patterns (eg. through incentives/planning/guidance/information campaigns, etc.) should be offered. Policy measures include a variety of instruments, including economic instruments (e.g., taxes/subsidies), regulatory instruments (e.g., zoning regulations, technology standards, mandatory practices, etc.), voluntary agreements, information dissemination and strategic planning, and research, development, and demonstration (RD&D) programmes both funded by the public and the private sectors.

The discussion should help identify:

i) the most relevant policy instruments to induce the implementation of key adaptation measures by private sector entities (e.g., to adopt priority adaptation practices such as changes in crop varieties and practices), and

ii) the priority public programmes for adaptation (e.g., new extension programme on new crop varieties) and their associated institutional needs (and assess the extent to which they can be met).