Economics of Agricultural Adaptation to Climate Change: Tools for Informed Decision-Making

Chase A. Sova

Climate change affects agriculture worldwide, endangering rural livelihoods and threatening food security. International funds are increasingly available for initiatives aimed at adapting agriculture to climate change, and numerous international studies have been conducted on the economic costs and/or benefits of such efforts. However, these studies have adopted a primarily global and multisectoral approach that involves complex econometric modeling. Pragmatic, high-resolution approaches to analyzing the costs of agricultural adaptation are therefore needed to obtain information that is sufficiently detailed for effective decision-making. This *Brief* describes different types of modeling available for conducting cost analyses.

Key Messages

- The costs and benefits of adaptation interventions should be measured through **participatory approaches** that identify **indicators relevant to key stakeholders** at the chosen level of analysis.
- **Global and national approaches** to adaptation cost analysis provide useful estimates of the economic costs of adaptation but **do little to support local decision-making**.
- Economic tools that estimate the costs and benefits of adaptation interventions can help stakeholders at all levels **make informed decisions** on the most cost-effective adaptation measures.
- Because of increased visibility and funding, **international support** for adaptation initiatives **is increasingly available**.
- **Adaptation to climate change is urgently needed** to respond to current climate-change risks and to increase the resilience of agriculture in the future.

Climate-change adaptation

The impact of progressive climate change on the world's agricultural sector is of great concern to policymakers, development experts, and farmers alike. In developing countries with economies based on agriculture, rising temperatures, unpredictable rainfall, and extreme climatic events are particularly damaging to rural livelihoods and national food security. The United Nations Framework Convention on Climate Change (UNFCCC) has assigned high priority to climate change adaptation for protecting our most vulnerable populations. Adaptation is urgently needed to reduce the impact of climate change today and to increase the resilience of agriculture in the future.

Weighing the options

Because of better visibility and funding, support for adaptation initiatives at the national and local level is increasingly available. However, resource availability has yet to translate into improved adaptive capacity in the agricultural sector. This failure can be attributed to several factors, but one in particular has stalled decision-making processes: the need to know which adaptation strategies are the most cost-effective. This question is more than appropriate, considering the multitude of adaptation options available to stakeholders in agriculture. As the UNFCCC has outlined, adaption strategies may fall within one of the following general categories:

- Behavioral changes
- Adaptive management strategies
- Technological and engineering options
- Risk management or risk reduction strategies (including financial instruments)
- Ecosystem management

To help decision-makers navigate these options, several international organizations have, over the past decade, attempted to provide estimates of the costs and/or benefits of adaptation to climate change. To help make sense of this wave of "costing" initiatives, this *Policy Brief* provides an objective review of the most commonly applied methodological approaches. It also offers recommendations on choosing key characteristics of adaptation cost studies to provide a basis for selecting from currently available tools and establishing a foundation for future analysis.

Methodological review

The demand for analytical tools to assess economic impact and prioritize interventions has led to a growing body of literature on *adaptation costing*. Broadly speaking, initiatives can be divided according to geographic scale, that is, global, national, or subnational. The overview below discusses the most commonly applied methodologies at each level, together with a general assessment of the pros and cons of each approach (Table 1).

Table 1. Summary of approaches to costing agricultural adaptation to climate change.

(A) Global analyses

Type of analysis	Pros	Cons
Investment and financial flows (IFFs)	• Provide basic estimates of the complete cost of adaptation • Successful in mobilizing initial funds for adaptation	• Arbitrary markup factor, usually 10%, is applied to "climate-proof" investments • Significant assumptions in identifying "climate-sensitive" investments • Applies fixed methodology to different sectors • Results not verifiable at the local level • Subsequent studies borrow heavily from initial World Bank model, creating a misleading convergence of results
Integrated assessment models (IAMs)	• Translate climate science into economic impact • Allow flexibility in the inclusion of social models • Allow for strong empirical analysis	• Rely on "black-box" computer-generated algorithms • Built on significant assumptions about the relationships between scientific and socioeconomic indicators • Suited only for long-term climate-change analysis • Results not verifiable at the local level

(B) National and subnational analyses

Vulnerability-based assessment (VBA), including 45 national adaptation programs of action (NAPAs)	• Replicable process for identifying inputs and costs for urgent adaptation interventions in least developed countries (LDCs) • Pragmatic, country-led processes integrated into global policy through UNFCCC	• Quality of NAPA assessment varies between countries • No assessment of adaptation benefits
Ricardian analysis	• Pragmatic approach to cost analysis • Allows for analysis at the local level • Uses available patterns of observed behavior	• Assumes farmers aim to maximize profits • Places insufficient weight on institutional, social, and economic factors when assessing changing production systems • Relies on global climate models and climate technology to identify analog sites for comparison
Computable general equilibrium (CGE) models	• Capable of capturing impact between sectors • Translates climate science into economic impact • Allows for strong empirical analysis	• Relies on "black-box" computer-generated algorithms and social accounting matrices (SAMs) • Built on significant assumptions of the historical equilibrium between sectors and indicators • Suited only for long-term climate-change analysis • Not verifiable at the local level
Traditional cost/benefit analysis (CBA)	• Provides a graphic representation of the cost/benefit relationship • Useful for quick, basic reference by decision-makers	• A static analysis that relies heavily on indicator availability • Can measure only known and identifiable interventions • Can analyze only discrete interventions; not variations of the same measure • Limited in its ability to measure nonmarket factors (i.e., social welfare) • Rarely exhaustive in the analysis of possible interventions

Global adaptation costing

Global studies typically define costs as "the additional resources that society expends in reacting to climate change." Most global initiatives provide only general prioritization schemes for interventions and do not attempt to value the benefits of adaptation. Global approaches to adaptation costing can be broadly divided into either (1) investment and financial flows (IFFs) or (2) integrated assessment models (IAMs).

Investment and financial flows. These are the total funds, both public and private, destined for programs and operations in any global sector (the total capital allocated to support irrigation in agriculture, for example). The World Bank pioneered the "first-generation" IFF model for analyzing the costs of adaptation. They identified "climate-sensitive" investment flows and applied a markup factor to represent the cost of "climate-proofing" these investments. By aggregating the costs for multiple sectors, the World Bank arrived at an overall estimate for an annual investment in adaptation. The IFF methodological framework has since been adapted and built upon by numerous institutions, who mostly confirmed the initial estimates.

Integrated assessment models. Although this category has grown to absorb several related approaches, integrated assessment is a generic term that describes the combination of different analytical models within a single analysis. IAMs are computerized tools that use complex algorithms to predict the impact that climate data will have on selected socioeconomic models. Most studies have applied IAMs to identify the yearly economic costs of climate change, the economic costs over time, or the cost per unit of greenhouse gas (GHG) emissions (Table 1A).

National and subnational adaptation costing

Adaptation cost analyses on national and subnational levels are more diverse. These studies use multiple definitions of adaptation costs, often including more detailed analyses of opportunity costs when sufficient data are available. In contrast to global approaches, national and subnational studies sometimes approximate adaptation benefits, even though, at this level, complete cost/benefit analyses for intervention prioritization are infrequent. Despite several studies adopting hybrid approaches, four distinct methodological tools can be distinguished: (1) vulnerability-based assessment (VBA), (2) Ricardian analysis, (3) computable general equilibrium (CGE) models, and (4) traditional cost/benefit analysis (CBA).

Vulnerability-based assessment. A prime example of VBAs comprises national adaptation programs of action (NAPAs). These are designed by international partners to provide "least developed countries" (LDCs) with priority activities that respond to urgent and immediate adaptation needs. The NAPA process results in detailed project descriptions and costs for adaptation in several sectors. It takes into account interventions only at the grass-roots level rather than focus on scenario-based climate modeling or econometric principles. As of February 2011, 45 LDCs have completed the NAPA process.

Ricardian analysis. Using patterns in agricultural production systems for several climates, this type of analysis predicts how farmers are likely to adapt to climate risk. The methodology applies the basic principle that farmers will always choose those production portfolios that maximize their profits. On this assumption, the analysis establishes the climate future of a site selected for analysis, site A, and identifies an analog location, site B, in the country that currently mimics that climatic future. It then assesses the impact of adaptation by estimating the costs of changing the production system at site A to that found at B. The benefits of adaptation can be determined by calculating the changes in net revenue that would result from the shift in production systems.

Computable general equilibrium. CGE models have been used at national level to provide decision-makers with economic substantiation of the effects of climate change, particularly across sectors. The CGE is a type of integrated assessment that relies on principles of market equilibrium (supply = demand) to drive the analysis. Time series data (household income, GDP, agricultural market prices, etc.) are used to feed internal variables into a computerized model. An external variable(s), typically a change in crop yield due to climate change, is then selected to "shock" the model. Social accounting matrices (SAMs) rearrange the internal variables according to the magnitude of the shock to return the system to equilibrium. The model's output thus comprises adjusted internal variables, which provide an empirical assessment of climate change impacts.

Cost/benefit analysis. Traditional CBA has also been applied to climate-change adaptation interventions at the national level. The Economics of Climate Adaptation Working Group (ECA) has been particularly successful in applying this approach, developing a methodology that explicitly compares the costs and benefits of competing adaptation strategies. Costs are typically identified using inputs from NAPA-style project costing; and benefits are measured, using immediately available economic indicators. The resulting analysis provides a cost curve, prioritizing interventions according to their cost per unit of benefit. Graphically, the most efficient interventions (highest return) are closest to the "y" axis with the progressively more costly measures tracking away (Table 1B).

Resulting implications

Given the evolution of methodologies, the following implications and key characteristics of cost analysis studies on agricultural adaptation have been identified. These observations highlight the gaps in costing research but also serve as criteria to assess the suitability of current approaches.

- Adaptation costing studies should clearly define the working definitions of both adaptation costs and benefits to ensure that the impact of interventions is assessed according to the same criteria.
- The study baseline must be identified with caution. Because of population growth and increasing household incomes, projects and policies dealing with climate-change adaptation (adaptation deficit) will need to take into account the already necessary growth (development deficit). The requirements for "business-as-usual" (BAU) development need to be reflected in this baseline.
- Studies should be demand driven and participatory, involving stakeholders from the entire agriculture supply chain. Above all, adaptation policies and projects need to be assessed for their impact on the most vulnerable stakeholders.
- Studies should seek to measure both the costs and benefits of adaptation interventions, ensuring that the resulting measures are appropriately prioritized and integrated into national development plans. These measures will also allow government and development practitioners to demonstrate informed, empirical decision-making to potential donors.
- An appropriate mix of quantitative and qualitative assessment tools should be used in studies to ensure that the wider socioeconomic and environmental effects of interventions are captured and that barriers to project implementation can be identified. Qualitative assessment complements in pragmatic ways the assumptions and uncertainties inherent to climate analysis.
- Methodologies should be capable of assessing the economic impact of both hard (infrastructure) and soft (capacity building, policy changes, etc.) adaptation interventions.
- Costing studies specific to the agricultural sector are preferable to those that apply analysis across a variety of sectors. However, attention must still be given to the cross-sectoral effects of agricultural adaptation policies or projects.
- Finally, costing analysis, where possible, should measure the economic impact of both adaptation and mitigation, as the most appropriate development plans will include elements of both.

Towards an inclusive cost/benefit analysis approach

The key observations in this *Brief* are reflected by a new approach to adaptation cost analysis developed in the last decade, which is known as *social return on investment* (SROI). It is currently being studied by CIAT and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). A modified CBA, this approach measures change in ways that are relevant to people or organizations experiencing or contributing to it. SROI is participatory, perspectives-driven, and is designed to capture the social and environmental effects of interventions for adaptation and/or mitigation in ways that traditional cost analyses cannot. For more information on SROI analysis, see www.thesroinetwork.org.

The International Institute for Environment and Development (IIED) is also researching practical and locally relevant approaches to cost analysis of adaptation strategies through a new initiative in stakeholder-focused CBA. For more information on IIED's Climate Change Group, see www.iied.org/climate-change/home.

Policy recommendations

Given the many options available for agricultural adaptation, economic tools that analyze the cost and benefits of competing interventions should be used to prioritize measures and to demonstrate informed, empirical decision-making to potential donors. When reviewing cost analysis studies or applying costing methodologies, the following key elements should be considered:

1. Intervention "costs" and "benefits" are clearly defined.
2. The impact of interventions is measured, using indicators that are relevant to the most vulnerable stakeholders.
3. Qualitative assessment should complement quantitative studies to avoid purely "black box" empirical analysis of already uncertain climate data.
4. The methodology needs to be equally suited for analyzing both "hard" and "soft" interventions.

Selected reading

Agrawala S; Fankhauser S. 2008. Economic aspects of adaptation to climate change: costs, benefits and policy instruments: executive summary. Organisation for Economic Co-operation and Development (OECD), Paris, France.

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For more information

Chase A. Sova is a member of CGIAR's Research Program on Climate Change, Agriculture and Food Security (CCAFS) and a visiting researcher in CIAT's Decision and Policy Analysis (DAPA) Program in Cali, Colombia. **c.sova@cgiar.org**

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