



# Mainstreaming Adaptation to Climate Change in Agriculture and Natural Resources Management Projects

Climate Change Team  
Environment Department

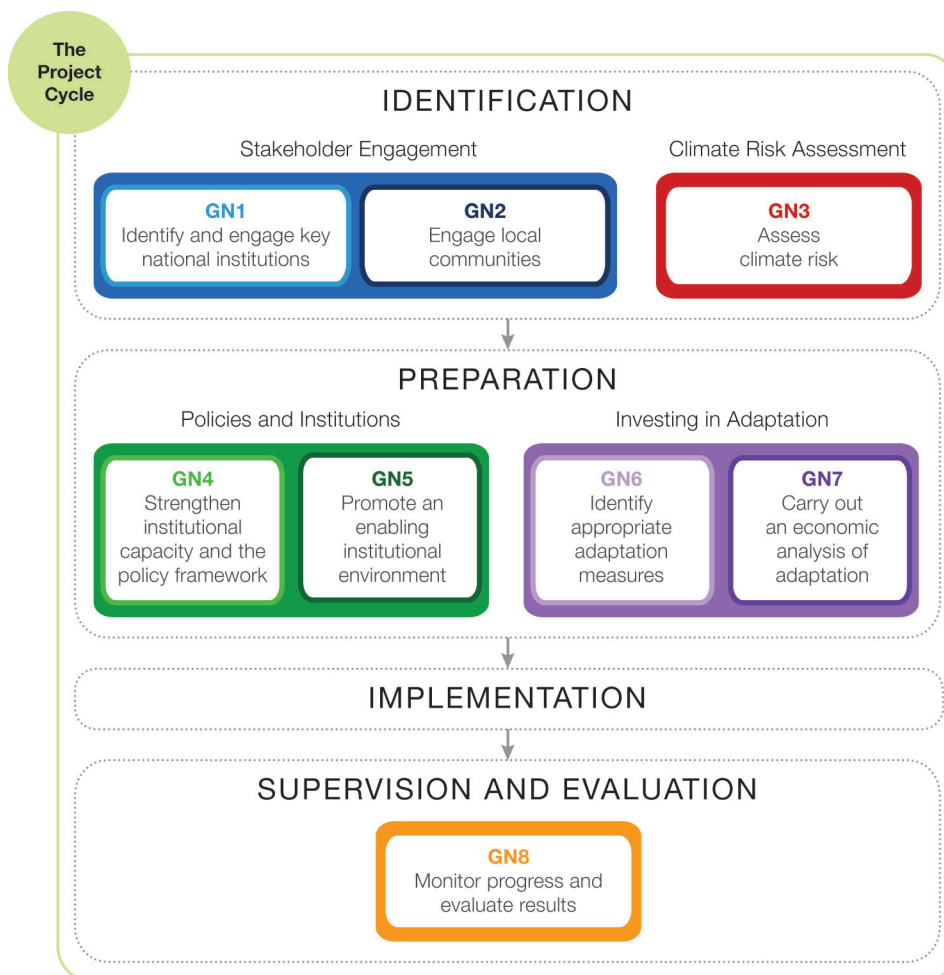
## Guidance Notes



# Guidance Notes

## Mainstreaming Adaptation to Climate Change in Agriculture and Natural Resources Management Projects

This series presents eight guidance notes (GN1 - GN8) that provide lessons learned, best practices, recommendations, and useful resources for integrating climate risk management and adaptation to climate change in development projects, with a focus on the agriculture and natural resources management sectors. They are organized around a typical project cycle, starting from project identification, followed by project preparation, implementation, monitoring and evaluation. Each note focuses on specific technical, institutional, economic, or social aspects of adaptation.



# Evaluating Adaptation via Economic Analysis



The main objective of this guidance note is to present various methodologies aimed at carrying out an economic evaluation of adaptation investments in agriculture and natural resource management (NRM), and provide some guidance in selecting the most suitable approach for the project under consideration. The problem of economically evaluating adaptation to climate change at the project level can be disaggregated into three distinct subtasks, namely: (a) evaluating potential impacts that climate change could have on agricultural productivity in the project area, assuming either only autonomous adaptation or no adaptation at all; (b) evaluating costs and benefits of possible planned adaptations; and (c) factoring in the implications of uncertainty with respect to the choice of specific adaptation options. This note is entirely based on a forthcoming 2009 World Bank report addressing this issue.

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## A. Introduction: Challenges in evaluating adaptation initiatives in agriculture

The main challenges for a project-level economic evaluation are briefly discussed below.

### Estimating the economic benefits of adaptation to climate change

The first issue concerns estimating expected impacts from climate change in the absence of *adaptation*\*. The relationships between greenhouse gas concentrations, temperature increases and climate patterns are very complex and partly arbitrary, depending on the region of the world. Different *global climate circulation models* (GCMs) can be more or less consistent with respect to the direction of changes, and this uncertainty has implications on the reliability of projections at the subregional level, obtained from GCMs via downscaling techniques (see GN3, Annex 3). Moreover, like other environmental issues, evaluating physical or ecological changes in monetary terms (i.e., biodiversity loss, loss of critical environmental services, etc.) remains a challenge.

The second issue concerns estimating the expected damage avoided through adaptation investments. The expected damage, or gross benefit, of adaptation is the difference between climate change-induced damages with and without adaptation. Given the limits in estimating, with reasonable approximation, expected local impacts from climate change in the absence of adaptation and a general inexperience regarding the effectiveness of adaptation measures in terms of avoiding damages, evaluating the gross benefits of adaptation investments can become a sophisticated guesswork. Moreover, *autonomous adaptation* should be factored in the analysis by defining the “baseline” or “without project” scenario. Finally, while evaluating the economic benefits of *hard adaptation* is relatively straightforward (although not trivial in practice) because a direct relationship can be constructed between inputs provided by the physical investment (i.e., water supply from a dam) and production output, *soft adaptation* is more complicated because benefits, to a great extent, must be inferred from resulting changes in private sector behavior and prices.

### Factoring uncertainty in the analysis

Given the abovementioned reasons, uncertainty needs to be factored into the economic analysis. Nevertheless, many existing methods for economic evaluation under uncertainty (such as probabilistic cost-benefit analysis) rely on probability distributions, which are not known in the

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\* For words in italics, please see Glossary for definition.

case of climate change (see Annex 1). Moreover, the need for modeling uncertainty will differ depending on the level of regret of the investment (see GN6, Part 3a). Many, if not most, of the needed adaptation investments, especially in the agricultural sector, are *no-regret* or *low-regret*, as they will bring benefits irrespective of how much the climate changes. On the other side of the spectrum, there are responses that largely have benefits only in the context of climate change risks, such as infrastructure projects (e.g., dams, dikes) that proactively respond to projected changes in factors such as runoff and sea level rise. Only the latter must explicitly consider the uncertainty of climate change, and the costs and benefits of adaptation, in the evaluation.

### **Isolating costs and benefits of adaptation from costs and benefits of other projects**

For a stand-alone adaptation project, both benefits and costs can be assessed relative to a no-project alternative. For a project that integrates adaptation within a broader set of development activities, the comparison would be made relative to a business-as-usual project without adaptation components. In either case, but especially in the latter, there is an inherent subjectivity and need for expert judgment in defining the hypothetical alternative as a basis for comparison.

### **Choosing the discount rate**

The choice of discount rate for evaluating costs and benefits of adaptation investments is subject to debate. In the case of projects with a short time horizon (20–30 years), discount rates should not be controversial, as the costs and benefits of adaptation measures are usually closer together in time, and ancillary benefits of investments make projects similar to other public investments. For example, in the case of investments in sustainable land management, benefits materialize quite rapidly and a standard discount rate for other public investments can be used, reflecting the social opportunity cost of capital. In some cases, including for particularly large-scale water resource infrastructure for storage and irrigation, adaptation investments have longer time horizons (e.g., 50–100 years). Some analysts have called for using a lower discount rate than the conventionally defined social opportunity cost of capital in evaluating such projects, but arguments exist both in support of and against this practice.

### **Deciding when to invest in adaptation**

Decision makers have a choice about when to invest, as well as how much and in what form. The argument for more rapid investment is strengthened when investment has high co-benefits in reducing a current adaptation deficit. More generally, however, deciding how much to adapt now, versus waiting to do more after gaining additional information on the impacts of climate change and the options for ameliorating those impacts, is not an easy decision given the uncertainties discussed above.

## B. Assessing the impacts of climate change on agricultural projects

When evaluating the impacts of climate change on agriculture, two approaches—the agronomic (or crop) model and the Ricardian (or hedonic) model—have become the most widely used in applications to country studies and projects dealing with climate change impacts and adaptation in agriculture. A third methodology, developed for application to natural disasters, is promising for estimating the impacts of climatic extremes (i.e., floods). See also Tools for a summary table of all methodologies described in this note.

### Agronomic models

Agronomic models are biophysical representations of crop production simulating the relevant soil-plant-atmospheric components that determine plant growth and yield. They can be used to assess the impacts of climate change on agricultural productivity, as well as to investigate the potential effects of different adaptation options, as specified by the analyst. Crop models can be part of more complex “integrated models”, where different components (i.e., climate, water balance, crop production and economic modules) interact with each other. In particular, agro-economic models include an economic module, and can be used to assess the economic impact of climate change on agriculture and reduced economic losses for farmers from implementation of particular adaptation practices. Costs of autonomous adaptation that fall on individual farmers can be accounted for (i.e., cost of fertilizers, energy costs for irrigation, etc.), while costs of planned adaptation (i.e., the investment cost of a water reservoir for irrigation serving a vast area) cannot be included in such farm-level assessments. See Annex 2 for more information on characteristics, advantages and disadvantages of using these models.



## Ricardian models

Ricardian models are economic models based on the idea that the long-term productivity of land is reflected in its asset value. The impacts of different influences on land value, including climatic differences, are econometrically estimated using cross-sectional data. After estimating how climate conditions (i.e., changes in temperature or precipitation) affect land values, it is possible to use climate scenarios to infer the impact of climate change on the value of farmland and, hence, its productivity. An important characteristic of this methodology is that the findings on longer-term climate change impacts incorporate autonomous adaptation responses to climate change that individual farmers are able to undertake over the longer term. The approach assumes that, over the longer term, a new climate regime will induce geographic redistribution of agricultural activity and other behavioral changes that are reflected in how farmers have adapted to different climate conditions in different geographical areas in the past. See Annex 3 for more information on characteristics, advantages and disadvantages of using these models.

The use of both crop and Ricardian models for project-level economic analysis is generally constrained by their complexity and data requirements, but there are examples of applying such models at the project level (see Annex 4). A simplification of these models, the possibility of applying results from other areas with similar characteristics (“benefit transfer”) and the development of a more user-friendly interface would constitute welcome advancements toward more widespread application of these tools at the local level, despite possible trade-offs with the precision of results.

## Probabilistic methods for impact assessment of extreme events

The literature and practice in the disaster risk reduction field suggest another method for estimating expected economic losses due to climate change, as well as economic benefits of adaptation measures. This method was developed for application to natural disasters and, hence, is immediately applicable to impacts of climatic extremes (i.e., floods). An “exceedance curve” showing the relationship between intensity and probability of a certain event (i.e., flood) is at the core of this technique, which allows for the probabilistic estimation of monetary losses due to natural disasters. See Annex 5 for more information on this technique. However, the reliance of this method on probability functions makes its use challenging in applications to extreme climate events because of the lack of observations for estimating historical probabilities and uncertainty over future probabilities of occurrence under climate change (see Annex 1).



## C. Evaluating costs and benefits of adaptation

Assessing costs and benefits of adaptation measures in agriculture can be done either within a cost-benefit economic framework, or by taking a non-economic evaluation approach. In both cases, some measures of costs and benefits need to be estimated, for which some guidance is provided below. If a cost-benefit framework is applied, another issue relates to the choice of the discount rate. This section ends with a discussion of the Multiple Criteria Decision Analysis approach as an alternative to the cost-benefit analysis approach. See Tools for a summary table of all methodologies described in this note.

### Estimating the costs of adaptation

The first decision to be taken with respect to *adaptation costs* is whether or not they should be considered as part of overall project costs, or whether they should be estimated as distinct and additional to other project costs.

For stand-alone adaptation projects or projects with a separate adaptation component, additionality of costs and benefits of adaptation may be useful to estimate in some cases. This can be important, particularly when alternative project designs exist with different benefits and costs that can then be compared. One way to identify the additional investment needs for adaptation activities is through expert judgment. For example, a “gap analysis” of an existing development project can be utilized to pin down which additional investments the adaptation project needs in order to increase its resilience to climate change by a specific degree (see Annex 6 for an example from an irrigation project in China). Otherwise, additional investment needs can be estimated through specialized models, but this approach is likely to be too complex for project-level analysis. Unit costs of specific adaptation measures can be piggy-backed from an in-depth analysis of past projects that financed the same types of interventions, which would be needed for adaptation purposes, such as irrigation, agricultural extension and flood protection (see Annex 7 for irrigation investments per hectare from a review of World Bank projects).

In the case of development projects that fully integrate adaptation into their design, it might be possible in principle to consider a hypothetical alternative project designed with less adaptation integrated into it, but such an effort would have little meaning and it would be more valuable to compare alternative project designs per se. If for any reason (i.e., access to dedicated financing for adaptation) additional adaptation costs of an integrated project must be evaluated and the project design does not make their identification possible, an educated guess can be made of the percentage of project costs that can be allocated to adaptation. For example, the Integrated National Adaptation project in Colombia (see Annex 8) calculated the additional costs of adaptation by comparing the total project costs with the costs of existing

projects with similar purposes implemented in the same areas, but without consideration of climate change.

In some circumstances, it may also be important to get an idea of the costs of autonomous adaptation (i.e., to calculate which economic incentives could be offered to farmers to compensate them for additional costs). A possible approach is based on the solicitation of information directly from the local communities, which are vulnerable to climatic risks and take adaptation-relevant decisions. An interesting methodology, based on participatory appraisal methods, is presented in Annex 9.

### Estimating the benefits of adaptation

The challenges associated with evaluating benefits of hard and soft adaptation investments are similar to those faced in evaluating such investments in other types of development projects. As mentioned in the introduction, evaluating the economic benefits of hard investments is conceptually straightforward because of the direct relationship between inputs provided by the physical investment (i.e., water supply for irrigation from a dam) and production output (agricultural produce). Soft adaptation, on the other hand, is more complicated as benefits to a large extent must be inferred from resulting changes in private sector behavior and prices. Assumptions based on experience and informed judgment must be made about how specific interventions (e.g., agricultural innovations, training programs or policy reforms) could alter farmers' decision making, outputs and economic returns (see Annex 10 for methods for ex-ante evaluation of agricultural innovations).



Co-benefits of adaptation investments also need to be considered in the economic analysis. For example, improved agricultural land management practices to prepare for climate change can also lead to reduced erosion/siltation and carbon sequestration. Co-benefits become particularly important in the economic evaluation if they otherwise would not be reflected in the project appraisal. This is typically the case if the co-benefits have the nature of public goods. An investment in improved water management for adaptation in agriculture, for example, can yield a stream of “private” benefits for the farmers, who are the primary beneficiaries of the project. Additionally, such investment may also convey “public” benefits for other categories of users, such as municipalities. Estimates of these co-benefits can be included and strengthen the overall case for the project. Of course, the contrary is also true, and some adaptation investments may entail negative spillovers (e.g., increased irrigation upstream may limit water availability downstream), which should also be considered. Finally, a project designed for other purposes may also deliver increased climate change resilience as a co-benefit, even without a specifically identified adaptation component. For example, improved water management may add to yields in the near term and generate additional value in the longer term by reducing climate-related risks if climate change is expected to decrease water supplies or make them more erratic.

### **Choosing the discount rate for evaluating longer-lived adaptation benefits**

The practice of applying lower discount rates to long-term net benefits of adaptation has both supporters and critics. Supporters argue that lower discount rates are justified by ethical considerations and/or by reasons linked to future uncertainty. For example, with a “high” discount rate, it will be difficult to justify almost any policy that imposes costs on society today but yields benefits only fifty to a hundred years from now. In addition, the possibility of an increase in rare disasters would yield “fat tails” in the probability distribution of future real interest rates, and thereby considerably reduce the current effective discount rate. Critics, on the other hand, are concerned with the consequent distortion in the allocation of scarce resources among investments with different future benefit streams (a project with more immediate benefits could be penalized in comparison with a project with long-term benefits, even if from a societal benefits’ point of view the former might be preferable).

The recommended discount rate depends on the characteristics of the project. Arguments for using lower longer-term discount rates depend, in part, on the project being of such significant value to the well-being of future generations that few alternative investments exist for accomplishing the same end. For the majority of primarily local-scale adaptation projects in agriculture and NRM, this condition is unlikely to be met. Hence, in most cases, whatever conventional discount rate is used for other projects in a particular country or region should

also be the default rate for adaptation projects. Use of lower longer-term discount rates should be limited to large-scale projects that arguably have long-term effects on the sustainability of people and/or natural systems, with few if any practical alternatives (for example, displacement of large populations from flood-prone areas or conservation of biodiversity that is likely to be lost forever as a consequence of climate change). Lower discount rates in such cases should be subject to a sensitivity analysis for comparison with a conventional present-value calculation. This would allow examining how sensitive the economic valuation might be to the valuation of long-term benefits and then making a judgment regarding the emphasis they should be given in project selection. Alternatively, to limit the distortion caused by lower discount rates over the life of the project, one can use a discount rate that declines over time, which is referred to as “hyperbolic” discounting.

### **Evaluating an adaptation project via non-economic approaches**

In many cases, information on the monetary value of potential benefits from adaptation or the likelihood of being realized is scarce and significant amounts of informed judgment must be substituted. For example, in gauging the impacts of climate change on ecosystem services and the benefits of adaptation measures (i.e., to combat land degradation), one approach might be to conduct structured interviews with affected local citizens who collectively could possess a great deal of qualitative information on how prior changes in ecosystem conditions affected productivity. This may be more useful than seeking to directly gauge an economic value of avoided ecosystem damages through survey-based methods. Moreover, often decision makers need or want to evaluate alternatives across a range of different and potentially incommensurate criteria. This is especially true in the context of agriculture and climate change where an adaptation project can help reduce the negative effects of climate change on a number of social, environmental and economic indicators. In such cases, the application of a cost-benefit analysis is not recommended and alternative approaches, such as Multiple Criteria Decision Analysis, can be more useful (see Annex 11).

## D. Accounting for future uncertainty

As already mentioned, the need for modeling uncertainty will differ depending on the level of regret of the investment (see Introduction). Economic evaluation with uncertainty usually takes the form of considering a set of future scenarios judged to have various degrees of likelihood. More sophisticated extensions of this approach will postulate explicit probability distributions for key factors, construct an implied distribution of results (in terms of net present value), and examine the mean (or median) and variability of the net benefits.

There are a few drawbacks to these approaches in evaluating adaptation. First, they assume knowledge of probabilities about which we may in fact know very little (see Annex 1). Second, they typically treat probabilities as given, when the purpose of some adaptation options is to reduce risks (defined as the probability of occurrence of threatening events). Finally, they do not incorporate the possibility of decisions that would, as in real life, unfold over time as circumstances change and new knowledge is gained. In such conditions, there is, in fact, an economic value to being able to maintain a larger set of options, over and above whatever expected net present value would be calculated in scenario-based approaches. Three alternative approaches are suggested here to deal with uncertainty. Each of them addresses some of the abovementioned limitations, but none addresses all of them. See also Tools for a summary table of all methodologies described in this note.

### Probabilistic methods for evaluating adaptation to extreme events

Probabilistic methods can be used for addressing reduction in risks from extreme events. For some adaptation initiatives, especially when a main focus of concern is with the impacts from climatic extremes, it may be possible to economically evaluate how the project (e.g., stronger flood protection) reduces risks and expected monetary losses associated with an uncertain adverse agricultural impact, and compare that to the cost of the interventions (see Annex 5 for more information).

### Real option analysis

“Real option analysis” takes into explicit consideration the fact that uncertainty about the future is reduced over time. It is based on the idea that if an investment creates the option of taking a particular decision in the future, when there is more certainty about the future impacts of climate change, the option has an economic value. For example, a water management project may help a community preserve the option of remaining in place rather than migrating to another location if future climate change makes local livelihoods infeasible. It can also be used to decide whether to invest now in adaptation or wait to gain more knowledge. This

economic approach reflects the state of the art in economic evaluation under uncertainty but remains difficult, thus far, to apply in concrete cases. See Annex 12 for more information on this methodology and project examples.

### **Robust decision making**

Robust decision making (RDM) can provide an alternative quantitative decision method that avoids subjective probability assessments and scenario predictions. RDM creates hundreds or thousands of plausible futures, in the judgment of the analyst, that are then used to systematically evaluate the performance of alternative actions. For example, adaptation efforts could be evaluated according to anticipated effects on yields given a climate scenario and an assumption about the productivity and cost of the intervention, differential effects across different economic subgroups of farmers, and performance if climatic conditions turn out much worse than anticipated in the scenario under consideration. This approach allows for identifying the set of conditions for any given alternative adaptation where performance is poor according to various evaluation criteria and reflecting the judgment of the decision maker. The decision maker can identify “robust” alternatives that, compared to other options, perform reasonably well across a wide range of plausible futures. See Annex 13 for more information on this methodology and project examples.

# Resources

## Tools

**Methodologies Summary Table** (available for download in the Resources section on the website)

## Readings

- Cline W. R. 2007. *Global Warming and Agriculture. Impact Estimates by Country*. Washington D. C.: Center for Global Development and Peter G. Peterson Institute for International Economics.
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- Groves, D. G., D. Knopman, R. J. Lempert, S. H. Berry and L. Wainfan. 2008. *Presenting Uncertainty about Climate Change to Water-Resource Managers*. Technical Report TR-505 Santa Monica, CA, USA: RAND Corporation.
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- Provention Consortium, 2008a. *Disaster Risk Reduction and Cost-Benefit Analysis*.  
<http://www.proventionconsortium.org/?pageid=26>
- Provention Consortium. 2008b. *From Risk to Resilience - Benefits and Costs of Disaster Risk Reduction*.  
<http://www.proventionconsortium.org/?pageid=37&publicationid=158#158>
- OECD. 2008. *Economic Aspects of Adaptation to Climate Change: Costs, Benefits and Policy Instruments*. Edited by Shardul Agrawala and Samuel Fankhauser.  
[http://www.oecd.org/document/2/0,3343,en\\_2649\\_34361\\_40691458\\_1\\_1\\_1\\_1,00.html](http://www.oecd.org/document/2/0,3343,en_2649_34361_40691458_1_1_1_1,00.html)
- START. 2006. *Estimating and Comparing Costs and Benefits of Adaptation Projects: Case Studies in South Africa and The Gambia* (AIACC, Project No. AF 47).  
[http://www.aiaccproject.org/Final%20Reports/Final%20Reports/FinalRept\\_AIACC\\_AF47.pdf](http://www.aiaccproject.org/Final%20Reports/Final%20Reports/FinalRept_AIACC_AF47.pdf)
- The World Bank. 2009. *Economic Evaluation of Climate Change Adaptation Projects: Approaches for the agricultural sector and beyond*. Forthcoming (contact: [ggambarelli1@worldbank.org](mailto:ggambarelli1@worldbank.org))

## Experts

For experts on community engagement, please contact the climate change team at [climatehelp@worldbank.org](mailto:climatehelp@worldbank.org).

## Project Examples

- Annex 4: Application of Crop and Ricardian Models in the “China Mainstreaming Climate Change Adaptation in Irrigated Agriculture Project”
- Annex 6: Additional Adaptation Costs in the “China Mainstreaming Climate Change Adaptation in Irrigated Agriculture Project”
- Annex 7: Additional Adaptation Costs in the “Colombia Integrated National Adaptation Project”
- Annex 11: Application of a Simplified Form of Multiple Criteria Decision Analysis in Bolivia, Mexico and Peru for the Economic Sector Work “Vulnerability to Climate Change in Agricultural Systems in Latin America: Building Response Strategies”
- Annex 12: A Case Study of Project Evaluation through Real Option Theory in Mexico
- Annex 13: Application of the Robust Decision Making Approach in the Water Sector in Southern California



# Glossary

## Adaptation

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects. Adaptation can be carried out in response to (ex post) or in anticipation of (ex ante) changes in climatic conditions. It entails a process by which measures and behaviors to prevent, moderate, cope with and take advantage of the consequences of climate events are planned, enhanced, developed and implemented. (adapted from UNDP 2005, UKCIP 2003 and IPCC 2001)

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[For the purpose of the Guidance Notes, the term adaptation refers only to “planned adaptation” measures. Some development practitioners include a wide range of activities under the term “adaptation” (i.e., natural resource management, improved access to markets, land tenure, etc.) that, although disconnected from climate risk issues, are considered to indirectly decrease vulnerability/increase adaptive capacity. For the purposes of the Guidance Notes, a measure is referred to as “adaptation” only when it is an explicit response to climate risk considerations.]

## Adaptation benefits

Avoided damage costs or accrued benefits following the adoption and implementation of adaptation measures. (IPCC 2007)

## Adaptation costs

Costs of planning, preparing for, facilitating and implementing adaptation measures, including transition costs. (IPCC 2007)

## Autonomous adaptation

Adaptation that does not constitute a conscious response to climatic stimuli, but rather is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation. (IPCC 2007)

## Global climate model (GCM)

Computer model designed to help understand and simulate global and regional climate, in particular the climatic response to changing concentrations of greenhouse gases. GCMs aim to include mathematical descriptions of important physical and chemical processes governing climate, including the role of the atmosphere, land, oceans and biological processes. The ability to simulate subregional climate is determined by the resolution of the model.

## “Hard” adaptation vs. “soft” adaptation

“Hard” adaptation measures usually imply the use of specific technologies and actions involving capital goods, such as dikes, seawalls and reinforced buildings, whereas “soft” adaptation

measures focus on information, capacity building, policy and strategy development, and institutional arrangements.

### **Low-regret adaptation**

Low-regret adaptation options are those where moderate levels of investment increase the capacity to cope with future climate risks. Typically, these involve over-specifying components in new builds or refurbishment projects. For instance, installing larger diameter drains at the time of construction or refurbishment is likely to be a relatively low-cost option compared to having to increase specification at a later date due to increases in rainfall intensity.

### **No-regret adaptation**

Adaptation options (or measures) that would be justified under all plausible future scenarios, including the absence of manmade climate change. (Eales et al., 2006)



Contact us at [CCDP@worldbank.org](mailto:CCDP@worldbank.org)

**The World Bank**

**1818 H Street NW, Washington, D.C. 20433**

**[www.worldbank.org/climatechange](http://www.worldbank.org/climatechange)**