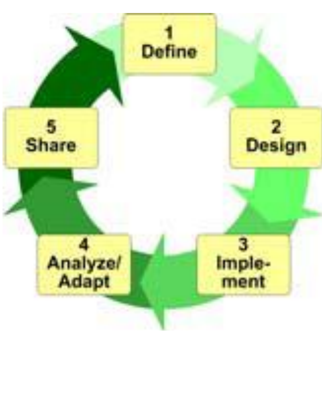
WWF for a living planet

Climate Adaptation:

Mainstreaming in existing Conservation Plans (full version)

July 2011



Resources for Implementing the WWF Standards

This document is intended as a resource to support the implementation of the *WWF Standards of Conservation Project and Programme Management.* It is intended as a supplement to those projects and programs that have already developed a conservation plan that does not adequately consider climate adaptation. Projects and programs that are just beginning to develop a plan may also find this document helpful, and the general guidance for the *WWF Standards* contains climate adaptation guidance for new projects and programs.

This document may change over time; the most recent version can be accessed at: www.panda.org/standards/climate_adaptation

Note that an abridged version is also available, at: www.panda.org/standards/climate_adaptation_abridged

Written by: John Morrison, Conservation Planning & Design, WWF-US (john.morrison@wwfus.org); Alfonso Lombana, Conservation Science, WWF-US (alfonso.lombana@wwfus.org) . Please address any comments to John Morrison.

The guidelines have evolved from three initiatives: 1) The Nature Conservancy's Climate Adaptation Clinic held in September 2009, in which 20 teams examined their conservation plans to incorporate climate adaptation; 2) a WWF-US Climate Change Adaptation Team (CCAT) workshop to develop adaptation guidelines for the WWF Standards. From these two sources, a set of basic adaptation guidelines was developed, followed by an extensive review by key WWF Network staff in 2010 and 2011; and 3) the experience using the guidelines for climate adaptation trainings in Madagascar, Argentina, Vietnam, Malaysia, and the Netherlands. These guidelines are the first of what will likely be many iterations over the years to come.

In March 2010 the WWF Network Climate Adaptation Team (NCAT) developed *Principles of Good Climate Adaptation* to guide the Network's climate adaptation work:

Good Climate Adaptation:
1. Is grounded in best available knowledge on climate variability and climate change;
2. Recognises that humans are part of nature;
3. Is undertaken in partnership with others;
4. Addresses uncertainty and integrates learning;
5. Works at the appropriate scale to address the problem;
6. Applies appropriate and robust approaches;
7. Influences policies and institutions;
8. Communicates to empower.

Audience

The audience for this document is WWF staff using the WWF Standards for conservation planning – however, anyone using the Open Standards for the Practice of Conservation (Conservation Measures Partnership 2007) should benefit. We assume that conservation goals are in some way part of your project or program. That said, an evaluation of the impacts of climate change on people is an integral part of this process. Impacts and of climate on people, and people's responses to those impacts will in turn affect WWF's abilities to achieve conservation objectives.

The WWF Standards assume that a range of stakeholders may be involved in the planning and implementation of conservation strategies, including specific adaptation strategies. How your team involves stakeholders in your project will depend on many factors that are beyond the scope of this document. There are a number of WWF resources that provide guidance on stakeholder engagement. We do however, include special sections and hints on how to use this methodology in a workshop environment, including with stakeholders.

Climate Adaptation

There is strong evidence that many natural systems have already been affected by a changing climate. While it is difficult to attribute individual events to climate change, global, regional, and local changes in the mean and variability of temperature, precipitation, and other environmental factors indicate trends driven by a changing climate. The most dramatic impacts for people may be most visible at high latitudes and elevations, such as the enlargement and increased numbers of glacial lakes, increasing ground instability in permafrost regions, avalanches in mountain regions, and changes in some polar ecosystems. However, evidence for direct impacts that are important for species and ecosystem integrity is widespread. There is growing evidence of increased run-off and earlier spring peak discharge in many glacier- and snow-fed rivers and warming of lakes and rivers in many regions, with effects on thermal structure and water quality. The uptake of anthropogenic carbon has also led to the ocean becoming more acidic. There is also evidence for terrestrial biological systems, with effects including earlier spring events, such as leaf-unfolding, bird migration and egg-laying, and pole-ward and upward elevational shifts in ranges in plant and animal species (Bates et al. 2008; IPCC 2007c; Parmesan 2006).

The global climate science community has concluded most of the observed increase in the globally-averaged temperature since the mid-20th century is very likely due to the increase in anthropogenic greenhouse gas concentrations, and further that anthropogenic warming over the last three decades is responsible for the observed changes in physical and biological systems. Perhaps the most frightening pronouncement by the UN's scientific climate change panel, however, is that the earth's atmosphere has absorbed so much carbon to date that even if all anthropogenic carbon emissions ended immediately, the earth's climate would continue to shift for decades and — in the case of sea-level rise and ocean acidification — centuries or millennia (IPCC 2007). Our environment is entering into a more dynamic phase that may last centuries. **Clearly, adaptation is critical to WWF's mission for**

conservation and sustainable resource management and to ensure that today's work remains relevant into the future.

Vulnerability is influenced by biogeophysical and socio-economic contexts. People are directly and indirectly affected, evidenced by agricultural and forest management (earlier spring planting, altered fire regimes, longer dry seasons) and human health (heat-related mortality, infectious disease vectors, allergenic pollen) (IPCC 2007c).

Human responses to climate variability and change may lead to direct and indirect positive or negative effects on biodiversity. Some examples of human responses are migration, changes to agricultural production and water resource use, and alteration of demographic and social behavior. In many cases, these human responses will have a greater or more rapid impact than the direct climatic changes. Regions of high social vulnerability to climate change are likely to witness bigger or earlier upheaval. Human responses to the changes can reduce the resilience of natural systems, further destabilizing systems upon which humans and the rest of the planet depend. Poor people tend to be most vulnerable since they have low capacity to respond due to poor access to, and control over natural, human, social, physical, political, and financial resources. Human vulnerability is also affected by factors such as governance, the status of people's natural resource base, conflict, urbanization, and demographic change (Ehrhart et al. 2009). Working across sectors may be particularly important, as many aspects of human welfare will be affected.

Mitigation of anthropogenic greenhouse gas emissions is extremely important to limit the change, but we are already committed to a certain amount of warming and the need for adaptation to the changes is inevitable. In other words, everything will be changing and WWF needs to recognize the dynamic nature of the system and plan accordingly. It is highly unlikely, even with stringent mitigation, that society will be able to avoid the climate changes associated with a 1.5° - 2.0°C **global** average temperature increase. Ideally, WWF should consider a minimum adaptation horizon taking into account a 2°C **global** average temperature increase, and the direct (acidification, carbon fertilization, phytotoxicity, protein reductions) and indirect (precipitation, enhanced warm related extreme) events associated with this, and a one meter **global** average sea-level rise. Note that there is considerable local variation associated with these global averages, based on local to regional climate processes and local geological conditions.

What Is Climate Adaptation?

The Intergovernmental Panel on Climate Change (IPCC) defines climate adaptation as an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007c).

This adjustment may include a range of existing and new strategies that can promote resilience in natural systems and in some cases facilitate a transition to different resilient natural systems. General conservation adaptation approaches include:

- Protecting the conservation targets and key ecological attributes (especially ecological processes) that underpin the system;
- Reducing direct (non-climate) threats to the system;
- Increasing the representation of genotypes, species, and natural communities under protection, especially where they are projected to persist;
- Increasing the replicates of ecosystems, natural communities, and species under protection, especially where they are projected to persist;
- Restoration of ecosystems that have been degraded or lost, especially considering directions and degree of change - as restoration may only be reasonable in some areas;
- Identifying and protecting climate refugia areas where the climate will likely be more stable;
- Identifying, protecting and restoring ecological corridors that allow systems and species to self-relocate;
- Relocation of organisms as a last resort (Kareiva et al. 2008).

Most of these approaches are familiar to conservation practitioners because they have been in use for decades. What distinguishes adaptation from 'conservation as usual' is that conservation strategies are reviewed in a climate vulnerability assessment, and they explicitly consider climate variability and change. While planned actions based on the vulnerability assessment may be the same or similar to former actions, often they are prioritized differently, and additional actions may be included (and maybe some previous actions dropped) to make a program 'climate-smart'. For some areas conservation as usual (taking into account climate variability) may be adequate for some time, while other areas may require a rapid shift in conservation practices over the next decade. The state of knowledge of impacts at the level of the priority place – down to the level of the project – is rapidly growing. Yet, there are limits to what can be adapted to, and the need for mitigating the driving causes of climate change will continue to be critical. Parallels with disaster risk reduction (DRR) may also be noted: many actions taken in a climate adaptation framework will also buffer and increase the resilience of ecosystems and human communities in the face of current threats or extreme stresses (e.g. surges, flooding, landslides, etc.) not necessarily related to climate change.

While there is uncertainty about some of the impacts of climate change, the climate ***is*** changing and will continue to change; this will continue to impact WWF conservation. No matter which approach is used, adaptive management – adjusting approaches based on measured results, should be employed to account for any uncertainty associated with climate change projections. This adaptive management approach forms the basis of the *WWF Standards of Conservation Project and Programme Management* (hereafter WWF Standards), WWF's version of the *Open Standards for the Practice of Conservation* (Conservation Measures Partnership 2007).

Why Is Climate Adaptation Important?

Since 1906, the global average surface temperature has increased by 0.74°C ± 0.18°C, and the rate of warming averaged over the last 50 years (0.13°C ± 0.03°C per decade) is nearly twice that for the last 100 years. Past carbon emissions are expected to result in a further 0.6°C relative to 1989-1999 levels even if greenhouse gas concentrations remain at 2000 levels (IPCC 2007b). Realistically, we are looking at a minimum of a 2°C **global** average temperature increase and a one meter sea-level rise. While these global, annual-scale numbers seem relatively small from a human perspective, regional and local exposures have been orders of magnitude greater, while some regions have seen little or no observable change to date. Moreover, studies such as (Root et al. 2002) and (Parmesan 2006) show that many species and ecosystems respond quite rapidly to even small shifts in climate regime.

Thus while the mitigation of greenhouse emissions, either through prevention or through carbon sequestration, is essential if we are to limit the future impacts of climate change, the earth has already experienced significant change and is committed to much more change. People must and will respond – the key is to respond appropriately. It is hoped that appropriate planning can direct adaptation responses such that natural systems are as resilient as possible or can facilitate change to new resilient natural systems. An integrated approach, involving both ecosystems and people, has the best chance of developing adaptation responses that avoid placing additional pressures on natural systems. In this way, we try to avoid maladaptation, which may bring benefits in the short term but causes adverse impacts to ecosystems and people in the longer term.

Until recently, people have based many of their climate and hydrologic engineering calculations on the idea of "stationarity," the assumption that natural systems vary within a fixed envelope of probability. Whether this concept was ever true is arguable, but it is clearly no longer true, and we must now plan while the world shifts around us (Milly et al. 2008).

When to Engage In Climate Adaptation?

There are two answers to this question. The first is that since we know climate is dynamic and will continue to change for decades or centuries, we must be flexible in our responses and anticipation of emerging impacts. Thus, adaptation must be viewed as a long-term, ongoing process rather than a single one-off step that will not be revisited in conservation and development work.

The second answer is more specific to WWF conservation planning procedures. Because climate profoundly influences natural and human systems, ideally climate adaptation principles would be integrated into conservation planning from the outset. However, many WWF conservation projects and programs have already developed conservation plans with minimal incorporation of climate adaptation thinking. This may not be a problem since many WWF conservation activities enhance the resilience of natural and human systems. However, given the increasing likelihood of climate impacts, it is necessary to understand and address the climate impacts on the human and natural systems that comprise the conservation plan. Programs should review and adapt existing conservation plans to consider climate vulnerabilities and to develop climate adaptation options. This document is a guide for this process.

How to Plan For Climate Adaptation?

This section is the core of the document, explaining a suggested process for assessing climate impacts and developing appropriate responses, all within the framework of the WWF Standards.

Integration of Climate Adaptation into Conventional Conservation Planning

This guide is not intended to help develop a stand-alone adaptation plan or to simply develop funded adaptation projects, but to fully integrate adaptation concepts into a conservation plan from a practical, applied perspective. Some specific adaptation projects may result, but they should be a means to an end (i.e. robust, effective, long-term conservation) rather than the end in itself.

Adaptive Management

Adaptive management, here the practice of iteratively modifying a conservation plan based on incoming data or changing conditions, is an important element of the WWF Standards planning process. The evolution of the terms "climate adaptation" and "adaptive management" has been quite distinct until recently, but they are now synthesizing in a useful way: adaptive management must incorporate climate change among the set of threats and drivers affecting resource management and there is a growing consensus from climate adaptation practitioners that the process of doing climate adaptation requires the commitment and monitoring and evaluation tools that have always been a part of adaptive management. As always with the WWF Standards, the team can go back several steps and revise conservation targets, threats, or any element of the planning process. Climate adaptation is a learning process for the entire planet; just make sure to document your successes and failures!

In the sections that follow, boxes highlight available tools and resources, as well as practical suggestions for how to get a useful product from participants in a workshop setting. Where applicable, the corresponding WWF Standards basic guidance step is referenced in italics below each of the steps in the guidelines.

Are you Prepared to Use these Guidelines?

This document is intended for those project teams that have already developed a strategic conservation plan, using some form of the Open Standards, that they would like to retrofit with climate adaptation principles. This document assumes an in-depth familiarity with the project site and context, as well as climate change and climate adaptation concepts. The WWF-US CCAT strongly recommends that project teams become familiar with climate change concepts and approaches. One option for building capacities is CCAT trainings (for more information contact Shaun Martin shaun.martin@wwfus.org).

Climate Adaptation Concepts

Since climate adaptation is a relatively new concept, agreement within the community on key terms and definitions is important. The fundamental concepts regarding the impacts of climate change can be summarized as:

Exposure + Sensitivity – Adaptive Capacity = Vulnerability

In other words, the vulnerability of an ecosystem, species, or community is a function of the degree of exposure to climate changes, plus its sensitivity to the changes, minus its capacity to adapt to the changes.

Exposure

Climate change exposure, for example in the timing and magnitude of changes in temperature and precipitation, can be mapped, but there are many uncertainties associated with future climate projections. These uncertainties are especially apparent with respect to precipitation or when focusing on relatively small areas (<50 km^2), or at less than an annual scale of temporal resolution (such as monthly or seasonal precipitation). Moreover, data for many of the most important elements of exposure to climate change --such as the number of degree-days for plants, evapotranspiration levels, the timing of lake stratification, shifts in the number of extreme events such as tropical cyclones (hurricanes or typhoons), or soil moisture levels--might not be available. These types of variables are associated with high levels of uncertainty in climate model projections, even though they are also often far more important from an ecosystem or resource management perspective than simple annual air temperature and precipitation trend data.

For the purposes of this guidance, we will treat exposure to climate changes as threats, or sources of stress. Technically, they are stresses resulting from the threat of increased CO_2 emissions. But treating the stresses as threats allows us to incorporate them into our overall threat ranking. This will also be the case for the results of exposure, such as increased frequency and intensity of flooding, which is an indirect effect of increased frequency and intensity of storm events; in other words, a direct exposure. Note that some exposures will be sudden (e.g., storm events) and some will have a gradual onset (e.g., changes in means or gradual changes in extremes).

Sensitivity

The sensitivity of ecosystems and species is often difficult to assess, but important thresholds may be identified. In some cases, experimental or field research has documented sensitivities, such as the likelihood for coral bleaching to occur with associated air and water temperature changes. Most species will have some sensitivities to indirect impacts from climate change. Elephants, for instance, may be more vulnerable to the climate change responses of their watering holes and low soil-moisture conditions that reduce available vegetation for food and shade. Clearly, deep knowledge about your conservation targets is critical to evaluating sensitivity. For communities and households, sensitivity is the degree to which they are affected by climatic stresses (e.g. the degree to which they are affected by climatic stresses, for example vulnerability from a change in access to, or the productivity of, natural resources that form the basis for income, food, fiber and/or medicinal products).

Adaptive Capacity

The evolutionary adaptive capacity of an ecosystem or species is also difficult to determine without expert knowledge, since climate has been reasonably stable for the past few centuries and we often know little about the flexibility of many systems and organisms. However, scientists do know from paleoecological studies that many (if not most) species have responded in the past to climate changes by moving. A good place to begin is to discuss with species experts how populations have responded in the past to extreme events, such as very hot or cold days, droughts, floods, and multiple tropical cyclones in a single year. If survey data are available then it is possible to see if climate variability (i.e., climate associated with El Nino) can be statistically linked to movement or population shifts (as has been demonstrated for many species). Because of the many uncertainties involved, the resulting assessment of vulnerability will often be qualitative. Nonetheless, this should not hinder the consideration of potential changes (vulnerability), potential solutions (adaptation), and how to reduce the uncertainties.

We also need to assess the adaptive capacity of the people affected by climate, and whose responses may be linked to their environment in positive or negative ways. Adaptive capacity of individuals, households, and communities is determined to a large degree by their access to and control over natural, human, social, physical, and financial resources. This varies within countries, communities, and even households. In general, the world's poorest people are also the most vulnerable to climate change because they have limited access to those resources that would facilitate adaptation. Additionally, women are often particularly vulnerable to the impacts of climate change due to their responsibilities in the home and their limited access to information, resources, and services (Dazé et al. 2009).

A component of a system's adaptive capacity is its resilience or the capacity of a system [human or ecological] to absorb disturbance and reorganize while undergoing change and still retain essentially the same function, structure, identity, and feedbacks (Holling 1973).

This guidance is intended for projects that developed their conservation plans in the WWF Standards framework. However, it would not take an extreme effort for plans developed under other frameworks to benefit, so long as they are willing to do a bit of extra work in order to consider their projects in the WWF Standards framework (perhaps identifying conservation targets, considering target viability, engaging in a threat ranking, and developing a conceptual model for their project). Most groups will want the assistance of an experienced Open Standards/WWF Standards coach to help quickly translate previous planning into the WWF Standards framework. A basic working knowledge of WWF Standards concepts would also be helpful.

Workshop Suggestion: Improve Efficiency and Results by Using a WWF Standards Coach

Any team would benefit from applying these guidelines with the help of an experienced WWF Standards coach from the WWF network or the Conservation Coaches Network (CCNet). For more information contact PJ Stephenson (PJStephenson@wwfint.org).

A generic workshop agenda can be found in Annex A.

Spatial Scale

Just like the WWF Standards themselves, these guidelines are applicable at any geographic scale, though various spatial scales carry with them distinct issues, challenges, and strategies. Large-scale planning results in policy, regulation, capacity building, agency reform, and sustainable financing strategies appropriate to that scale. Finer-scale planning generally results in more localized enforcement, restoration, engineering, community engagement and protection strategies. Plans developed at one scale may have little effect at another scale. Even when focusing on one scale of planning, it will be helpful to consider what is happening at finer scales. For example, it is difficult to plan for adaptation at river basin scale without at least considering the vulnerabilities of stakeholders at local scale, and how they are likely to respond. Conversely, community-level planning that doesn't take ecosystem processes into account could result in maladaptation since ecosystem processes are often at a much larger scale than an individual community.

If you are working at landscape level or larger, these guidelines may not help produce a comprehensive, climate-adapted conservation plan that provides for every species in your project area. The WWF Standards aim to identify the most strategic actions for the scale at which you are working. The use of the WWF Standards--and these guidelines--for a broad program will lead you to the most critical actions to be taken at that large scale. One of those actions may include a detailed spatial analysis at finer resolutions, indicating potential climate impacts on important species. That analysis is part of a strategy in and of itself (see box below about the relationship between the WWF Standards and spatial planning).

That said, the impacts of climate change and the necessary responses will often draw a project toward consideration of larger scales – so don't be surprised if this happens during the course of planning.

Time-Frame

Normal application of the WWF Standards suggests a 10-year horizon for consideration of threats. Ten years is still probably the limit for practical strategy development. However, for some potential climate change impacts, teams are encouraged to think beyond this 10-year window to explore the potential long-term changes.

Increased Variability vs. Directional Change

It is important to recognize and anticipate that the climate is changing in both its mean and variability. Changes in mean affect conditions in a general way, but the increased variability will cause more or fewer extreme events that may differ in magnitude and frequency compared to baselines.

Uncertainty

Uncertainty plays a large role in climate adaptation. The farther out in time you consider, the greater the uncertainty. There is uncertainty regarding the amount of future CO^2 emissions; this is compounded by uncertainty in global circulation models used to project climate based on the CO^2 emissions; there is additional uncertainty in regional climate downscaling of the global circulation models. How natural systems will respond to changes in climate also involves uncertainty. And how will people be affected and how will they respond? With all of this uncertainty, how can one plan for the future?

Conservation planners and managers have always acted without important information – uncertainty in and of itself should not prevent us from taking action. Our advice is to take action based on:

1. Current vulnerabilities to climate extremes;
2. The need to collect specific information for decision making and for signaling significant change;
3. Avoiding actions that may be maladaptive;
4. Facilitating the transition of relevant policies and institutions towards a "climate-smart" approach.

Perhaps the most important thought that we can leave you with regarding uncertainty is that the outcome of your conservation work would be even more uncertain were you to ignore the potential effects of climate change, uncertain as they are.

Use These Guidelines Appropriate to Your Project Size and Investment

Exercising every option in this guide would involve a significant amount of work. This is especially true of the options to consider alternate climate and development scenarios, which can multiply the amount of work to be done. Small projects may want to consider only the most basic options (e.g. if there are no obvious alternative development scenarios, then skip the strategy ranking). Larger projects and programs, involving significant investments and concomitant risks, should consider following the steps more closely.

The heart of this climate adaptation planning process is a vulnerability assessment that should be seen as a prerequisite to informed planning. Most of the time required to follow this process is involved in the vulnerability assessment. Workshop hints are provided to those who would consider working with a team in a workshop environment, but the process is certainly not limited to a workshop, and it is assumed that even with a workshop, important information would be gathered both before and afterwards. Few teams will have the perfect set of information available, even with good preparation. Some information will need to be obtained in the long term and may require additional study or more specific vulnerability assessments by sector.

Workshop Suggestion: Having the Right Participants Present

Conservation planning workshops are greatly influenced by the composition of participants and advisors. There are many ways to structure a workshop, so these suggestions are not intended to be prescriptive.

Project Team

The project team is composed of WWF and non-WWF staff comprising the following disciplines:

- Biology and/or ecology;
- Social sciences;
- Economics;
- Indigenous knowledge;
- Synthetic thinkers knowledgeable about the project area;
- Climate adaptation.

Stakeholders

Stakeholders can contribute greatly to a workshop's effectiveness, by providing a variety of perspectives that round out what could be a very insular plan. Their active participation in the human response substep (3.4) will be crucial. Such representation in a workshop is a reality check on how people are really likely to respond to climate change, rather than the staff's best guess. And an additional sub-step, focusing specifically on the risks to ecosystem services, could even be inserted as part of the vulnerability assessment. However, stakeholders may slow down the process and the flip side of their many viewpoints is that they are often primarily interested in how the plan will affect them. It may be wise to consider two workshops – an internal planning effort followed by a larger, stakeholder-driven exercise. Knowing roughly what some of the results of the steps are likely to be can accelerate a larger workshop, and provide options for combining group exercises with presentations that present options and answers.

Note: the lack of specific expertise should not preclude the planning process, but any such limitations should be documented. Some steps (e.g., Step 3.1 Current Climate Extremes) require little technical knowledge and are easily explored with a small team.

A Suggested Process for Integrating Climate Adaptation into Existing Conservation Plans

1. Gather Existing Climate Data and Reports

(*PPMS 0.1 General Practices and Assumptions*)

The first step for incorporating climate factors into a conservation plan is to gather existing data that may inform analyses and strategy development. Use your contacts in local universities, government agencies, and other NGOs, plus the internet to find climate-related documents for your project area. Such a search makes a good student project if begun early enough. Be sure that the information gathering exercise considers the entire region that you're working in.

Possible data sources:

- Documents, reports, and maps detailing historic climate patterns, current climate data, and future climate projections for your project area at relevant scales;
- Journal articles, reports, and maps that detail potential climate impacts on the ecosystems, species, or human communities in your project area, including existing vulnerability assessments (which may have been done at different scales or for different audiences);
- Relevant climate adaptation policies at different levels of government;
- Documents, reports, and maps that detail future development plans or scenarios. These may be produced by governments at various levels;
- Documents, reports, and maps about conservation or development used during the original conservation planning may prove useful again. If these have been updated, then the most recent versions would be appropriate.

Tools to Assist with Document Searches

Documents, reports, and maps are available from many government agencies and NGOs. You may also consider searching for relevant material online, using the following sources:

- Google Scholar (www.googlescholar.com)
- WWF's Global Library on OneWWF (https://sites.google.com/a/wwf.panda.org/global-library/)

Tips:

- Search terms including "climate change," "adaptation," and your particular ecosystems and species should help.
- Gathering this information can take weeks or months, so gather information well before any workshop(s).

2. Review Stakeholders

(PPMS 1.4 Context and Stakeholders)

A stakeholder analysis could be placed anywhere in the process, and is one component often revisited and revised several times. There are three basic issues to be addressed:

- Who has information or knowledge to inform the vulnerability assessment and planning process?
- Who will be affected by current or predicted climate changes and how might they react? These people may be inside the geographical limits of the plan, but they could be outside (for example, they could migrate in, or consume resources from the area)
- Who can influence the success of proposed strategies?

A review of stakeholders should identify all of those groups and individuals that have a vested interest in the project or program, or may have in the future as conditions change. A stakeholder analysis, even if brief, can help identify:

- The interests of all stakeholders who may affect or be affected by the program/project;
- Potential conflicts or risks that could jeopardize the initiative;
- Opportunities and relationships that can be built on during implementation;
- Groups that should be encouraged to participate in different stages of the project;
- Appropriate strategies and approaches for stakeholder engagement; and
- Ways to reduce negative impacts on vulnerable and disadvantaged groups and enable them to adapt.

Note that different stakeholders are likely to be involved in different parts of the vulnerability assessment and planning.

Workshop Suggestion: Stakeholder Analysis

A simple table is all you need to capture the key aspects of stakeholders for your project or program.

Stakeholders	Stake/Mandate	Potential role	Leverage point	Strategy for engaging
Save our Turtles (local NGO)	Mission to conserve turtles	Partner; advocacy	Donors; none needed?	Invite to partner; budget for activities
Fisheries department	Sustainable revenue from fishing	Changing policies	Minister; Planning Commission	Information giving
Bay Fishermen's Association	Continuing income and jobs	Adversary?	Members; money	Target of advocacy
Local communities	Income from fishing and from ecotourism	Community based management	Money	Consultation

Additional Tools to Assist with Stakeholder Analysis

The following documents and sources therein are useful guides for doing a stakeholder analysis:

WWF Standards guidance on Stakeholder Analysis (http://assets.panda.org/downloads/1_1_stakeholder_analysis_11_01_05.pdf);

Stakeholder Collaboration: Building Bridges for Conservation (http://www.rmportal.net/library/content/tools/biodiversity-conservation-tools/putting-conservation-in-context-cd/participatory-approaches-resources/1-1.pdf)

3. Vulnerability Assessment

(PPMS 1.4 Context and Stakeholders)

The first step in developing climate adaptation strategies is to understand the possible climate change impacts and assess vulnerability. Vulnerability assessments are the primary tool or process that informs adaptation planning. There are many varieties of vulnerability assessments, and they can be sophisticated and expensive or simple and inexpensive. The next section describes a simple vulnerability assessment process using the WWF Standards as a framework. More detailed vulnerability assessments for particular sectors or species may eventually be appropriate, but the following steps should spell out the range of likely climate change impacts. Existing vulnerability assessments from the study area may also prove useful as a reference for your own assessment.

Links to Resources or Good Examples of Vulnerability Assessments

General

- Resource: "Scanning the Conservation Horizon A Guide to Climate Change Vulnerability Assessment". Note that this resource is excellent on ecological impacts but tends to ignore the indirect effects of human responses. (http://www.nwf.org/Global-Warming/Climate-Smart-Conservation/Safeguarding-Wildlife/~/media/PDFs/Global%20Warming/Climate-Smart-Conservation/ScanningtheConservationHorizon.ashx)

Marine

- Resource: "Adapting to Climate Change: A Planning Guide for State Coastal Managers" (http://coastalmanagement.noaa.gov/climate/docs/adaptationguide.pdf)
- Example: "The Coral Triangle and Climate Change; Ecosystems, People, and Societies at Risk " (http://assets.panda.org/downloads/climate_change___coral_triangle___full_report.pdf)
- Example: "Vulnerability Assessment of the North East Atlantic Shelf Marine Ecoregion to Climate Change" (http://www.ngo.grida.no/wwfneap/Projects/Reports/CC_Vulnerability.pdf)

Freshwater

- Resource: "Flowing Forward" (http://www.flowingforward.org/pdf/full.pdf)

Coastal

- Example: Climate Change Vulnerability Assessment in Mangrove Systems (expected, June 2011)

A. Examine Vulnerability to Current Climate Variability and Extremes

The first substep of the vulnerability assessment is to gauge the conservation targets' vulnerability to current climate variability and extremes. In many parts of the world, oscillations like El Nino lead to consistent changes in the annual climate of that year (hotter, dryer, wetter, colder). This analysis can be retrospective (considering changes that have occurred to today) or current (considering the current situation). The objective is the same: to get the project team thinking about how the conservation targets are currently vulnerable to extremes in climate (since, in general, increases in the mean will not be the most important exposure). The idea of this step is to document the vulnerability (exposure + sensitivity – adaptive capacity) of each conservation target. In addition, it is far easier to monitor for adaptation success to variability and extreme events than to a change that might be decades away.

Some teams seem to have a difficult time estimating the future, either because the modeled projections are too uncertain, the indirect impacts are difficult to predict, or there are other non-climate factors (e.g. rapidly rising population) to account for that will compound, or be compounded by, climate impacts. Future climate projections can also be very uncertain, but a sound understanding of existing climate extremes helps to minimize the uncertainty since, in many cases, existing extremes will simply be exacerbated or more frequent.

Besides noting the exposure, you are looking to identify resulting vulnerabilities, usually associated with sensitivities:

- Universal elements of sensitivity
    - Hydrology;
    - Fire;
    - Wind and storm events;
- Species level elements of sensitivity;
    - Physiological factors (e.g. temperature, moisture, pH, salinity);
    - Dependence on sensitive habitats (e.g., wetlands, alpine, low-lying floodplains);
    - Dependence on ecological linkages, including ecological processes
        - Physical (e.g. access to a range of habitats)
        - Functional (e.g. dependence on prey items, abundance of irruptive species);
    - Phenological changes (changes in plant and animal life history cycles, especially where they interact);
    - Population growth rate and reproductive strategy (ability to rebound quickly may favor some species over others);
    - Specialization (less specialized species may be more flexible)(Glick et al. 2011).

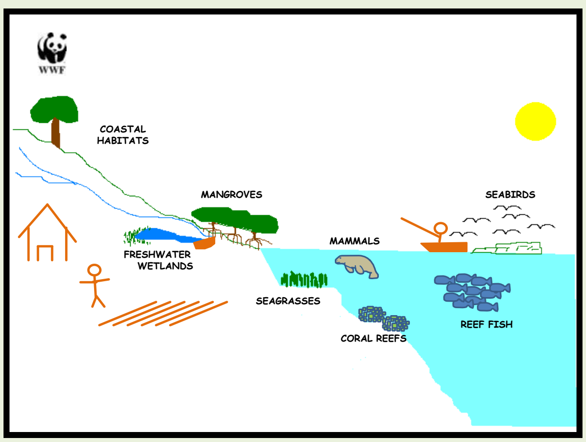
Non-ecological programs may not find the drawings helpful, and may simply organize their thoughts for this and subsequent steps in a list or table.

Workshop Suggestion: Current Climate Extremes

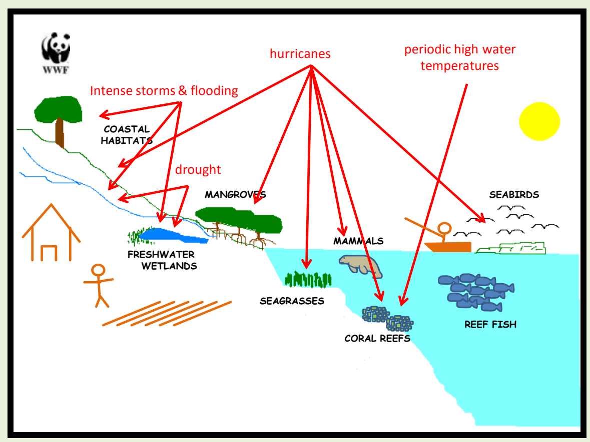
We suggest investigating existing climate extremes using an "ecological drawing", a cartoon that shows the conservation targets, human communities, and the impacts of current climate extremes as they are currently understood. The goal is to understand how one is vulnerable to climate, period. The process is as follows:

1. Quickly develop a picture of your conservation targets;
2. Add human activities, especially as they link to the conservation targets;
3. Review current and recent climate extremes and add those to the drawing, noting the sensitivities of the conservation targets and people. Attempt to build from collective memory and any existing VAs, especially including indigenous knowledge. These should include exposure to:
    - Extreme heat (intensity and/or duration);
    - Extreme cold (intensity and/or duration;
    - Storm events (including hurricanes, typhoons, tornadoes);
    - Drought events (duration);
    - Flood events (volume and/or timing and/or duration)

4. If time permits, note how people are coping with/adapting to these extremes, especially where those responses link to the conservation targets.
5. Discuss, noting any critical ecological or human thresholds.



Basic Ecological Drawing



Ecological Drawing with Impacts of Current Climate Extremes

Tools for Ecological Drawings

Flip chart paper and colored pens work well. If your team is thinking about polishing up your ecological drawing for inclusion in a report, consider the following tools:

- Integration and Application Network Image Library - free high resolution and vector environmental science images for use in science communication. Over 5,000 files of vector images for creating ecological drawings (University of Maryland, USA) (http://ian.umces.edu/imagelibrary/).
- MS PowerPoint
- MS Word

B. Consider the Range of Future Climate Projections

In this substep, a team should assess the long-term potential exposure of the conservation targets and people to climate changes, that is, the potential direction, magnitude and variability of climate changes. Refer to existing climate models or vulnerability assessments (see box below). These projections may assist in understanding whether what is now seen as an extreme event becomes much more like the mean in the future (i.e. if drought is a problem and the models consistently point to the same or less precipitation, then drought will become more of a norm). The point is not necessarily to plan for these potential but uncertain futures, but to understand what the projections are saying, informing actions to develop monitoring systems and identify thresholds which would trigger more drastic actions. There are some adaptation practitioners who believe that reference to future climate models, as rife with uncertainty as they are, is not advisable. We believe that it is important to understand both the uncertainty and what these models are saying, and that ignoring the results of these projections is even more inadvisable.

Climate Modeling

The following section on climate modeling will eventually be supplanted by stand alone guidance – hopefully in 2011.

As background, the following describes climate models and how they are generated.

> "Projections of future climate are based on the output of atmosphere/ocean general circulation models and are used to simulate conditions in the future based on projected levels of greenhouse gases. These models are physically based, computer codes that couple the dynamics among the ocean, the atmosphere, sea ice and land along with biogeochemical processes that affect concentrations of CO_2…, drawing on classical fluid dynamics and thermodynamics. However, due to the finite resolution of the models the exact physical processes must be approximated. Due to their size and complexity, most climate system models cannot achieve a resolution much smaller than regions of 100 kilometers square. The result is that the model must account for physical processes that are not resolved, i.e. explicitly simulated, such as cloud

> formation and complex topography. These unresolved processes still have a strong influence on climate at large scales. The technique of representing unresolved processes is termed a parameterization and is an active area of climate research. Not surprisingly, parameterizations are also a key factor in model uncertainty" (Nychka et al. 2009).

Unfortunately, the subject of climate modeling is not straightforward. There are three primary variables involved:

- Emissions scenarios and "Representative Concentration Pathways" – assumptions about how humanity will develop and control emissions;
- Time horizons – future time frames (e.g., 2020, 2030, 2040, etc.);
- General circulation models – may vary depending on the university or development group that developed them.

In the past, there been a large number of emissions scenarios, which made assumptions about how human society would develop, in terms of economies, populations, and technologies. Existing information for your region will often refer to these scenarios (e.g. A1, B2, etc.). For the immediate future, the emissions scenarios have been supplanted by Representative Concentration Pathways (RCPs) which are consistent sets of projections specifically about the climatic parameters that are the starting point for climate modelers.

There are more than a dozen commonly used climate models and it is worth considering a wide range, looking at the distribution of averages and extremes among the models. The extremes are often more relevant than average monthly temperature. The online tools cited below can help you do this.

There are a number of sources of uncertainty in future climate projections, including:

- initial conditions – current climate, which is relevant for short timescale projections, since the oceans and carbon cycle are not in equilibrium with the climate;
- boundary conditions – the solar cycle, volcanic eruptions, and human carbon emissions;
- parameterizations – attempting to capture the effects of complex processes like cloud formation;
- model structure – human choices about model design and development (Nychka et al. 2009).

The possible combinations of emissions scenarios, time horizons, and models are almost limitless and reviewing and understanding the climate models can be complicated. Given the myriad model outputs and uncertainties associated with them, it is wise to constrain the set of possibilities to promote efficient planning.

Global model projections are often downscaled to achieve greater spatial resolution and to make outputs more relevant at smaller scales. Be aware that downscaling may introduce more uncertainty into the results. Model outputs are often presented either in terms of a future time frame or given a certain global temperature increase.

Below are several alternatives approaches to exploring the climate model projections, ranging from simpler to more complex:

1. Least effort - Use existing reports (e.g., vulnerability assessments, climate models) that have previously been prepared for your area/region. This choice represents the least work but also the least control – you are limited to what the authors chose to do. It is still important to understand where the authors made choices;
2. More work - Choose a **global** average temperature increase – say 2.0°C. Using a web-based tool that presents the results of multiple climate models (see below), look at the range of **local** projections for that single global average increase. What do the models say about future **local** temperature? Precipitation? Is the direction of change the same between the models? Magnitude of change? If there are differences, look for obvious groupings of the outputs (e.g., some models predict a wetter climate, some predict a drier climate).
3. A bit more work – Develop a "tipping point" analysis. Choose a series of **global** average temperature increases – say 2.0°C, 2.5°C, and 3.0°C. Look at the range of local projections for each global average increase. As above, consider the patterns of projections for each **global** average temperature increase. Attempt to identify critical local ecological or human thresholds or "tipping points."

Expectations for the detail and accuracy of model projections should be held in check. Look for the possible directionality of changes in major climate parameters, including:

- temperature (daily minimums and maximums, monthly average, annual average);
- precipitation (amount, timing, form);
- changes in seasonality (temperature, precipitation);
- changes in extremes (highs, lows, lengths of droughts, volume of precipitation);
- sea surface temperature;
- range of projections for the above parameters;
- uncertainty associated with the projections.

Sources of Climate Modeling Data and Maps

Be sure to search for existing modeling reports and data first.

Climascope (http://wwfus-climascopeweb/)

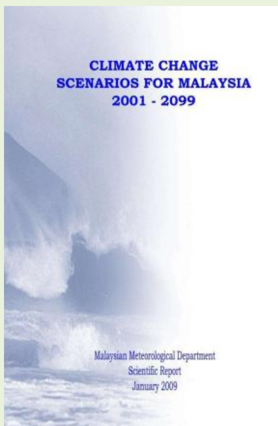
- data visualization system providing access to information on climate, climate change, and impacts. Designed to run in areas with slow internet connections or even to be distributed on a hard disk. It is in development now and should be available in 2011. It provides observed gridded climate data (from seven models) for monthly maximum, minimum and average terrestrial temperature, sea-surface temperature, precipitation, and wet day frequency.

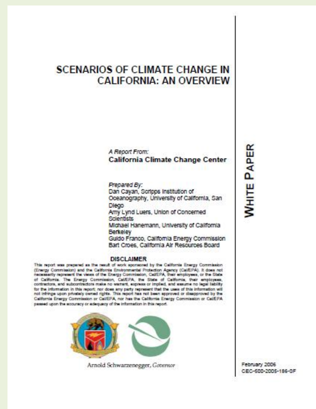
Climate Wizard (www.climatewizard.org)

- view and download historic temperature and rainfall maps, future projections of temperature and rainfall, and climate change maps for anywhere in the world in a few steps.

Workshop Suggestion: Reviewing Future Climate Projections

In a workshop setting, the idea of this step is to allow team members to rapidly get an understanding of the direction, magnitude, and range of climate projections. Ideally, an arrangement would be made to have a knowledgeable and personable representative of a local, regional, or national agency present the modeling that has been done, and provide participants with a 1-page handout that summarizes the projections to date – in whatever format they exist. Short of that, there are usually documents that have been prepared by the relevant agency that presents the results of one or a suite of climate projection models. These can be summarized for participants.





If a summary is not prepared before the workshop, participants can spend an hour attempting to summarize the projections that have been presented or are available to them in hardcopy. The ideal product emerging from such an exercise might look like this:

Example Summary of Projected Climate Exposures				
Climate Exposure		**2030**	**2060**	**2090**
Temperature	**Mean**	+ 0.5 to 0.75^0 C	+ 0.75 to1.25^0 C	+ 1.5 to2.0^0 C
	Extreme	More extreme heat days	More extreme heat days	More extreme heat days
Precipitation	**Mean**	Either slightly less or slightly more rain	Slightly less rain	Moderately less rain
	Drought	Unclear	Longer droughts	Longer droughts
	Flooding	More and larger flood events	More and larger flood events	More and larger flood events
Wind/Storm Events	**Frequency**	More frequent	More frequent	More frequent
	Intensity	Unclear	Probably more intense	More intense
Etc.				

C. Assessing Ecological Impacts of Climate Projections

In this substep, a team will assess the vulnerability of the conservation targets given likely climate exposure. In other words, how are ecosystems and species likely to be affected by the most likely or most serious future climate impacts?

To consider:

- The full range of direct climate impacts to the environment;
- The full range of indirect climate impacts (i.e., where climate is exacerbating existing threats);
- The range of human response impacts will be covered in the next substep.

If you have obtained scenario-based tipping-point modeling (see above) for key climate parameters (e.g. temperature, precipitation) the ideal next step would be to combine these outputs with a mechanistic spatial model which can project how habitats are likely to change in extent and/or condition. Large changes in the spatial model outputs between climate parameter steps indicate a tipping point or threshold and, once these thresholds are identified, they can be planned for. Another alternative is to use a range of emissions scenarios to look for thresholds for individual species. Further information is available from the Wallace Initiative (see box below).

Most programs will not have access to this kind of modeling expertise so a more realistic approach is to look at the range of climate projections available and consider the implications for each target, identifying tipping points stepping through a range of futures for key climate parameters. For example, if climate models predict a **local** rise of 1.0 to 2.5^{0}C in the next 50 years, first consider the potential impacts to each of the conservation targets of a 1.0^{0}C rise, then at 0.5^0 increments until reaching the predicted maximum. If it is unreasonable to speculate about the effect of differences of 0.5^{0}C, consider the extremes only (i.e. 1.0^{0}C and 2.5^{0}C).

What are the likely impacts on the conservation targets for each of the 0.5^{0}C steps that you examine? Do you encounter any obvious thresholds? You may not have enough information to say. This kind of thinking can help you structure a research agenda on critical ecological thresholds.

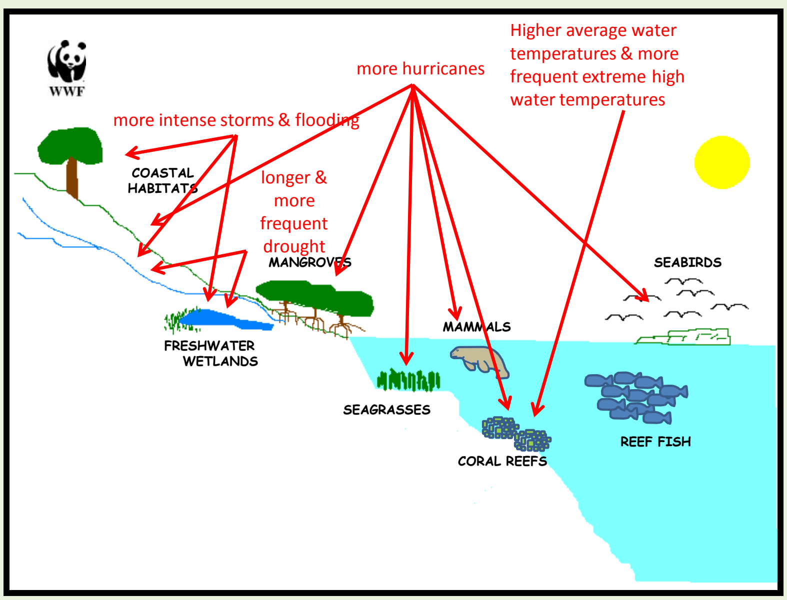
Consider Other Development Scenarios?

Here, the team may consider alternative development scenarios ranging from rampant, unchecked growth to business as usual to climate-smart planning. If the latter scenario is a realistic possibility, consider how to contribute by implementing strategies focused on policy and affecting decision makers.

Workshop Suggestion: Future Climate Projections and Ecological Impacts

The “ecological drawing” used earlier to examine the impacts of current climate extremes may be useful to examine potential impacts of future climates. The drawing is essentially a cartoon that shows the conservation targets, human communities, and the impacts of current climate extremes as they are currently understood. The process can go as follows:

1. Quickly sketch another version of the ecological drawing with conservation targets, people, and their activities, especially as they link to the conservation targets;
2. Review the outputs of available climate modeling and add expected climate exposures to the drawing, noting the impacts on the conservation targets. If model projections point to divergent futures (e.g., either wetter or drier) make two ecological drawings to represent the respective scenarios. Consider all potential impacts of the respective future climate scenarios but don't pin the impacts to any particular date. With a very detailed analysis of climate projections, the team would use multiple copies of the drawing to perform a “tipping point” analysis – looking for critical thresholds. But simply capturing the direction of change would be helpful. The impacts can include:
   - Heat (intensity and/or duration);
   - Cold (intensity and/or duration;
   - Storm events (frequency and/or magnitude of hurricanes, typhoons, tornadoes, etc.);
   - Drought events (duration);
   - Flood events (volume and/or timing and/or duration)
3. Discuss, noting any critical ecological thresholds.



Ecological Drawing with Impacts of Future Climate

Note: Effects of alternative development scenarios can also be illustrated by additional ecological drawings. This option may be valuable when including powerful stakeholders in a workshop.

Additional Tools to Further Evaluate the Ecological Impacts of Climate Change

The process that we suggest in this document will outline most of the potential issues arising from climate change, but if your team finds itself needing more information, the following tools may help determine how ecological systems or species are likely to react.

Ecological Response Models

If you have your fine-scale spatial data for the locations of ecosystems and species, and you are prepared to devote the time, you may want to take advantage of free software that can help you develop niche and occupancy models for species and vegetation, and predict where those species and vegetation are likely to be in a new climate envelope.

Niche-Based Models

A type of ecological response model, niche-based models produce probabilities of occurrence of a species or vegetation type using locations records of species (e.g. from museum records) combined with biophysical data such as elevation, topography, temperature, precipitation, soils, and geology. Once a biophysical envelope is developed, a new occupancy can be calculated based on a new climate. Two examples include:

- Genetic Algorithm for Rule-Set Production (GARP) (http://www.nhm.ku.edu/desktopgarp/)
- Maximum Entropy (Maxent)((http://www.cs.princeton.edu/~schapire/maxent/)
- Wallace Initiative - Using Maxent models, the Wallace Initiative provides climate maps as well as associated occupancy maps for 50,000 species (wild and crops) – already loaded on an interactive website. The site also allows you to download the climate data should you wish to model the responses yourself (the standard 18 Maxent bioclimatic variables) (https://wwftest.hpc.jcu.edu.au/wallace)

Physiologically-Based Models

Another type of ecological response model, physiologically based models attempt to incorporate sensitive aspects of individual species physiologies that influence life history processes such as foraging, nesting/reproduction, thermoregulation, and migration. The idea is to tie physiological traits and processes to particular climate change parameters, because changes in species distributions have been associated with physiological constraints. These are not available off-the-shelf.

Ecological Models

Ecological models focus on the vulnerability of basic ecological processes such as carbon and nitrogen fluxes, evapotranspiration, and plant nutrient cycling.

- CENTURY (http://www.nrel.colostate.edu/projects/century5/)
- RHESsys (http://fiesta.bren.ucsb.edu/~rhessys/)

Note that unfortunately, none of these tools are very good at incorporating some of the most critical aspects of climate change, that is, the ecological thresholds that are crossed by short-lived extreme climate events. Thus, there is no substitute for your own and your colleagues' expert judgment.

D. Considering Future Projections, What are the Likely Human Responses and Associated Ecological Impacts

This sub-step is to evaluate human coping and adaptive actions and the close and often complex linkages with natural systems. In many cases, ecosystem services can help vulnerable people adapt, and their provision can be designed in a way to minimize adverse impacts on natural systems. However, human responses can also be "maladaptive", bringing benefits in the short term but in the longer term diminishing the ability of ecosystems to support biodiversity and people. Conceptually, this substep could be combined with the previous substep, and some teams may choose to do that. We have separated it deliberately to ensure it gets sufficient attention.

The team should evaluate the full range of possible ecological impacts (positive and negative) resulting from human responses to climate impacts (this will require an understanding of the direct climate impacts on people and human vulnerability first). Tools for this analysis are highlighted below.

Additional Tools for Assessing Human Impacts

Development agencies and NGOs have developed several tools to assess the vulnerability of humans to climate impacts. These are not good at assessing the compounding effects from humans coping with climate changes so these connections must be analyzed separately.

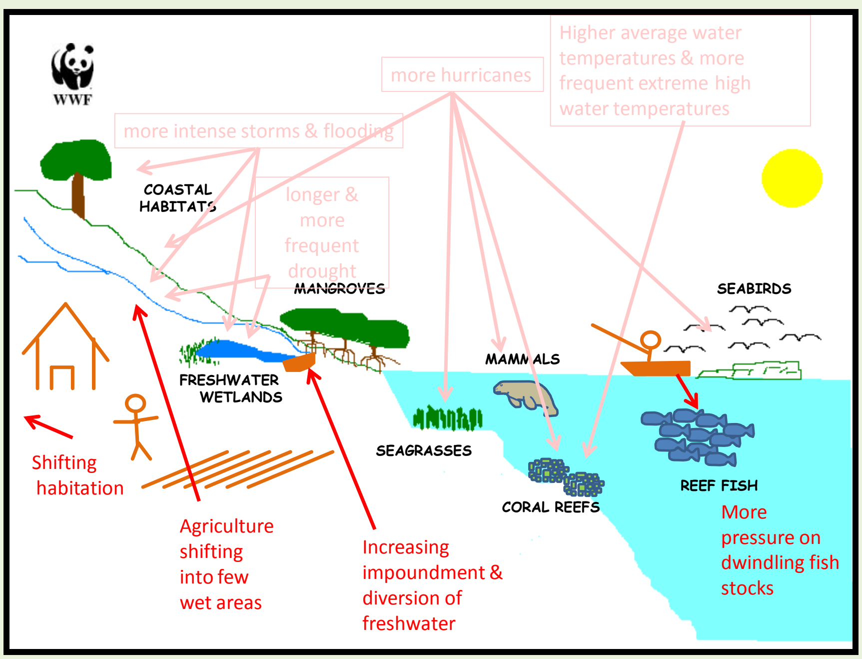
- Community-Based Risk Screening Tool (CRisTAL) - A screening tool designed to help project designers and managers integrate risk reduction and climate change adaptation into community-level development projects. Module 1 is useful for analysis, as it helps project planners and managers understand the links between livelihoods and climate in their project areas. (Developed by International Institute for Sustainable Development (IISD), the International Union for Conservation of Nature (IUCN), the Stockholm Environment Institute (SEI-US) and Intercooperation.) (http://www.cristaltool.org/content/download.aspx)

- Toolkit for Integrating Climate Change Adaptation into Development Projects - Practical, "how to" guidance for integrating climate change adaptation into the design, implementation, monitoring and evaluation of development projects. Water resource management and agriculture projects are specifically highlighted. (Developed by: CARE International and IISD.) (http://www.careclimatechange.org/tk/integration/en/)

- Climate Vulnerability and Capacity Analysis (CVCA) Methodology - a framework for analyzing vulnerability and capacity to adapt to climate change at the community level. (Developed by CARE International) (http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf)

Workshop Suggestion: Assessing Likely Human Responses and Associated Ecological Impacts

1. Use the same ecological drawing you used to examine the ecological impacts of future climate projections; (sub-step 3.3);
2. Review the outputs of available climate modeling and add expected hazards to the drawing, noting the impacts on humans. If model projections point to divergent futures (e.g. either wetter or drier) make two ecological drawings to represent the respective scenarios. Consider all potential impacts of the respective future climate scenarios but don't pin the impacts to any particular date. With a very detailed analysis of climate projections, the team would use multiple copies of the drawing to perform a "tipping point" analysis, looking for critical thresholds. But simply capturing the direction of change would be helpful. The impacts can include:
   - Heat (intensity and/or duration);
   - Cold (intensity and/or duration;
   - Storm events (frequency and/or magnitude of hurricanes, typhoons, tornadoes, etc.);
   - Drought events (duration);
   - Flood events (volume and/or timing and/or duration)
3. Carefully note how humans are likely to cope with and respond to these extremes, especially as those responses affect the conservation targets.
4. Discuss, noting any human thresholds.



Ecological Drawing highlighting Human Responses

Note that development organizations working on community based adaptation take a rights based approach to adaptation that is community driven, and aims to help the most vulnerable. But to date there has not been a strong focus on its environmental impact, which risks maladaptation. Work is currently in progress to promote much closer collaboration between the environment, development and disaster risk communities on adaptation, using ecosystem services to help vulnerable people to adapt. At the same time, this collaboration will try to ensure in turn that adaptation measures do not place extra pressure, and instead will relieve pressure, on natural systems to build their resilience and facilitate adaptation.

E. Capture Most Certain and Most Critical Potential Impacts as "Hypotheses of Change"

This substep will help filter out the perceived most critical potential climate impacts. The most critical risks may be a combination of some certain but moderate impacts plus some uncertain but high severity future impacts. The idea is to formally capture the most critical ideas from the two previous steps (potentially messy drawings) as organized hypotheses in a table.

The following table is provided as a guide and includes:

- relevant climate change exposure (e.g., increased precipitation & associated flooding, more frequent storms);
- likelihood that the climate exposure will occur (e.g. certain, highly likely, somewhat likely, unlikely, remote, unknown likelihood);
- human climate stresses
- possible human responses (note: if the indirect human response may have significant ecological effects, that response should get its own row in the table);
- likelihood of the human response;
- vulnerable or threatened conservation targets;
- relevant key ecological attributes;
- hypothesized impact of the climate exposure or human response on the conservation targets;
- likelihood of the ecological impacts;
- notes, including:
    - information sources;
    - ecological or human thresholds that emerge during discussion or research;
    - capacity for human adaptation;
    - potential for maladaptation;
    - potential loss of ecosystem services.

Again, this table will include more certain, shorter term impacts, as well as impacts that are uncertain but would carry a high risk if they occur. Only include those impacts the team feels it must address now or must track carefully. When the table is complete, you may want to sort the table based on the likelihood of impact, severity of the ecological change, or both. If alternative climate or development scenarios are applicable, develop a separate hypothesis of change table for each.

Example Hypotheses of Ecological Change Due to Climate Change									
Climate Exposure	**Likelihood of Climate Exposure**	**Potential Human Stress**	**Potential Human Response**	**Likelihood of Human Response (assuming Climate Exposure Occurs)**	**Conservation Target**	**Key Ecological Attribute**	**Hypothesis of Ecological Change**	**Likelihood of Ecological Change (assuming that Climate Impact Occurs)**	**Notes**
Sea level rise	Virtually certain				Mangroves	Sediment-erosion deposition regime	Predicted increase in sea level will modify sediment-erosion deposition regime resulting in loss of mangroves in existing areas and the potential for mangrove establishment in upslope areas	Virtually certain	Direct impact of sea level rise; from Smith et al. (2008) report
Sea level rise	Virtually certain	Loss of infrastructure or agriculture land	Building sea walls	Likely in some areas	Mangroves	Extent of mangroves	Sea walls will prevent landward mangrove transgression, resulting in a net loss of mangrove extent	Virtually certain where seawalls are built	Indirect impact of sea level rise
Longer and more severe droughts	Highly likely				Freshwater stream systems	Flow regime – volume of flow at height of dry season	The longer and more severe droughts are predicted to entirely dewater several key streams every 2-3 years	Likely	Direct impact of longer and more severe droughts
Longer and more severe droughts	Highly likely	Loss of freshwater for drinking and irrigation	Building small check dams to hold water during dry season	Virtually certain	Freshwater stream systems	In-stream connectivity	In-stream connectivity would be severed for catadromous fishes by a series of check dams	Certain	Indirect impacts of longer and more severe droughts

Workshop Suggestion: Hypotheses of Change

We suggest that the table can be done using flipcharts (might need two, side by side) or Excel projected onto a screen.

If you choose to have more than one hypotheses of change table – corresponding to alternative climate or development scenarios – consider allocating each table to a separate breakout group and reviewing in plenary.

The following sub-steps, developing conceptual models and re-ranking threats, can be done in any order. The advantage of doing the conceptual model first is that you have a better sense of all of the implications of each element of climate change before you do your threat ranking. The advantage of ranking the direct threats first is that you can choose to add only the highest ranked threats to the conceptual model to keep it simple and the team focused.

F. Capture All Projected Future Climate Impacts in Box & Arrow Conceptual Model(s)

Your project should already have a conceptual model showing the conservation targets, direct threats, and drivers (also called indirect threats, factors, etc.) and "climate change" may have been included as a direct threat. Now that climate threats have been analyzed with the ecological drawings and hypothesis of change table, they can be put into the conceptual model, including the indirect human responses which may raise new threats or simply exacerbate existing threats. The ideas were sketched in the ecological drawings and then summarized in the hypotheses of change matrix systematically along with existing threats (which will also allow threats to be re-ranked in the next step using Miradi software if desired).

Add the climate impacts, one by one, and any associated human responses from the hypothesis of change table into the conceptual model. You will want to be sure to identify:

- direct climate threats;
- indirect climate threats (interactions between climate and other existing threats);
- human responses that may affect the conservation targets;
- institutional and policy challenges (drivers).

You may choose to create several copies of your new conceptual model, for alternative climate and development scenarios or for impacts with varying degrees of certainty. It may be useful to indicate the degree of certainty of occurrence for the given factors.

Note that a vulnerability assessment should also look specifically at the policy and institutional context in which your project is working; and consider how climate change might affect key policies or institutions. For example, a freshwater conservation project should consider how climate-related impacts on seasonal water flows might create new allocation challenges for the local water management authority. These issues on the left hand side of a conceptual model (drivers) will have implications for project design as well as for the prioritization of certain adaptation strategies or other project interventions.

Workshop Suggestion: Modifying Conceptual Model(s)

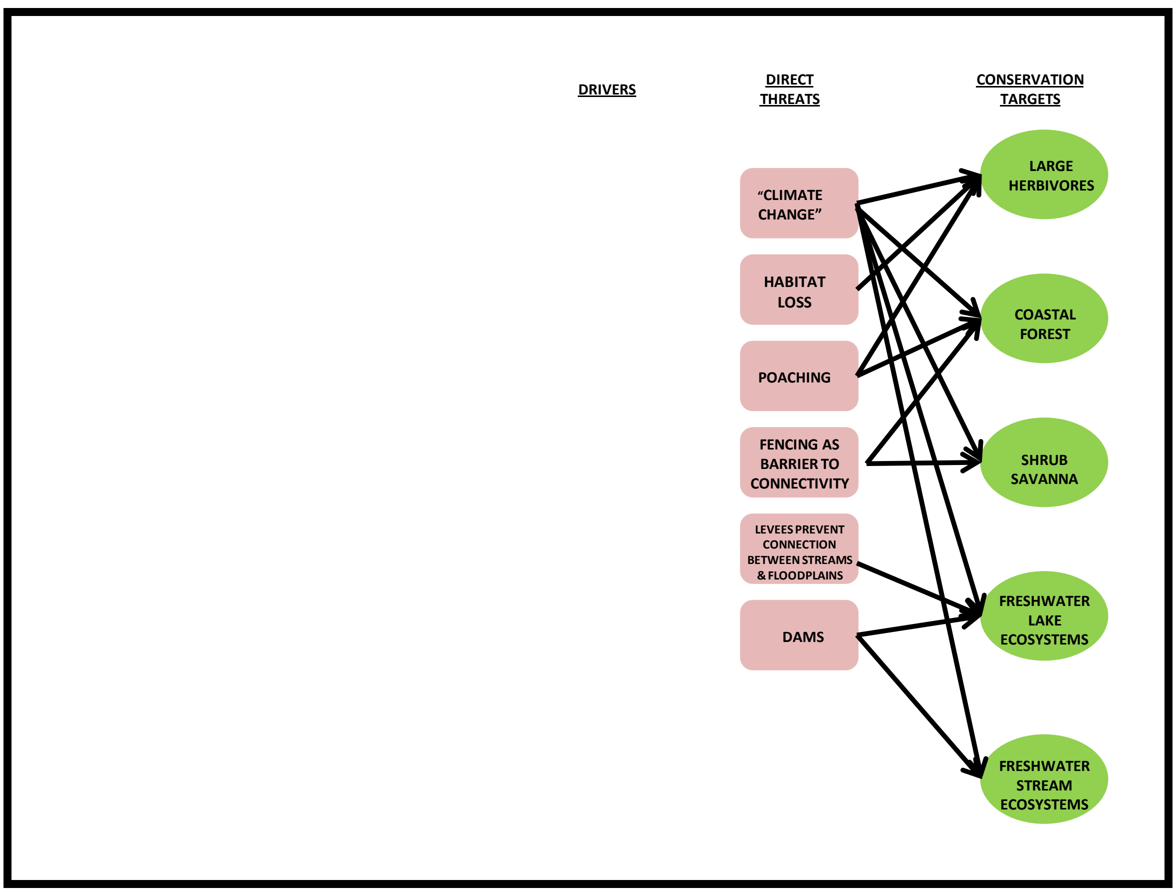
For larger groups, it may be best to work with easily moved cards on a large sticky-tarp or a large wall covered with flip-chart paper. One participant can capture the new strategies in Miradi if desired. Smaller groups may be able to make modifications directly in Miradi, projected on a screen. The typical process consists of a facilitated discussion with suggestions for realistic strategies noted on cards placed appropriately in the conceptual model.

Teams should first address the most critical threats and their associated drivers, moving to lower ranked threats as time permits.

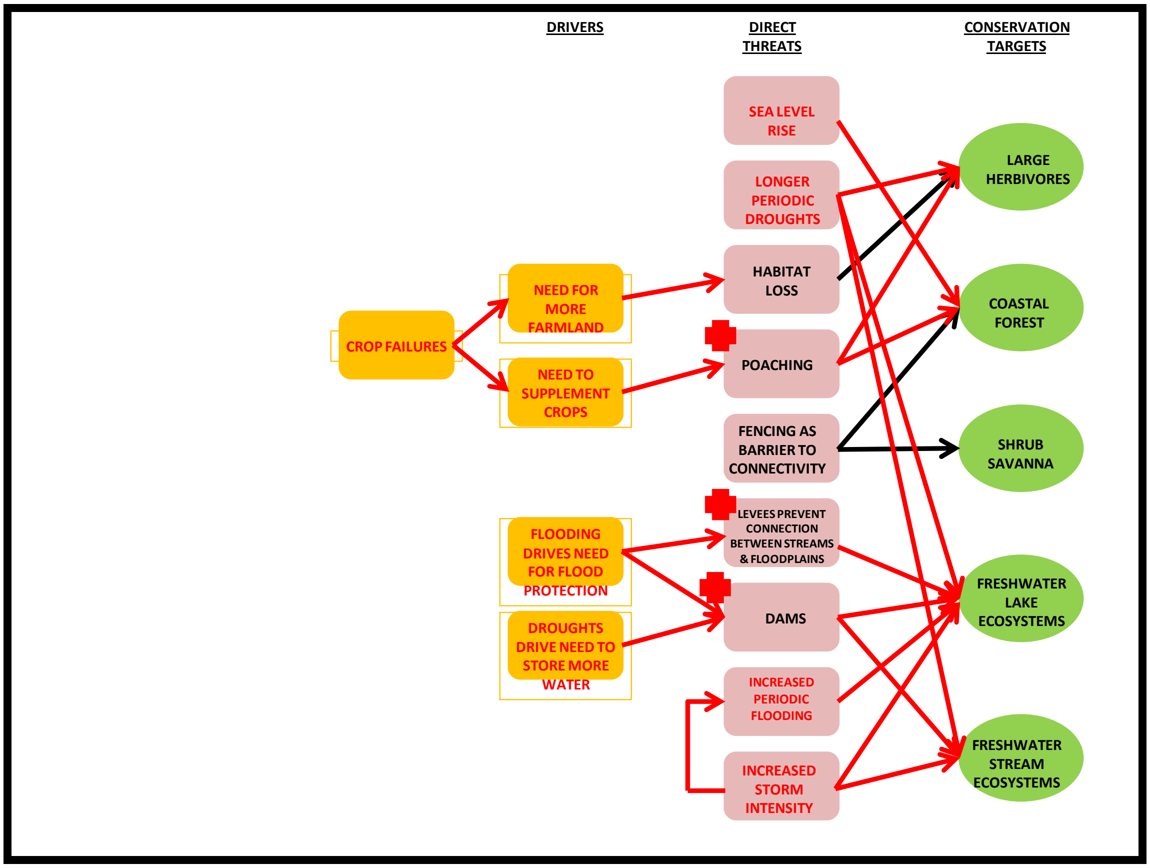
If you do choose to develop more than one version of your conceptual model, consider doing so in breakout groups and reviewing in plenary.

The following example illustrations show how a typical conceptual model might be modified to capture more detail about climate change.

Original Conceptual Model (Drivers Removed for Clarity)



Modified Conceptual Model (Changes Highlighted in Red)



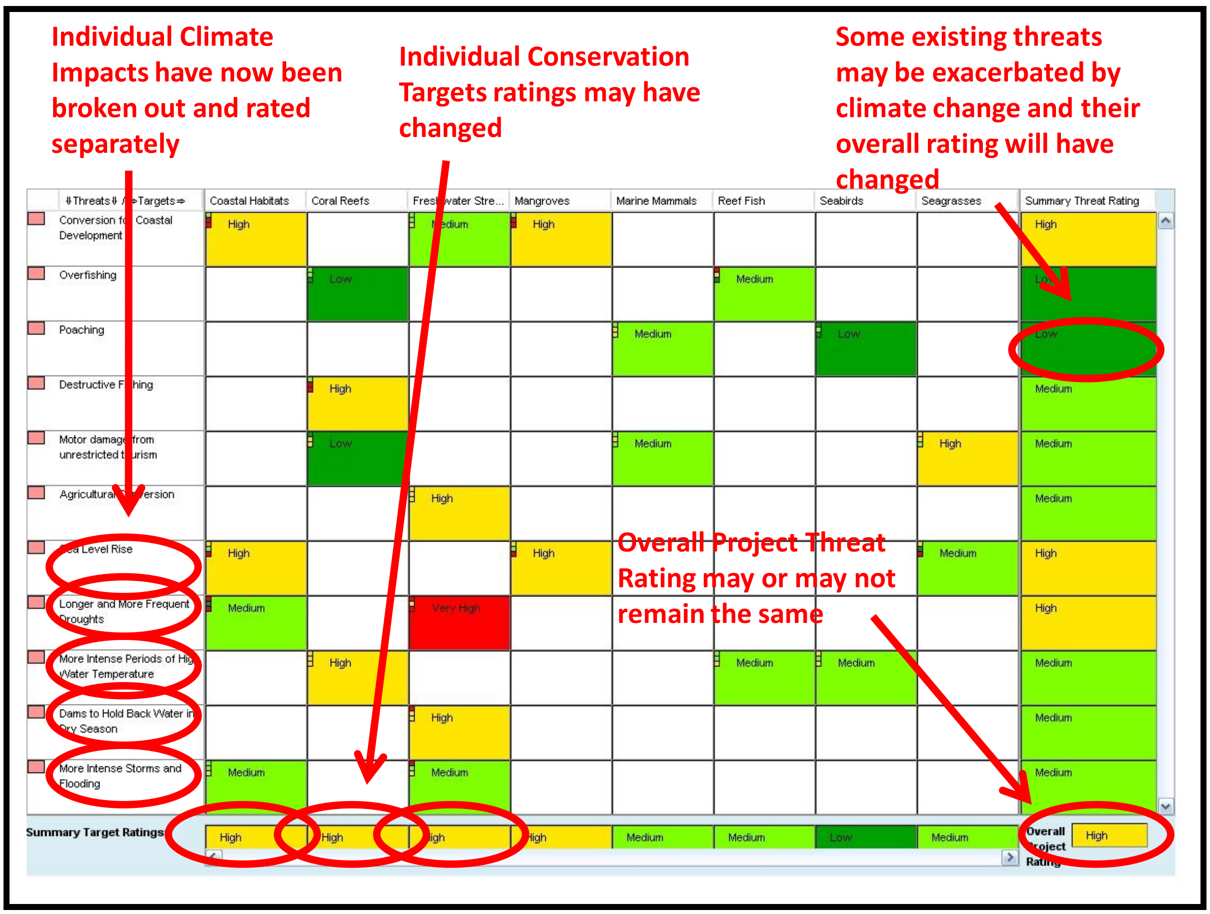
G. Re-Rank Direct Threats

In this step, direct threats are re-prioritized to include the impacts of climate change. Referring to the revised conceptual model, re-rank the direct threats by scope, severity, and irreversibility using Miradi.

Recall that, for conventional planning, the time horizon for the threat ranking is 10 years. Ten years is still a reasonable time frame for planning, but some severe climate change hazards may not be felt for several decades. Therefore, we suggest the threat ranking be reviewed both using the 10-year scale and some longer (e.g., 30 to 50 year?) time horizon, depending on available projections and the appetite of the planning team. Note that this applies to each alternative climate and development scenario.

Be sure to include the specific direct climate impacts and the indirect human climate impacts from your revised conceptual model, and you should do a threat ranking for each conceptual model. When considering the longer term timescale, assume original strategies' success where appropriate, but be sure to document the assumptions.

The following illustrates some changes to anticipate.



Note that while WWF has trained staff on a simple threat-based system, other organizations use a stress-based system which requires distinguishing between stresses (the impacts on conservation targets) and the sources of stress – threats that humans are engaging in. If your team would like to pursue this stress-based and more accurate threat-ranking, there is expertise in the WWF Network to assist you, and Miradi software supports the stress-based system.

Compare the original threat ranking with the new 10 year threat ranking. Has anything changed? Have the ratings for particular threats changed due to additional direct or indirect climate stresses? Which aspects of climate change are the most critical? Now consider the longer term ranking. What has changed? Are the changes in the 30 to 50 year ranking the result of changes with much uncertainty? Would your team be prepared to take action today given the uncertainties?

Based on the new threat rankings, you may remove some complexity in the conceptual model by removing the lower ranked direct threats.

Having completed a vulnerability assessment, you may decide to do further work, possibly involving outside expertise or addressing aspects of climate change where your team lacks expertise (see box below). However, your team now has thought considerably about climate impacts and further vulnerability assessments may not be necessary.

Workshop Suggestion: Re-Ranking Threats

Use of Miradi, projected on a screen, is beneficial for the threat ranking process. Participants can follow the threat scoring and see, in real time, how overall ratings are calculated and rankings are affected by each criterion. The criteria for scoring these should be displayed prominently.

When is a More Detailed Vulnerability Assessment Necessary?

Upon completion of Step 3 of this guide, teams will have done a basic vulnerability assessment, however limited by their inherent knowledge and experience. But when is a more detailed--and sometimes expensive--formal vulnerability assessment warranted? When additional studies and/or external experts would provide specific information, data, and practical advice not accessible by the project team, and the vulnerability assessment would significantly improve project results.

A follow-on, more focused vulnerability assessment could produce more detailed information on one or more of the basic components of vulnerability:

- Exposure (predictive climate modeling);
- Sensitivity and thresholds (ecological or human)
  - Individual species
  - Ecosystems or natural communities
  - Various human sectors such as agriculture or indigenous communities;
- Adaptive capacity of species, ecosystems and people
- Recommended strategies (though not necessarily part of a vulnerability assessment, the team may seek ideas or advice with very technical strategies).

Alternatively or additionally, there may be very specific analyses that would be helpful to future decisions, such as:

- Mapping the locations of species restricted to isolated high mountain tops;
- The locations of bleaching-resistant reefs from previous bleaching events, etc.
- Identifying adaptive capacities of local communities and how they are likely to change land and resource use patterns.

4. Review Targets and Goals

(PPMS 1.2 Scope and Vision, 1.3 Targets)

This step is a review of two fundamental aspects of a conservation plan: targets and goals. Some possible climate hazards may jeopardize the project's goals. For example, will the conservation targets still be viable in the project area? Will other conservation targets move in? Are the long-term goals for each conservation target achievable? Are the goals appropriate in light of potential climate change? This step does not require wholesale restructuring of a project, but it provides impetus for the project team to think about whether its goals and objectives are achievable or even desirable.

Are these responses by natural systems a bad thing? The answers are often revealing. Over the last few decades there has been a presumption among a lot of conservation practitioners that any kind of change in status quo is bad. But given that we are already committed to substantial environmental change, perhaps we have to lose the mindset of stationarity and embrace change. We need to ask the question how to facilitate those changes, sometimes including the evolution to no-analog ecosystems (e.g., novel ecosystems that have not recently or ever existed before). This kind of thinking is very difficult, but it also shows how flexibility and regular re-evaluation are critical to doing good conservation and development now.

The following elements of the project should be reviewed:

1. conservation targets – while it is probably premature to remove conservation targets, one or two new conservation targets may be needed;
2. key ecological attributes and indicators – look to add climate-vulnerable key ecological attributes or climate-related early-warning indicators;
3. scope – evaluate the need for changes in scale or boundaries;
4. desired state – though difficult, try to determine the desired condition of the conservation targets;

It may be appropriate to develop more generalized conservation targets or "desired state" goals that don't pertain to the individual conservation targets, but to the area in general (e.g. general connectivity, amount of natural cover in general, etc).

Workshop Suggestion: Reflective Moment

This is the opening round of a long-term discussion that will not be resolved during one workshop. Notes should be captured on a flip chart. There may be next steps of research on particular technical topics.

5. Identify potential climate adaptation strategies based on new conceptual model

(PPMS 2.1 Action Plan: Goals, Objectives and Operations)

This step develops a portfolio of strategies; some certain, some alternative in nature.

The number of climate and development scenarios and short- vs. long-term timelines will help determine how many conceptual models you need. We suggest that you brainstorm strategies on the conceptual model in two stages:

1. A short-term (1-3 year) time horizon – for strategies that you would realistically pursue (e.g., "no-regrets" strategies that build resilience to current or very likely climate extremes in species, ecosystems and people); and
2. A second, longer term time horizon to implement strategies considering the range of climate changes associated with a 2°C **global** average temperature increase.

Given all of the uncertainties associated with climate projections, which strategies does it make sense to pursue in the short-term? As mentioned early in this document, in the section on uncertainty, our advice in the short-term is to pursue "no-regrets" strategies associated with:

1. Reducing vulnerabilities to current climate variability and extremes;
2. The need to collect specific information for decision making and for signaling significant change;
3. Avoiding actions that may be maladaptive;
4. Facilitating the transition of relevant policies and institutions towards a "climate-smart" approach.

Within each conceptual model (with multiple development or climate scenarios you may have several conceptual models at this point), this step is essentially no different than the normal WWF Standards process, but some of the strategies themselves will be different.

At its simplest, adaptation is reducing vulnerability. So, once vulnerability to a given climate factor is identified, how can that vulnerability be reduced? A menu of climate adaptation strategies can be found in Annex B. Which strategies will be most useful? Are existing strategies sufficient to maintain ecological resilience? Or are there new requirements in light of the changing climate? The menu provided is just a starting point; there is no substitute for a group of clever conservationists (complemented by relevant specialists).

The brainstormed strategies should be practical. Does the team really have the resources and capacity to implement additional adaptation strategies?

Workshop Suggestion: Identifying Potential Climate Adaptation Strategies

Similar to revision of the conceptual model, we suggest that for larger groups, it may be best to work with easily moved cards on a large sticky-tarp or a large wall covered with flip-chart paper. One participant can capture the new strategies in Miradi if desired. Smaller groups may be able to make modifications directly in Miradi, projected on a screen. The typical process consists of a facilitated discussion with suggestions for realistic strategies noted on cards placed appropriately in the conceptual model.

If you do decide to brainstorm strategies in two rounds (i.e. short- and long-term), you may want to use differently colored cards to differentiate the timescale.

Teams should first address the most critical threats and their associated drivers, moving to lower ranked threats as time permits.

Relationship of WWF Standards to Spatial Planning

Spatial planning can be considered a strategy itself (e.g. a collaborative land-use planning process) or part of another strategy (e.g. identifying refugia for protection). The use of WWF Standards does not always result in a spatial plan, though the use of spatial data can be an extremely useful and important adjunct to the strategic plan that emerges. Spatial data can inform the WWF Standards process for Scope, Target Viability, Threat ratings, and in the use of alternative development scenarios. Additionally, strategies calling for detailed spatial assessment of current or potential climate impacts, or to identify corridors and refugia, may or may not be identified during this WWF Standards strategic planning process.

6. Rank strategies by feasibility, cost, benefit, and "no-regrets"

(PPMS 2.1 Action Plan: Goals, Objectives and Operations)

Ranking the brainstormed strategies by objective criteria helps to evaluate their predicted effects and practicality. Appendix C contains an overall threat ranking based on benefits, feasibility, and cost. Another criterion is "no-regrets." The process for no-regrets is straightforward: take each strategy one by one and evaluate whether it would be adaptive against all of the known potential future climate parameters that you examined during the Vulnerability Assessment (Step 3). A no-regrets strategy should increase the resilience of natural systems (either directly or indirectly) no matter what future climate comes to pass. Strategies that are helpful in a drier climate but maladaptive in a wetter climate do not qualify. Strategies should be ranked separately for each climate and development scenario.

If desired, the team could arrange a diverse set of adaptation options organized by a number of criteria:

- Degree of confidence that the strategies are needed (i.e. certainty of impacts, from hypotheses of change);
- Degree of confidence that the strategies will work (from the strategy ranking);
- Institutional and policy options;
- Threat reduction options;
- Restoration options.

Note that some climate hazards are fairly certain (e.g. sea level rise) and call for detailed planning now, whereas other impacts are considerably less certain (e.g. longer term precipitation changes in some areas) and would necessitate contingency plans and the identification of climate or other thresholds that trigger their implementation.

Finally, within the overall strategy ranking, organize strategies with respect to whether they are robust to a variety of long-term potential alternative climate states. These "no regrets" strategies will build resilience of conservation targets no matter which long-term alternative climate state occurs (e.g. wetter or drier). To do this, simply consider the realistic strategies one by one, and sequentially ask whether a strategy will be effective when implemented in each potential climate scenario. If the answer to this question is "no" – and the strategy will not work in some climate scenarios – then a trigger is needed that will indicate when that strategy is appropriate.

Workshop Suggestion – Ranking Strategies

This exercise can occur as a group or in breakout groups. If you use breakout groups, be sure to leave plenty of time for discussion and to harmonize results between groups. Our suggestion is to first rank the strategies for benefit, cost, and feasibility (Appendix C) then review each strategy in turn finding "no-regrets."

After developing logic chains in the following Step 7, teams may briefly revisit the strategy ranking using the more detailed and realistic cost estimates discussed during that exercise. Review of the stakeholder analysis may be prudent, given the revised conceptual model, strategies, and expected results. The additional information may indicate a need for assistance from additional stakeholders not already considered. For example, is there a possibility that people will move into the area, in response to flood or drought elsewhere?

7. Develop detailed logic chains for climate adaptation strategies

(PPMS 2.1 Action Plan: Goals, Objectives and Operation, 2.2 Monitoring Plan, 2.3 Operational Plan)

This step documents the logic of strategies' expected effects on reducing threats or improving ecosystems' adaptation to climate change. That may include assisting with human adaptation in order to provide for ecosystems. Once strategies have been selected, this step is essentially the same as in the typical WWF Standards process.

Teams may build separate results chains for strategies dealing with alternative climate or development scenarios or a contingent, bifurcating results chain that accounts for different climate, development, or ecological outcomes together. Evaluating multiple alternative strategies in the same diagram makes it clear the team has acknowledged uncertainty about what scenarios may occur, but has considered a range of alternative strategies. When considering multiple strategies, do your best to identify critical climate, development, or ecological thresholds that would trigger an alternative strategy. These thresholds will need to be monitored, so be realistic. In any case, the documentation of risks and assumptions is all the more critical when considering the uncertainties of climate change.

Look for solutions that may help people while at the same time making ecosystems more resilient.

Seek peer review, whether internal or external!

Workshop Suggestion: Accommodating Alternative Strategies

This step is no different than developing logic chains (results chains) for any strategy. We strongly suggest allowing plenty of space (a large wall covered with flip-chart paper) and cards that are easy to move around.

Although also possible for conventional strategies, alternative climate adaptation strategies in the same diagram may be more common, given the many uncertainties of future climate projections. Therefore, use your physical diagram space wisely, and be ready to link multiple results chains together as needed.

Monitoring

WWF Standards guidance on monitoring suggests allocating monitoring effort wisely between conservation target status and strategy effectiveness measures; that recommendation is applicable here as well.

Climate adaptation is different from most types of areas of conservation in one respect: it is absolutely critical to track the progress of climate change in order to make decisions about contingent strategies, but often that basic climate data is lacking. This elevates the importance of gathering basic climate data. Ideally, governments would perform such monitoring but they often lack required resources or capacity. In some cases it is appropriate to implement a strategy to deploy climate monitoring equipment and manage the data. Your project team is likely not the only group that would benefit from additional climate information, so coordinate other interested parties (e.g., government, NGOs, etc.) to spread the burden to purchase, install, and monitor appropriate equipment.

Tools for Gathering Basic Climate Monitoring Data

There are a number of companies that sell automated weather stations, data loggers, and associated software. They can usually advise on what equipment is most appropriate for your situation.

- iButton temperature loggers – a computer chip enclosed in a 16mm thick stainless steel can that can be mounted virtually anywhere and is rugged enough to withstand harsh environments, indoors or outdoors. It is small and portable enough to attach to a tortoise, for example (http://para.maxim-ic.com/en/search.mvp?fam=ibutton&1028=Temperature&tree=ibutton)
- Hobo temperature loggers - easy deployment indoors, outdoors, or underwater, even in the harshest environments. Standalone, wireless, and web-based temperature data loggers available (http://www.onsetcomp.com/products/data-loggers-sensors/temperature?gclid=CLyom_TKzqgCFQFM5QodPG2ehw).
- Campbell Scientific - From single research weather stations to meso-scale weather networks. Campbell sells automated weather stations and software for use all over the world (http://www.campbellsci.com/).
- Skyview weather instruments - from the basics (temperature, pressure, wind speed) to more specialized UV radiation and solar radiation sensors. Wireless capability means sensors can be placed in whichever location is convenient (http://www.skyview.co.uk/dept1/acatalog/Wireless_Weather_Stations.html).

The deployment and monitoring of climate stations is a science in itself, and you will eventually want to solicit local or regional expertise. The placement and operating procedures will need to be documented clearly, as in this protocol (probably more than you will need but a survey of the issues to be considered:

http://science.nature.nps.gov/im/monitor/protocols/NCCN_Climate_Protocol_Vol_1_20100913.pdf

Outputs

The outputs from this process can vary greatly. Some programs may revise their entire conservation plan; others may want to develop an addendum to an existing conservation plan. Key components of the revised plan or addendum may include:

Revisions to the Scope;

- Review of Stakeholders;
- Revisions to the conservation targets;
- Revised conceptual model;
- Revised threat ranking table;
- Results chains for new strategies;
- Revisions to the Monitoring Plan.

Additional analysis may include:

- Description of how local stakeholders are likely to be affected by climate change and how their interests line up with conservation interests;
- Explanation of alternative climate scenarios;
- Explanation of alternative development scenarios;
- Extent to which ecosystem services are at risk.

The effort put into any new conservation plan or addendum should be scaled to the size of the project.

Additional Assistance & Resources (current as of March 2011)

Climate Adaptation Trainings
Shaun Martin, WWF-US (shaun.martin@wwfus.org)

Climate Adaptation and PPMS
John Morrison, WWF-US (john.morrison@wwfus.org)
Alfonso Lombana, WWF-US (alfonso.lombana@wwfus.org)

Climate Modeling, Species Modeling, Climate Science
Jeff Price, WWF-US (jeff.price@wwfus.org)

Freshwater Climate Adaptation
Bart Wickel, WWF-US (bart.wickel@wwfus.org)
Sarah Freeman, WWF-US (sarah.freeman@wwfus.org)

Marine Climate Adaptation
Alfonso Lombana, WWF-US (alfonso.lombana@wwfus.org)
Marianne Fish, WWF-US (marianne.fish@gmail.com)

Specialized or General Climate Vulnerability Assessments
Mangroves - Jonathan Cook, WWF-US (jonathan.cook@wwfus.org)

Community adaptation
Judy Oglethorpe, WWF-US (judy.oglethorpe@wwfus.org)

Governance, Policies, and Institutions
Jonathan Cook, WWF-US (jonathan.cook@wwfus.org)
Helen Jeans, WWF-UK (hjeans@wwf.org.uk)

Links to Additional Climate Adaptation Resources

There are numerous resources available, including:

- WeADAPT - an online 'open space' on climate adaptation issues (including the synergies between adaptation and mitigation) which allows practitioners, researchers and policy makers to access credible, high quality information and to share experiences and lessons learnt. It is designed to facilitate learning, exchange, collaboration and knowledge integration to build a professional community of practice on adaptation issues while developing policy-relevant tools and guidance for adaptation planning and decision-making. Includes a Google Earth interface to show 'who is doing what, where' and to create 'adaptation stories', a climate adaptation Knowledge Base, customized user and organization profiles and adaptation decision support tools such as the prototype Adaptation Decision Explorer (ADx) (http://www.weadapt.org/).

- EcoAdapt – an adaptation NGO that strives to make adaptation resources more accessible, build adaptation capacity of current and future professionals in conservation, planning, and development so they can engage in climate change adaptation, and support implementation. Website includes Climate Adaptation Knowledge Exchange (CAKE), links to featured publications (http://www.ecoadapt.org/).

- The Nature Conservancy's Knowledge Base for Climate Change Adaptation – updated daily. Tools & Methods, Reference Materials, Materials Organized by Habitat, Materials Organized by Places, News Archive (http://conserveonline.org/workspaces/climateadaptation/documents/coastal-marine-0/view.html)

Glossary of Key Adaptation Concepts

The following were collected largely from Glick et al. (2011).

Adaptive Capacity

The ability of a system, institution, or individual to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2001).

Climate Adaptation

Climate change adaptation for natural systems is a management strategy that involves identifying, preparing for, and responding to expected climate changes in order to promote ecological resilience, maintain ecological function, and provide the necessary elements to support biodiversity and sustainable ecosystem services (Glick et al. 2009). Alternatively, adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPPC 2001).

Climate Exposure

The nature and degree to which a system is exposed to significant climate variations (IPCC 2001).

Climate Model

A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties (IPCC 2007a).

Downscaling

A method that derives local- to -regional-scale (10 to 100 kilometers) information from larger-scale models or data analyses. In statistical downscaling, a statistical relationship is derived between observed local climate variables and predictors at the scale of global climate model output. Dynamical downscaling, or regional climate modeling, explicitly simulates the process-based physical dynamics of the regional climate system using a high-resolution, limited-area climate model (IPCC 2007b).

Ecological Threshold

An ecological threshold is the point at which there is an abrupt change in an ecosystem quality, property, or phenomenon, or where small changes in an environmental driver produce large responses in the ecosystem (Groffman et al. 2006).

Global climate model

Global climate models are large, three-dimensional coupled models that incorporate the latest understanding of the physical processes at work in the atmosphere, oceans, and earth's surface. They range from lower-level General Circulation Models (GCMs) to coupled Atmosphere–Ocean General Circulation Models (AOGCMs) (IPCC 2007b).

Refugia
Physical environments that are less affected by climate change than other areas (e.g. due to local currents, geographic location, etc.) and are thus a “refuge” from climate change for organisms (USCCP 2008).

Resilience
The capacity of an ecological or socio-economic system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Holling 1973).

Resistance
The ability of an organism, population, community, or ecosystem to withstand a change or disturbance without significant loss of structure or function. From a management perspective, resistance includes both: 1) the concept of taking advantage of/boosting the inherent (biological) degree to which species are able to resist change; and 2) manipulation of the physical environment to counteract/resist physical/biological change (USCCP 2008).

Sensitivity
Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli (USCCP 2008).

Stationarity
The idea that natural systems fluctuate within an unchanging envelope of variability is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g. annual stream-flow or annual flood peak) has a time-invariant (or 1-year-periodic) probability density function, whose properties can be estimated from the instrument record (Milly et al. 2008).

Uncertainty
An expression of the degree to which a value (e.g., the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures, for example, a range of values calculated by various models, or by qualitative statements, for example, reflecting the judgment of a team of experts (IPCC 2007b; Manning et al. 2010; Moss & Schneider 2000)

Vulnerability
The degree to which a system, institution, or individual is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. It is a function of exposure to climate changes, sensitivity to those changes, and capacity to adapt.

Vulnerability Assessment
A key tool for carrying out adaptation planning, and informing the development and implementation of climate-smart resource management practices (Glick et al. 2011). A vulnerability assessment identifies who and what is exposed and sensitive to change (OECD 2006).

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References

Bates, B. C., Z. W. Kundzewicz, S. Wu, and J. P. Palutikof. 2008. Climate Change and Water. Page 210. IPCC Secretariat, Geneva, Switzerland.

Conservation Measures Partnership. 2007. Open Standards for the Practice of Conservation.

Dazé, A., K. Ambrose, and C. Ehrhart. 2009. Climate Vulnerability and Capacity Analysis Handbook. CARE International.

Ehrhart, C., A. Thow, M. de Blois, and A. Warhurst. 2009. Humanitarian Implications of Climate Change: Mapping Emerging Trends and Risk Hotspots. CARE International.

Glick, P., A. Staudt, and B. Stein. 2009. A New Era for Conservation: Review of Climate Change Adaptation Literature. National Wildlife Federation, Reston, VA, USA.

Glick, P., B. A. Stein, and N. A. Edelson. 2011. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, Washington, D.C.

Groffman, P. M., J. S. Baron, T. Blett, A. J. Gold, I. Goodman, L. H. Gunderson, B. M. Levinson, M. A. Palmer, H. W. Paerl, G. D. Peterson, N. L. Poff, D. W. Refeski, J. F. Reynolds, M. G. Turner, K. C. Weathers, and J. Wiens. 2006. Ecological thresholds: The key to successful environmental managementor an important concept with no practical application. Ecosystems **9**:1-13.

Holling, C. S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics **4**:1-23.

IPCC 2000. Emissions Scenarios Cambridge University Press, Cambridge, UK.

IPCC 2001. Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

IPCC. 2007a. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva, Switzerland.

IPCC. 2007b. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change - The Physical Science Basis in S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller, editors.

IPCC. 2007c. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change - Impacts, Adaptation and Vulnerability in M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, editors. Cambridge University Press, Cambridge, UK.

Kareiva, P., C. Enquist, A. Johnson, S. H. Julius, J. Lawler, B. Petersen, L. Pitelka, R. Shaw, and J. M. West. 2008. Synthesis and Conclusions. Pages 9-1 to 9-66 in S. H. Julius, and J. M. West, editors. Preliminary review of adaptation options for climate sensitive ecosystems and resources. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington, DC.

Manning, M. R., J. Edmonds, S. Emori, A. Grubler, K. Hibbard, F. Joos, K. Kainuma, R. F. Keeling, T. Kram, A. C. Manning, M. Meinshausen, R. Moss, N. Nakicenovic, K. Riahi, S. K. Rose, S. Smith, R. Swart, and D. P. van Vuuren. 2010. Misrepresentation of the IPCC CO2 emission scenarios. Nature Geoscience **3**:376–377.

Milly, P. C. D., J. Betancourt, M. Falkenmark, R. M. Hirsch, W. K. Zbigniew, D. P. Lettenmaier, and R. J. Stouffer. 2008. Stationarity Is Dead: Whither Water Management? Science **319**:573-574

Moss, R. H., and S. H. Schneider 2000. Uncertainties in the IPCC TAR: Recommendations to lead authors for more consistent assessment and reporting. World Meteorological Organization, Geneva, Switzerland.

Nychka, D., J. M. Restrepo, and C. Tebaldi. 2009. Uncertainty in Climate Predictions. American Mathematical Society.

OECD. 2006. Adaptation to Climate Change: Key Terms. Organisation for Economic Co-operation and Development, Paris, France.

Parmesan, C. 2006. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology, Evolution and Systematics **37**:637-669.

Root, T. L., J. T. Price, K. R. Hall, S. H. Schneider, C. Rosenzweig, and J. A. Pounds. 2002. Fingerprints of global warming on wild animals and plants. Nature **421**:57-60.

The Nature Conservancy. 2009. Conservation Action Planning Guidelines for Developing Strategies in the Face of Climate Change. Page 26. Conservation Science, The Nature Conservancy, Arlington, VA.

USCCP. 2008. Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research in S. H. Julius, and J. M. West, editors. U.S. Environmental Protection Agency, Washington, D.C.

Annex A - Sample Agendas for Climate Adaptation WWF Standards Workshop

5 Day Agenda
Day 1
Welcomes, Introductions, Ground Rules
Climate Adaptation Concepts

Day 2
Quick WWF Standards Refresher
Overview of Adaptation Planning Method
Vulnerability to Existing Climate Extremes
Overview of Climate Projections

Day 3
Re-review of Climate Projections
Examine Potential Direct Ecological Impacts
Examine Potential Human Responses and Associated Ecological Impacts

Day 4
Hypotheses of Change
Capture Potential Impacts in Conceptual Model(s)
Re-rank all Direct Threats

Day 5
Reflective Moment
Brainstorm Adaptation Strategies on Conceptual Model
Develop Results Chains for selected Strategies
Rank Strategies if Necessary
Next Steps

Alternative 3 Day Agenda
Day 1
Overview of Adaptation Planning Method
Vulnerability to Existing Climate Extremes
Overview of Climate Projections
Examine Potential Direct Ecological Impacts

Day 2
Examine Potential Human Responses and Associated Ecological Impacts
Hypotheses of Change
Capture Potential Impacts in Conceptual Model(s)
Re-rank all Direct Threats

Day 3
Reflective Moment
Brainstorm Adaptation Strategies on Conceptual Model
Develop Results Chains for selected Strategies
Rank Strategies if Necessary
Next Steps

Annex B – Menu of Climate Adaptation Strategies

I. By Type

Ecological Strategies

Maintain or build resilience to current climate extreme vulnerabilities
Systematically maintain environmental gradients to maintain diversity for adaptation and evolution
Reduce existing anthropogenic stresses
Representation in protected areas
Replication in protected areas
Ecological restoration
Identifying climate refugia
Collaborative spatial (land-use) planning to increase protection and rationalize land-use
Relocation of species
Ex-situ conservation

Institutional and Policy Strategies

Facilitate the transition of all policies and institutions towards a "climate-smart" approach

Community-based Strategies

Facilitating alternative livelihoods (including microfinance)
Community education
Women's empowerment
Planned and assisted human migrations
Facilitate the transition of all policies and institutions towards a "climate-smart" approach

Monitoring Strategies

Collect monitoring data (climate or ecological) that would indicate significant change

II. By Time Frame

Short-term ("no-regrets") Strategies

Maintain or build resilience to current climate extreme vulnerabilities
Collect specific information for decision making
Collect monitoring data (climate or ecological) that indicates significant change
Facilitating the transition of all policies and institutions towards a "climate-smart" approach
Community education
Reduce existing anthropogenic stresses
Ecological restoration
Collect monitoring data (climate or ecological) that would indicate significant change

Medium-term Strategies

Remove infrastructure and sensitive human investments from flood-prone river floodplains and low-lying coastal areas
Representation in protected areas
Replication in protected areas
Collect monitoring data (climate or ecological) that would indicate significant change

Longer-term Strategies
Relocation of species
Ex-situ conservation
Collect monitoring data (climate or ecological) that would indicate significant change
Install relatively hard engineering solutions (e.g. check-dams, artificial cover or substrate, supplemental water, etc.)

III. By Scale

Site-scale Strategies
Build resilience to current climate extreme vulnerabilities
Facilitate alternative livelihoods (including microfinance)
Community education
Women's empowerment

Landscape-scale Strategies
Maintain or build resilience to current climate extreme vulnerabilities
Representation in protected areas
Replication in protected areas
Systematically maintain environmental gradients to maintain diversity for adaptation and evolution
Identify climate refugia
Collaborative spatial (land-use) planning to increase protection and rationalize land-use
Facilitate the transition of all policies and institutions towards a "climate-smart" approach
Facilitate alternative livelihoods (including microfinance)
Community education
Women's empowerment

National- or Ecoregion-scale Strategies
Maintain or build resilience to current climate extreme vulnerabilities
Representation in protected areas
Replication in protected areas
Systematically maintain environmental gradients to maintain diversity for adaptation and evolution
Identify climate refugia
Collaborative spatial (land-use) planning to increase protection and rationalize land-use
Relocate species
Ex-situ conservation
Facilitating the transition of all policies and institutions towards a "climate-smart" approach

Annex C – Overall Strategy Ranking

To use this tool below, follow this process:

1. Assess the Benefits of each strategy using the criteria below and note.
2. Assess the Feasibility of each strategy using the criteria below and note.
3. Assess the Cost of each strategy using the criteria below and note (feel free to adjust the Cost criteria based on your national economic and funding situation).
4. Use the colorful tables – if your benefits were "High," use the "High" table and corresponding Feasibility and Cost results to determine the "Overall Strategy Ranking."

Benefits – the estimated degree to which the strategy will lead to the desired outcome.

- **Very High** – the strategy will rescue a conservation target from the brink of imminent loss.
  - Makes a substantial contribution to effective, enduring improvement for one or more KEAs projected to be Poor.
- **High** – the strategy will move a conservation target's projected KEA from Fair to Good, or make an important contribution towards preventing imminent loss.
  - Makes a substantial contribution to effective, enduring improvement for one or more KEAs projected to be Fair. OR
  - Makes an important (but not full) contribution for one or more KEAs projected to be Poor.
- **Medium** – the strategy will make an important contribution toward improving a Fair KEA, or will "buy time" for a conservation target.
  - Makes an important (but not full) contribution to effective, enduring improvement for one or more KEAs projected to be Fair.
  - Would not assure effective, enduring improvement, but would temporarily or partially abate the threat that leads to the projected Poor or Fair KEA.
- **Low** – the strategy will make a relatively small contribution towards improving a KEA or "buying time."

Feasibility – includes ease of implementation, lead individual or institution, institutional support, ability to motivate key constituencies, ability to secure sustainable financing.

- **Very High –** the strategy is relatively straightforward and all key success factors are attainable.
- **High –** the strategy is somewhat complex but most key success factors are attainable.
- **Medium –** the strategy is very complex with many hurdles or uncertainties, but most key success factors are attainable, <u>or</u> the strategy is straightforward or somewhat complex but two key success factors are doubtful.
- **Low –** three or more key success factors are doubtful.

Cost – order of magnitude number of dollars over 10 years.

- **Very High** **~$ 5,000,000+** (e.g., 2 FTE for 5 years plus $5,000,000 direct costs)
- **High** **~$ 2,000,000** (e.g., 1 FTE for 10 years plus $1,000,000 direct costs)

- **Medium** **~$ 500,000** (e.g., 0.5 FTE for 10 years plus $100,000 direct costs)
- **Low** **~$ 100,000** (e.g., 0.25 FTE for 5 years plus $25,000 direct costs)

Overall Strategy Ranking

Benefits = Very High

< Cost > \ <------------------ Feasibility ------------------>	Very High	High	Medium	Low
Very High	Very High	High	High	Medium
High	Very High	Very High	High	Medium
Medium	Very High	Very High	Very High	High
Low	Very High	Very High	Very High	***High***

Benefits = High

< Cost > \ <------------------ Feasibility ------------------>	Very High	High	Medium	Low
Very High	High	Medium	Medium	Low
High	High	High	Medium	Low
Medium	Very High	High	High	Medium
Low	Very High	Very High	High	High

Benefits = Medium

< Cost > \ <------------------ Feasibility ------------------>	Very High	High	Medium	Low
Very High	Medium	Low	Low	Low
High	Medium	Medium	Low	Low
Medium	High	Medium	Medium	Low
Low	Very High	High	Medium	Medium

Benefits = Low

< Cost > \ <------------------ Feasibility ------------------>	Very High	High	Medium	Low
Very High	Low	Low	Low	Low
High	Low	Low	Low	Low
Medium	Medium	Low	Low	Low
Low	High	Medium	Low	Low