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INTEGRATION OF BIODIVERSITY CONSIDERATIONS IN THE IMPLEMENTATION OF ADAPTATION ACTIVITIES TO CLIMATE CHANGE AT THE LOCAL, SUBNATIONAL, NATIONAL, SUBREGIONAL AND INTERNATIONAL LEVELS

Note by the Executive Secretary

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Executive summary

Adaptation includes autonomous and directed actions. Biodiversity has already adapted autonomously to the observed changes in climate.

- Biodiversity can adapt naturally to changing conditions (ie autonomous adaptation). Biodiversity at ecosystem and species level has adapted to observed changes in climate, e.g. changes in growth, population size, and migration patterns and frequency and intensity of disturbances such as fires. It is not clear how many species and ecosystem functions can go through this change without affecting the ecosystem services they provide.
- For most human systems and with greater rate and magnitude of climate change, intentional or planned adaptation is needed.
- Directed adaptation requires an awareness of potential impacts of climate change, the need for taking action, an understanding of available strategies, measures and means to assess adaptive responses, and the capacity to implement effective adaptation options.
- There are some ecosystems and species, especially those in high latitude and altitude and coastal systems that are already highly impacted by climate change and sea level rise and are not able to cope with these changes.

Conservation and sustainable use of biodiversity can provide opportunities for adaptation and is an adaptation option itself.

- Biodiversity, especially functional diversity, affects the resilience of ecosystems.
- Conservation and sustainable use of biodiversity especially in non-intensively managed systems including genetic diversity is a way for the system to cope with climate change. These measures can also provide a means and opportunities for adaptation options, e.g. search for drought tolerant species, pest management and disease or vector control.

Many human activities, especially through land use and land cover change form multiple pressures on biodiversity; climate change is an added pressure on many ecosystems and species. Reduction of these other pressures maybe a realistic adaptation option for biodiversity in many systems.

- The pressures from human activities, especially land use and land cover change, pollution in particular persistent organic pollutants, pose and will pose a challenge for biodiversity to adapt to climate change.
- Adaptation options for minimising these impacts on biodiversity have to be considered as the question remains open as to what will be the consequences of climate change on biodiversity without planning and implementing these adaptation options.
- In cases of ecosystems and/or species that have already been highly affected by climate change, there are few adaptation options, making them vulnerable to the present changes in climate, with vulnerability increasing with greater magnitude and rate of projected climate change. Apart from minimizing the other pressures, there appear to very few adaptation options and this has dire consequences for biodiversity and many of the ecosystem services as well as the humans that depend on them.

Planned adaptation actions can have positive and negative impacts on biodiversity.

- The projected changes in climate include increasing temperatures, changes in precipitation, sea-level rise, and increased frequency and intensity of some extreme climatic events leading to increased climate variability. The impacts of these projected changes in climate include changes in many aspects of biodiversity and disturbance regimes (e.g., changes in the frequency and intensity of fires, pests, and diseases).

- The projected changes in temperature by the end of the 21st century are 2 to 14 times greater than those observed. It is obvious that humans would implement adaptation measures, in terms of infrastructure (such as building of sea walls, changes in flow of water to and from wetlands), behavioral changes (e.g. using mosquito nets in areas not used at present, spraying with pesticide due to changes in vector and disease distribution, migration into different areas) and other measures (e.g. use of hardier crop species which use less water and or can cope with higher temperatures during the growing season).

- Many of the infrastructure changes as well as changes in water flows can have potential negative impacts on biodiversity although careful planning can minimize these impacts.

- Many of the adaptation options that involve more efficient use of water can potentially have a positive impact on biodiversity and ecosystem functioning through the conservation and sustainable use of surface and ground water. Adaptation options that have reduced the canals and allowed the wetlands to be used in their normal function of flood control in some parts of Europe would in fact have positive impacts on biodiversity, especially those relying on seasonal floods.

- It is also not clear as to how much biodiversity will adapt to the rate and magnitude of change being projected and if there are thresholds at which certain species and ecosystems would become endangered or even extinct. For example changes in seasonality of rainfall may be such that the suitable temperatures for germination do not overlap with the precipitation patterns and hence although the species could persist in an area if it is long-lived, it is no longer a suitable habitat for it in terms of its long-term persistence.

Adaptation measures would mean active management within landscapes for the survival of certain species or ecosystems, particularly vulnerable species

- Climate change due to its direct and indirect effect along with land use and land cover change is likely to result in more weedy species becoming dominant especially in areas that have a high frequency and intensity of disturbances. This would affect ecosystem services being provided as well as increasing the proportion of vulnerable species and ecosystems.

- Given that humans rely on many ecosystem services (e.g. timber, aesthetic/recreation/spiritual), there may need to be careful management of some species to ensure the continuation of these services. For example, this may include transplanting well developed seedlings into certain areas and managing invasive species.

Tools, such as risk management, strategic environmental assessment would have to be modified to include climate change and adaptation.

- The best possible adaptation options would entail inclusion of climate change in national policy and planning. This would ensure that climate change is an integral component rather than a stand-alone activity; the latter is less likely to be implemented and/or effective.

- There is a need to develop tools that would allow policy makers to decide when climate change has to be considered and when it is likely to be less of an issue compared to the overall national planning, such as land use and land cover change. These tools can include a check list for systems that are considered to be particular important for biodiversity and/or most likely to be affected by climate change and would aim to minimize the negative effects on biodiversity and ecosystem services and if possible increase ecosystem resiliency. This is akin to carrying out risk management and can be imbedded in national or regional strategic environmental assessment.

Lesson learned from adaptation policy and projects have to extracted and distributed to the planners and managers

- Very few policies and projects that address adaptation have been implemented. Most of the information is guidelines and policy frameworks with many being “academic”. Few that have been implemented would have to be examined in detail and lesson learned from these have to extracted and distributed to the practitioners as a resource.

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) in its Third Assessment Report concluded that adaptation as well as mitigation options have to be considered as part of response to climate change (IPCC 2001b). The conclusion was based on the fact that there have already been observed impacts of climate change. In recent years, more emphasis has been placed on adaptation in many of the international, regional and national discussions, however it is unclear as to what measures (policies, strategies and projects) are being discussed and what would be the potential impact of these measures on biodiversity. There is also the question as to what are the implications of climate change on biodiversity, especially in conjunction with other human pressures and what adaptation options have to be considered to conserve and sustainably use biodiversity.

GEF in its recent guidelines for its strategic priority on adaptation suggested that given that climate change is already occurring and as many developing countries rely on climate sensitive sectors, adaptation has to be seen as part and parcel of national development planning and as part of achieving sustainable development (GEF 2004).

Pursuant to CBD SBSTTA recommendation X/13, this report provides background to the work that the Ad Hoc Technical Expert Group on Biological diversity and Climate Change will develop for consideration by the eleventh meeting of the SBSTTA. Specifically, the report

- summarises the importance of biodiversity in the functioning of ecosystems
- provides a working definition of adaptation,
- summarises some adaptation frameworks,
- presents planned adaptation measures specifically for biodiversity
- presents tools that can be developed or adapted to integrate biodiversity considerations in adaptation activities.

Much of the material for this report comes from recent assessment including those of:

- The Intergovernmental Panel on Climate Change (IPCC), especially the report on climate change and biodiversity (IPCC 2002) and the Synthesis report (IPCC 2001)
- The report of the CBD Climate Change Ad hoc Technical Group (CBD 2003)
- The Millennium Ecosystem Assessment reports, particularly chapter 13 in the Responses Working Group which concentrates on adaptation as a response to climate change, the Synthesis report for the CBD and for Ramsar Convention (Noble et al 2005)

These reports are supplemented by other documents especially activities related to adaptation in the Global Environmental Facility and other multilateral and bilateral funding agencies.

1.1. Role of Biodiversity in ecosystem functioning

The Convention on Biological Diversity defines biological diversity as the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Biodiversity is critical to the functioning of ecosystems and it underlies the goods and services they provide. To help illustrate this, the Millennium Ecosystem Assessment (MA) categorisation of ecosystem services is useful. It systematically lists the direct and indirect goods and services from ecosystems into four main categories. They include provisioning, supporting, regulating and cultural services (see Box 1).

Many ecosystem services are largely unrecognized in their global importance or in the pivotal role that they play in meeting needs in particular regions (CBD 2003). For example, biodiversity contributes to the absorption by terrestrial and ocean ecosystems of nearly 60 percent of the carbon that is now emitted to the atmosphere from human activities, thereby slowing the rate of global climate change. An estimated 40 percent of the global economy is directly based on biological products and processes, and the goods provided by biodiversity represent an important part of many national economies. Ecosystems also provide essential services for many local and indigenous communities such as non-timber forest products and other needs for subsistence and traditional medicines.

Box 1: Ecosystem Services categorisation of the Millennium Ecosystem Assessment

Source: Millennium Ecosystem Assessment 2003 Report "People and Ecosystems: A Framework for Assessment"

Provisioning Services (products obtained from ecosystems): Food; wood fuel; fiber; biochemicals; natural medicines; pharmaceuticals; genetic resources; ornamental resources; clean water; minerals, sand and other non-living resources;

Supporting Services (services that maintain the conditions for life on earth): Soil formation and retention; nutrient cycling; primary production; pollination and seed dispersal; production of oxygen; provision of habitat;

Regulating Services (benefits obtained from regulation of ecosystem processes): Air quality maintenance; climate regulation; water regulation; flood control; erosion control; water purification; waste treatment; detoxification; human disease control; biological control of agriculture and livestock pest and disease; storm protection;

Cultural Services (non-material benefits obtained from ecosystems): Cultural diversity and identity; spiritual and religious values; knowledge systems; educational values; inspiration; aesthetic values; social relations; sense of place; cultural heritage; recreation and ecotourism; communal; symbolic.

Note that in reality, there is an overlap between some of these categories, especially the supporting and regulating services they are hard to distinguish. Water in many ways is special, that it can be seen to be driving many of the global biogeochemical cycles and climate system and thus would be a supporting service with clean water being a provisioning service.

In scientific literature, there has been a long standing debate on the importance of biodiversity on ecosystem functioning and in particular ecosystem resiliency. The conclusions are that a simple monoculture is less able to cope with disturbances than a multi-species, less disturbed (or natural) ecosystem. Thus the species composition of ecosystems affects their functioning including their ability to cope with disturbances or changes, such as climate change, pest and disease outbreaks. Instead of just considering species composition, there is also the concept of functional types. The concept of functional types (a group of species (or even different ages) that determine specific function and the maintenance of functional groups is important in maintaining ecosystem functioning. Biringer et al have suggested some properties of systems that help in improving its resilience and include the idea of redundancy, complementarity, spatial heterogeneity and memory of the system or its components (see Box 2). Related attributes or properties include genetic diversity and phenotypic plasticity(determined through time consuming and sometime expensive physiological studies, or through molecular techniques), ability to migrate or disperse, which can be a function of rare events as shown by modelling work (Dispersal workshop 1997). In practice, apart from attempting to conserve ecosystems with high species diversity, the concept of resiliency is hard to apply. This is partly due to the fact that many ecosystems have multiple states in which they exist and switch between (e.g. grass dominated rangeland or shrub dominated one, a dry inland wetland and a flooded one) and provide different ecosystem services. Many of the changes from one state to another abrupt and part of the "natural" dynamics of the ecosystem and cross thresholds which are not necessarily predictable. This is an area of research that is being addressed within the Resilience Alliance but could be considered by a wider scientific community.

Box 2: Attributes that can enhance resiliency of an ecological system

(from Biringer et al in press)

Redundancy —the number of species is less important to an ecosystem than the presence of "functional groups" (e.g., short-lived and long-lived trees, shrubs, annual and perennial grasses). If a functional group loses a species, other species within that group are likely to take over by increasing in abundance

Complementarity —the number of species plays an important role in the way an ecosystem works, as different species contribute to its structure and function in complementary ways; e.g., coexisting tree species with shallow and deep root systems.

Spatial heterogeneity—tends to favour the coexistence of different species in a given area (to fulfil the abovementioned roles) and makes reorganization possible.

Memory—e.g., (i) genetic makeup present in current biological communities selected over long time periods expressed in a selective manner under different environmental conditions.

(ii) dormant seeds in the soil that allow a forest to regenerate after large scale-and sometimes catastrophic events—such as hurricanes, deforestation.

To help in the discussion of what ecosystem properties may be useful to consider in determining the impact of climate change and thus adaptation options, the terms and concepts of sensitivity of a system, its adaptive capacity or coping capacity and vulnerability are useful (see Box 3). Coping capacity can be related to resiliency of the system. For human societies, ttraditional coping mechanisms are often the starting point for developing adaptation strategies. Initially, the impacts of climate change will fall within the general range of experience of systems, although damaging events may be more frequent or intense, and stress periods may be longer. Adaptation efforts begin with the existing assets and capabilities that can be strengthened to reduce vulnerability and increase resilience to climate change. Maintaining social networks, capacity building, effective information flow and efficient local control of limited financial assets (for example, through micro-finance and micro-insurance) appear to be important components of building and maintaining community resilience. However, the traditional coping mechanisms are already failing, so specific plans for adaptation to climate change need to be incorporated into wider regional and national development planning.

Biodiversity also has coping capacity - it has coped with changes in climate in the past in various ways including migration to more favourable sites (see Dias et al in CBD 2003 for a summary), although the rate and magnitude of change may not have been similar to that being experienced in the past 50 years. In addition, the Earth is subjected to many human-induced and natural pressures that have significantly altered, degraded, displaced and fragmented terrestrial, (including aquatic or inland wetlands), coastal and marine ecosystems, often leaving biologically impoverished landscapes or seascapes. Given the impoverishment and the current rate of loss of species, it is not clear that biodiversity will be able to continue to cope with the multitudes of pressures.

Box 3:System properties: Sensitivity, vulnerability, resilience and resistance

Systems are considered to be vulnerable if they are exposed and/or sensitive to climate change and/or adaptation options are limited. Vulnerability has two components: sensitivity of the system and its adaptive capacity (IPCC 2001b), where

Sensitivity is a degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. Climate-related stimuli include the elements of climate change: mean climate characteristics, climate variability, and the frequency and magnitude of extremes.

Adaptive capacity - ability of a system to plan, prepare and implement actions to moderate potential damages, to take advantage of opportunities, or to cope with the consequences of climate change and climate variability.

Vulnerability - Systems are vulnerable if they have low adaptive capacity. This may mean that they are highly adaptable or in human systems have the institutional and financial capacity to develop and implement options to reduce the impact of pressures. On the other hand, systems are highly vulnerable if they have low inherent capacity to cope with the change and/or there are few or no options to reduce impacts of pressures and/or they are naturally sensitive to pressures (for example due to their geographic or socio-political location). Vulnerability is determined at specific spatial and temporal scale and is a dynamic property as it changes depending on the local conditions, e.g. a system maybe vulnerable at a particular time (e.g. the dry season) but may not be at other times.

Resistance and Resilience. Resistance is the ability of a system to avoid change, or its capacity to stay in the same state in the face of perturbation. Resilience is the rate at which a system returns to its former state after being displaced by perturbation. Functional diversity may also play a role; e.g., the dominance of short lived, fast growing plants (e.g., annual grasses) leads to high resilience and low resistance, whereas the dominance of long lived (e.g., trees) slow growing, stress-tolerant plants favours resistance. Thus species attributes and types of species (e.g., trees, shrubs, grasses) may have important implications in climate change adaptation projects as it may determine the longevity, rate and direction of desired ecosystem processes (CBD 2003)

1.3. Multiple drivers of change

Climate change is but one of the pressures or drivers of change affecting biodiversity. Human activities, often referred to as pressures or direct drivers of change, affect biodiversity in many ways, both directly and indirectly.

At the global level, human activities have caused, and will continue to cause, a loss and/or degradation of ecosystems through climate change, land-use and land-cover change, including drainage, urbanisation and changes in flow regime; water pollution (through land and/or air); water abstraction and diversion of water to intensively managed ecosystems and urban systems; habitat fragmentation; selective exploitation of species; introduction of non-native and/or invasive species; and stratospheric ozone depletion. (IPCC 2002, CBD 2003, MA 2003). The underlying causes driving these changes (indirect drivers of change – MA 2003) include economic, demographic socio-political, scientific and technical factors. The drivers of change interact with each other, e.g. climate change and climate variability can lead to increased frequency and intensity of floods and drought. This can affect surface and ground water flow, which in turn can affect the establishment or dispersal of invasive species. It is thus important to consider the linkages between these drivers when analysing the impacts and subsequently developing adaptation options.

2. Adaptation

This section builds on the system properties listed in the previous section, provides a working definition of adaptation in relation to these properties and presents the arguments for planned adaptation to maintain ecosystem function and the ability of ecosystems to provide the goods and services that are necessary for human survival. It has been suggested that planned adaptation is likely to be most effective if it is part of national development plans and can help in achieving sustainable development goals and is briefly covered in the last sub-section.

2.1 Working definition of adaptation

Adaptation is context specific. Here adaptation is any adjustment occurring in biophysical and social system as a response to actual or projected impacts of climate change. Adaptation would thus aims to moderate the harm or negative impacts and exploit the beneficial opportunities. (IPCC 2001, Noble et al in press). Adaptation often involves measures to increase the capability of a system to cope with impacts of climate change and other pressures. It is thus linked to coping capacity of the system, its sensitivity, resiliency and vulnerability[1] (see Table 1). It is generally at very local level and this creates challenges as adaptation options are very specific to given circumstances.

Table 1: Relationship between sensitivity, resiliency and vulnerability of the system

	Resiliency	
	High	Low
Sensitivity		
high	Vulnerable	Very vulnerable
low	Not vulnerable	Vulnerable

Modified from Alwang et al., 2001; IPCC 2001

2.2 Need for planned adaptation

Climate change has already impacted biodiversity (see Annex 1, Root et al. 2003, van Oene 2001) and socio-economic systems and the projected impacts are greater both in magnitude and rate (see Annex 1). The impacts of the projected changes in climate include changes in many aspects of biodiversity and disturbance regimes (e.g., changes in the frequency and intensity of fires, pests, and diseases). Changes in climate projected for the twenty-first century will occur faster than they have in at least the past 10,000 years and, combined with change in land use and the spread of invasive species, are likely to limit both the capability of species to migrate and the ability of species to persist in fragmented habitats (IPCC 2001b). Climate change is projected to exacerbate the loss of biodiversity, increase the risk of extinction for many species, especially those that are already at risk due to factors such as low population numbers, restricted or patchy habitats and limited climatic ranges, change the structure and functioning of ecosystems, and adversely impact ecosystem services essential for sustainable development. Using the climate envelope/species-area technique, estimated that the projected changes in climate by 2050 could lead to an eventual extinction of 15-52% of the subset of 1103 endemic species (mammals, birds, frogs, reptiles, butterflies, and

[1] Associated with adaptive capacity is the concept of hazard. Ecological systems can be exposed to different climate hazards with the potential to cause harm (Brooks & Adger in Lim et al 2004) thus the sensitivity of a system can result in different outcomes (or harms). Hazards can be discrete (e.g. a single flood or drought), changes in mean condition or a singular or unique hazard with a low probability of occurrence (e.g. change in the thermohaline circulation). Climate change can include all three and the projected changes in mean temperature and precipitation are also projected to change the frequency and intensity of extreme events in many parts of the world.

plants) they analyzed (Thomas et al. 2004). Other studies also show similar results for the Cape floristic flora and Proteas in general due mostly to the loss of habitat range (Hannah et al 2005).

There is also some feedback in the system. Changes in biodiversity at ecosystem and landscape scale, in response to climate change and other pressures (e.g., deforestation and changes in forest fires), would further affect global and regional climate through changes in the uptake and release of greenhouse gases and changes in albedo and evapotranspiration. Similarly, structural changes in biological communities in the upper ocean could alter the uptake of carbon dioxide by the ocean or the release of precursors for cloud condensation nuclei causing either positive or negative feedbacks on climate change.

Given the observed impacts of climate change and the lag times in the global climate system no mitigation effort, however rigorous, is going to prevent further climate change from happening. Thus, adaptation is an essential component of our response to climate change both for the observed impacts but also putting measures in place to reduce the impact of the projected changes.

It is unlikely that autonomous adaptation to climate change by ecosystems will suffice to reduce the potential impacts of climate change to an acceptable level. In many parts of the world, the future impacts of climate change are projected to be significantly greater than those that have been experienced in the past as a result of natural climate variability alone. Future impacts may be more than what many ecosystems are able to handle effectively with autonomous adaptation, particularly given additional pressures such as barriers to the migration of species.

As a result, it is now widely acknowledged that there is a need for planned adaptation, aimed at preparing for the impacts of climate change and at facilitating and complementing autonomous adaptation by biodiversity and human society.

2.3 Adaptation and sustainable development

Adaptation is becoming an increasingly important issue in the international negotiations (e.g. in United Nations Framework Convention on Climate Change). However, the burden of adaptation will fall most heavily on developing nations. Developing nations have the least resources to commit to adaptive actions. So it is necessary to identify the impacts of climate change, to devise responses from the community level to national planning, and to determine how the necessary responses should be funded. Clearly, adaptation measures need to be an integral part of any national program or action plan for combating climate change. Implementation of such a plan would be beneficial for all, especially the most vulnerable. The Global Environmental Facility has developed a pilot program for adaptation for at least addressing some of these issues (see Annex 2 – SPA guidelines). Two other funds have been set up for meeting some of the costs of adaptation in developing countries.

Adaptation to climate change needs to be factored into current development plans and coordinated with strategies for poverty reduction, disaster management (see to be an emergency response), environmental management (including conservation and sustainable use of biodiversity. Coordination of these type of strategies or management can reduce the burden to adapt (IISD 2003). Thus, it is generally considered that adaptation options are best carried out as part of an overall approach to sustainable development, integrated, for example, with national biodiversity strategies and action plans. It also means that multiple drivers of change can be considered. The CBD ecosystem approach provides a unifying framework for adaptation activities to climate change in the context of sustainable development and can be part of the suggested landscape management in later sections.

3. Frameworks for adaptation

Various frameworks that incorporate adaptation strategies have been devised over the last decade. The first classification of adaptation strategies into protection, accommodation, and planned retreat was developed for coastal zones by Intergovernmental Panel on Climate Change (IPCC) (IPCC's CZMS 1990), and it is still the basis of many adaptation analyses and frameworks. Many of the frameworks developed have similar steps and include:

- *Examination of the present ecological and social system*.
- *Stakeholder analysis and engagement*.
- *Understanding current vulnerability to multiple stresses*.
- *Evaluating narratives (scenarios) of future vulnerability*.
- *Identifying and evaluating potential adaptive strategies and measures*.
- *Communication and integrations:*

A further elaboration in these frameworks can include:

- developing a multi-stakeholder management approach, including consideration of alternative and sustainable livelihoods for local and indigenous communities
- incorporating adaptive management to include monitoring of the systems
- creating institutions for management of the systems
- specific inclusion of local and/or indigenous peoples in co-management

Downing and Doherty (2004), drawing together many approaches used for climate vulnerability and adaptation, have suggested a detailed framework. The steps and methods for each of them suggested can be modified to include ecosystems. Downing & Doherty emphasise the approach should be seen to be a process. Although they do not explicitly incorporate monitoring and adaptive mangement, these can be seen to be part of the overall process. Their framework is centred on stakeholder engagement, extrapolation of the present risks and pressures and incorporates role playing and visualisation exercises. It can be seen to be an awareness raising exercise but also empowerment to be able to deal with the present climate variability and to develop adaptation options (or responses) for the projected changes. Their framework and the associated methods, can be summarised as follows (see also figure 1):

- *Examination of the present ecological and social system*. The methods concentrate on the knowledge from stakeholders.
- *Stakeholder analysis and engagement*: This can include an inventory of stakeholders, analysis of their organisational capacity (e.g., focus, legal structure, resources) and a mapping of stakeholder that form the basis of social institutions.
- *Understanding current vulnerability to multiple stresses*. This can be done using a series of matrices to show the relative vulnerability of different groups and activities to climatic hazards (e.g., droughts, floods, extremely high temperature events). In this matrix, the columns can be the present climatic threats (or opportunities) and trends that are important for the vulnerable components of the system (specific ecological characters). Other pressures can be added. The matrix can be filled in with relative scores (say from 1 to 5) for the degree to which each climatic hazard can affects each ecological component or livelihood.

- *Evaluating narratives (scenarios) of future vulnerability*. Understanding future vulnerability requires an extension of the current vulnerability methods with some sort of scenario analysis. They can include backcasting or time-dependent projections, Note: this has limitations, as the system behaviour may not remain the same in the future. Stakeholders can categorise the risks to particular components (e.g. of ecological character or their livelihood).
- *Identifying and evaluating potential adaptive strategies and measures*. The analysis can include financial, technical capacities, data requirements, time required to plan and implement the options, stakeholder commitment and involvement that would be needed and over what time period, who/what would be losers and who/what the beneficiaries and thus the potential conflicts that would need to be managed. Techniques to evaluate adaptation options range from qualitative checklists to full cost-benefit analysis. In most cases, some sort of multi-criteria analysis is essential.
- *Communication and integrations:* Would include testing potential responses and policy options. Rule based and multi-agent modelling and/or formal models of environmental stresses, the responses of individual actors and social networks can provide a means to test a wide range of scenarios. Simple rule based approaches can be readily implemented, for instance in the Java Expert Systems Shell. Role playing is one form of an interactive policy exercise. Role playing and policy exercises can provide Insight into the dynamics and processes driving future vulnerability and the implementation of adaptive options can be gleaned from stakeholder-driven exercises. For instance, a drought crisis could be ‘played’ for the present and then for a future scenario, perhaps with greater economic trade and an early warning system.

Lim *et al* (2004) have moved from project based approaches to policy frameworks again focussed on human society, but can be modified to include the biodiversity. They have suggested six major components for adaptation policy frameworks:

1. Scoping and designing an adaptation project (see table 2 for examples) that is imbedded in the national policy and development plan
2. Assessing current vulnerability, especially to current climatic extremes
3. Assessing future climate risks through developing climate scenarios (note the challenges for doing local level projections – see section 7)
4. Formulating an adaptation strategy taking the current and projected changes and developing a coherent policy
5. Continuing the adaptation process, through monitoring, evaluating, improving and sustaining the adaptation project.
6. Throughout the above “steps”, engaging stakeholders with the aim of assessing and enhancing their adaptive capacity.

These six steps form the basis of their User Guidebook to developing and implementing an adaptation project. They also develop a checklist or a conceptual model (see section 6)

Figure 1: Some suggsted methods for each of the components in developing adaptation options by Downing & Doherty (2004)

Step:	**Conceptual framework**	**Stakeholder analysis and engagement**	**Current vulnerability and exposure to climatic hazards**	**Future vulnerability**	**Adaptation options, planning and capacity**	**Integrated analysis and synthesis**
Objectives:	To describe the ecological and socio-economic system & actors	To identify actors and their motivations for climate adaptation	To identify vulnerable groups and current exposure to climatic and other stresses	To describe pathways of future vulnerability and adaptive capacity	To identify the range of choice and potential effectiveness of adaptive responses	To link the elements of the assessment together To communicate with stakeholders and support greater awareness and effective decision making
Analysis:	To define pathways through the analysis	Inventory & typology Networks & regimes	Attributes of vulnerable groups (e.g., livelihoods) Prevalence & location	Same analysis, with: Changing prevalence, location, attributes	Inventory of adaptation options for sectors and stakeholders, including vulnerable groups	Pathways and narratives for core scenarios Visualisation of results Risk assessment
Key methods:	Workshops Mental mapping	Interviews Analysis of secondary material Knowledge elicitation	Sensitivity matrix Vulnerability indicators & profiles Sectoral impact models Geographic information system Rule-based dynamic modelling	Overlays of future risks (climate, socio-economic) Scenario generation Scenarios in dynamic models Probabilistic climate forecasts	Checklist of attributes of adaptation options Typology of adaptation measures, strategies and capacity Multi-criteria analysis Dynamic simulation Cost-benefit analysis	Formal risk assessment with expert and stakeholder judgement Policy exercises Role playing and gaming
Synthesis:	Elements (dimensions) of a risk analysis	Trends and transformations underway that shape vulnerable groups and stakeholders	Target vulnerable groups and risks Scales of risk Narratives, case histories, self reporting News stories, photography, video	Same as for current vulnerability, with: Projections, backcasting, visions of future conditions	Identify high priority responses	Press release and news stories Video CD and decision support

Lim et al also develop four specific approaches within their framework which they suggest can be applied at different scales (see table 2). The approaches include: hazard-based approach (where hazard is defined as potential threat to humans and their welfare), vulnerability based approach (where vulnerability is the exposure and susceptibility to losses), adaptive-capacity approach and policy-based approach.

Table 2: Examples of adaptation projects and their implementation at national, regional and local scale for floods, storm surges and sea level rise

Approach	Hazard-based	Vulnerability-based	Adaptive-capacity	Policy-based
	Increase resilience to severe flooding and future climate risks	*Improve access to new markets and diversification of livelihood activities*	*Improve awareness to climate variability and change*	*Reduce vulnerability to climatic extremes(e.g. storm surges, sea level rise) and climate change*
National	What changes are needed in institutions dealing with weather forecasts and monitoring of climate systems?	How would recent changes in markets affect the aquaculture industry in a particular country already facing other pressures (e.g disease outbreaks, salt water intrusion)	What awareness raising is needed to alert particular private sectors for the present storm surges and projected changes in sea level?	Can voluntary measures (incentives and disincentives) be used to discourage development along coastal zones? Should regulations be developed to discourage development in areas likely to be affected by sea level rise?
Regional	How can flood and early warning systems be made more effective for projected changes in sea level rise and storm surges?	How can access to markets and diversification be enhanced under projected changes in climate?	How can regional consortiums be developed to support local livelihoods most vulnerable to climate change?	How to decide on the areas to priorities for protection against sea level rise? And which ones to give up on?
Local	What techniques are most likely to be effective for local level preparedness?	How can credit schemes or government support livelihood schemes that may face increasing frequency and intensity of storm surges?	How can active community participation be used to identify threats and opportunities from sea level rise and build it into their business plans?	What stakeholder-led projects are most appropriate for investigating ways to limit damage from floods and storm surges and how can these be used for future policy development?

Modified from Lim et al (2004)

Biringer et al (in press) have specifically developed adaptation framework for ecological systems. Their framework is project oriented, but is based on the general steps for an adaptation framework and includes the following:

1. specifying priorities and objectives for the project
2. defining area of focus (scope and geographic scale of adaptation efforts, including priority landscapes or sites)
3. identifying and engaging stakeholders and project participants
4. Assessing the impacts of climate change on biodiversity in area of focus (baseline and future projections)
5. Identifying and formulating adaptation options
6. Evaluating and selecting and perhaps prioritising adaptation options
7. Developing and implementing selected adaptation options
    a. Description of planned activities
    b. Timetable
    c. Resources needed
    d. Baseline & Targets
    e. Participants and their roles
8. Implementing a monitoring program

Stakeholder identification and engagement as stated above is important. They suggest stakeholders can include:

- ecosystem managers and resource users (government, private and local communities)
- policy makers: often government staff, but can include local community members that are responsible for developing and implementing policies
- knowledge brokers: NGOs and expert groups that have the knowledge of resources both locally and from elsewhere that can help in assessing impacts and developing adaptation options.

4. Planned adaptation

Planned or directed adaptation can be a combination of protection, accommodation and retreat and fit into the adaptation frameworks suggested above. They can also incorporate the four different approaches suggested by Lim et al (2004). What are some common planned adaptation actions and what are their impacts on biodiversity. This section addresses this question and then goes onto to specify three major adaptation options for biodiversity. It ends by giving examples of adaptation options for specific ecosystems.

4.1 Common examples of planned adaptation and their impacts on biodiversity

Common examples of planned adaptation actions include:

- infrastructure and investments e.g., expanding buffer zones or building sea walls to reduce the impact of sea level rise or storm surges
- Zoning plans that would prevent or discourage investments in highly vulnerable areas (e.g. near the coast or in 100-year flood plains);
- Innovations for intensively cropped systems, e.g. develop and introduce new crop varieties that are better adapted to the potentially increased temperatures and decreased precipitation
- Diversion of water to areas for agriculture (or in some instances as watering holes of animals)
- Removal perverse incentives especially for water use in agricultural systems – thus aim for better or sustainable use of water
- Removal of some infrastructures – e.g. sea walls and drainage ditches that are maladaptation for extreme climatic events (e.g. storm surges and floods)

Depending on the location, some climate change adaptation activities may have either beneficial or adverse impacts on biodiversity. Physical barriers against extreme climatic events (e.g., storm surges, floods) may have positive or negative impacts on biodiversity**.** Resulting loss of biodiversity due to the development of the physical barrier may affect ecosystem functioning, resulting in increased vulnerability to future climate change. For example, in some cases, some ecosystems in small islands may be largely destroyed by efforts to obtain construction material for coastal protection. On the other hand, certain adaptation options may benefit biodiversity; for example, the conservation of ecosystems that serve as natural protection against potential impacts of climate change, such as mangrove forests and coral reefs, and the strategic placement of artificial wetlands.

Potential increase in the use of pesticides and herbicides to control new pest and diseases or expanded phenology of the pests and invasive alien species may adversely affect non-target species, water quality, and human health. In addition, non-target species could include natural predators of other pests thus creating more problems including more likely pest outbreaks. In some cases, use of integrated pest management may offer a more sustainable solution.

Changes in agriculture and increased use of aquaculture--including mariculture--employed to compensate for climate-induced losses in food production, may have negative effects on ecosystems and associated species. For small changes in climate, altering planting times or moving to new varieties of crops or livestock may be sufficient. Larger changes may require wholesale changes in farming systems such as new crops or livestock management systems or major changes in land and water use, for example, changing from farming to grazing lands (Noble et al 2005) and/or from rainfed to irrigated agriculture. FAO and the CGIAR are already experimenting with new varieties of early maturing rice, expansion into uplands or rainfed agriculture and development of salt-tolerant species. There are many lessons learned from irrigated agriculture which need to be heeded as there is no doubt that irrigation has to be sustainable and managed to avoid land degradation (Hillel 2000).

Other options under experimentation include conserving rainwater for irrigation, irrigation structures with multiple uses, agroforestry and crop/fruit/vegetable mix most suitable for the projected changes in the area can have beneficial or neutral effects on biodiversity.

4.2 Planned adaptation options for biodiversity

With the aim of including adaptation as part of national planning and development, three different objectives for planned adaptation (Noble et al 2005) can include:

- *Reduce the risk of impacts by decreasing their probability of occurrence:* This can involve, for example, the upgrading of coastal flood protection, or irrigation in the face of increasing drought. For biodiversity, it can mean the inclusion of climate change in developing conservation and sustainable use areas

- *Reduce the risk of impacts by limiting their potential magnitude*: This can involve a broad array of adaptation actions, ranging from elevating buildings in flood-prone areas, including new crops in agricultural systems to removing barriers to the migration of plants or animals and introducing insurance schemes. It may also involve relocating people from exposed areas such as floodplains and small islands, or changing livelihoods, such as replacing cropping by pastoralism.

- *Increase a systems ability to cope with and adapt to the impacts – increasing coping capacity:* This can include promoting autonomous adaptation. In human systems autonomous adaptation requires: an awareness of potential impacts of climate change, the need for taking action, an understanding of available strategies, measures and means to assess adaptive responses, and the capacity to implement effective options. Thus informing the public about the risks and possible consequences of climate change, setting up early-warning systems for extreme weather events, and providing incentives for risk-reducing behaviour can help in autonomous adaptation.

These three objectives are used as a starting point for planned adaptation for biodiversity. Essentially for biodiversity, adaptation options can be seen to be in the categories of

- enhanced conservation and sustainable use, including mechanisms for increasing the coping capacity or resiliency

- active management to reduce the changes (e.g. management of invasive species)

- off-reserve management – accepting the role that human dominated landscape has for biodiversity and adaptation options

As with any categorisation, these are not mutually exclusive. Active management is needed in the present areas designated for conservation and sustainable use. This is well illustrated in WWF's (2003) manual aimed at mangers of protected areas both for enhancing conservation and sustainable use but also for actively managing the areas. It uses the OECD state, pressure, response frameworks and gives an overview of a given ecosystem or biome, its present functioning and the goods and services it provides and the pressures including climate change affecting it and likely to affect in the future. These pressures then have to be addressed (response options) so it can help in increasing the resistance and resilience of the ecosystems in the protected areas and form part of adaptation options with changes in climate. The obvious step includes protecting the most vulnerable systems in as big an area as possible, reducing other stresses. In addition, given that there are very few directed adaptation activities on the ground, there is a need to include adaptive management, which incorporates monitoring, as part of the implementation so that lessons learned can be incorporated in future activities (see Box 2 and 4 for some examples). One of the main aspects advocated by the manual is to incorporate the threats posed by climate change to the existing reserves and also design of any reserves in the near future. This is crucial or else it is quite likely that in the next 50 years we will have protected areas without the valued biodiversity. It is unfortunate to see that projects aimed at conservation and sustainable use of biodiversity that are funded by multi-lateral agencies (such as the GEF) are still being designed and implemented without due consideration to observed and projected climate change (STAP 2004).

4.2.1 Enhanced conservation and sustainable use

Measures that are essentially aimed at conservation and sustainable use of biodiversity are important adaptation options (WWF 2003) as it is generally accepted that intact and “near natural systems” are more resilient to change than degraded or impoverished or human created monocultures. Based on this, an important step in adapting to climate change is the appropriate design of conservation reserve system, taking into consideration the fragmented nature of our landscapes. Conservation areas should be designed to take into account the expected long-term shifts in the distribution of plants and animals (essentially pole-wards and upwards), although this has to be planned in detail for each conservation system. Another action is to protect reserves from disturbances or sequences of disturbances, such as drought damage followed by fire, which are likely to hasten species losses and invasions.

Ultimately the conservation priorities of each reserve need to be carefully considered. If the primary goal is to protect certain species, management may be directed at resisting change. In some cases, deliberate introduction of threatened species may be considered. If the primary goal is the maintenance of ecosystems functioning in a relatively pristine (that is, free of human interference) state then the primary management goal is to restrict that interference especially through disturbances entering from outside and species invasions. Most conservation areas have multiple goals, including recreation and the protection of scenic values. Management plans are an essential tool for sound conservation management; a strategy for climate change should be part of such plans.

In conservation planning, it may be necessary to realize that certain genotypes, species, and ecosystems could no longer be conserved in a particular area or region due to the impacts of climate change and thus efforts should be directed towards actions to increase the resiliency of biodiversity for future climate change. These activities can include (IPCC 2002, CBD 2003, Noble et al, in press):

- The placement and management of reserves (including marine and coastal reserves) and protected areas will need to take into account potential climate change if the reserve system is to continue to achieve its full potential. Options include corridors, or habitat matrices, that link currently fragmented reserves and landscapes by providing potential for migration.

- Maintaining intact natural vegetation along environmental gradients (e.g., latitude and altitude gradients, soil moisture gradients), providing buffer zones around reserves, minimizing habitat fragmentation and road-building, and conserving genetic diversity within and among populations of native species. Protection of major biodiversity hotspots could halt much of the current and projected mass extinction, but this is threatened by climate change. Ecotones serve as repository regions for genetic diversity. Additional conservation of biodiversity in these regions is therefore an adaptation measure.

- Conservation of biodiversity and maintenance of ecosystem structure**:** Genetically-diverse populations (including those of food crops, trees, and livestock races) and species-rich ecosystems have a greater potential to adapt to climate change. This strategy also means a greater potential adaptation options for human societies to climate change. While some natural pest-control, pollination, soil-stabilization, flood-control, water-purification and seed-dispersal services can be replaced when damaged or destroyed by climate change, technical alternatives may be costly and therefore not feasible to apply in many situations.

- Accepting loss of some populations of widely distributed species: Efforts may have to be directed to actions that increase the resiliency of existing protected areas to future climate change while recognizing that loss of some populations is inevitable as a consequence of the range shift of species due to climate change. In addition, there are some vulnerable systems and they include high latitude ecosystems, boreal forests, island and coastal and peninsula systems. For some of these inevitably there will be loss of species (up to 50% of the species (see Thomas et al 2004) and ecosystems.

- Learning to live with the change: For inland wetlands, especially those that are large but can be ephemeral (e.g. Lake Eire), many of the animal and plant species are able to cope with the high variability through migration or aestivation. It may mean that at least animal species may have to learn to live with the increasing variability and unpredictability (see Robin 2004 – "living like a banded stilt").

4.2.2 Active management and reducing multiple pressures

One of the great challenges is to devise ways of managing change especially in less intensively managed ecosystems. As stated above, biodiversity undergoes autonomous adaptation, for example as temperatures increase and sea level rises, species migrate to higher latitudes and altitudes, and coastal wetlands re-establish on higher ground. However, human activities have reduced the potential of natural systems to adapt in this way in many places, as settlements and other infrastructure form barriers to the migration of species. For example, coastal protection works could block the landward migration of wetlands, causing the wetlands to be squeezed between a rising sea level and immobile infrastructure. This limits the autonomous adaptation options and thus has to be considered in the design of protected areas.

There are also other management options for reducing the multiple pressures. Many are options used in mangement of current protected areas and include prevention (if possible) and slow the proliferation of invasive species, decrease grazing pressures, avoid fragmentation of protected areas, actively manage pests and diseases. Some of these can become important as adaptation options including:

- *Controlling invasive species*: Many conservation areas face threat of invasive species both from native and introduced species. The include land and aquatic species. Direct changes in climate (temperature, precipitation, seasonality) and indirect changes (changes in hydrology, frequency of pests and diseases) and likely to increase the risk of invasive species (see Annex 2) and thus any mangement of these species including early detection will be crucial if the conservation area is to maintain its biodiversity value.

- *Captive breeding, translocation*, replanting, *collection of germ plasm and seedbanks*. When combined with habitat restoration, may be successful in preventing the extinction of small numbers of key selected taxa under small to moderate climate change. Captive breeding for reintroduction and translocation is likely to be less successful if climate change is more dramatic as such change could result in large-scale modifications of environmental conditions, including the loss or significant alteration of existing habitat over some or all of a species' range. It may be necessary to collect germplasm, seedbanks and create zoos or gardens to maintain the species. All of these are often technically difficult, expensive, and unlikely to be successful in the absence of knowledge about the species' basic biology and behaviour.

- *Species introduction – assisted migration*: there are many examples of species introduced to provide ecosystem services such as soil stabilization, pollination, or pest control. Loss of natural biological control species could also be compensated by the use of pesticides and herbicides. While replacing these services may sometimes be technically possible, it could also be costly and lead to other problems. For example, introduction of a pollinator or a pest control may itself result in a pest, and use of pesticides may cause soil and water pollution. In other cases, such as biogeochemical cycling, such services would be very difficult to replace.

In many places ongoing activities and thus multiple pressure increase the vulnerability of biodiversity to climate change. The development of exposed areas and the degradation of ecosystems that protect against hazards can result in a situation where climate impacts are much more pronounced than would have been the case otherwise. Thus reducing vulnerability to climate variability and change would be to reverse these "maladaptive" trends. For some systems, especially the more vulnerable ones, these would include removal or minimisation of other pressures on biodiversity arising from land use land cover change, over-harvesting, pollution, and alien species invasions. For other systems, it would mean managing biodiversity in the human dominated landscapes.

4.2.3 Off-reserve management of biodiversity and landscape management

Many of the protected areas capture the "natural" ecosystems and their size if often constrained by other demands for the land or seascapes. Together with these competing demands, it is also sometime financially not possible to extend the protected areas. Thus one possibility is to concentrate on off-reserve conservation and can be seen to be part of CBD's ecosystem approach

The management of biodiversity outside of formal reserve systems is likely to become increasingly important under climate change. Successful dispersal of the gene pools of local species will increase the likelihood of disturbed areas being re-colonized by local species best adapted to the new conditions rather than exotic invasive species. Successful dispersal is usually sensitive to the matrix of landscapes that surround areas managed for conservation priorities. Patches of remnant vegetation, or even appropriate exotic species, may facilitate the movement of dispersal agents such as birds and also accommodate other ecosystem functions such as pollination. The off-reserve management can form part conservation planning in national development plans and also be important adaptation options.

4.3 Planned adaptation for ecosystems of particular interest to CBD

Many of the adaptation actions apply equally to the areas of interest to the CBD and include biodiversity in dry and sub-humid lands, forests (tropical and temperate), inland wetlands (rivers and lakes), marine and coastal systems.

CBD (2003) summarised options for specific ecosystems of particular interest to CBD and are presented in Box 4. In addition, drawing on material from the WWF manual and IPCC reports, (particularly Chapter 5 of the Third Assessment report of the IPCC (Gitay et al 2001), IPCC (2001)) as well as CBD (2003),adaptation options for rangelands /grasslands (as part of drylands) and tropical forests are presented as expanded examples. In all these examples, there are a number of similarities in the suggested adaptation options which are captured in the general enhanced conservation and sustainable use, active management and reduction of non-climate pressures and off-reserve management – the approaches in sections 4.1-4.2.

The areas in the Arctic are chosen as a special case as they are being impacted by large regional changes in climate. The Arctic Climate Impact Assessment has suggested that there can be lessons learned by looking at this particular system and they can apply to other vulnerable systems. In addition, as specified in the preface, this is one system that has the AHTEG has been asked to look at specifically.

Other ecosystems are projected to be vulnerable to climate change and include mangroves, coral reefs, high altitude and high latitude ecosystems. Also particular species may be vulnerable and they include species with limited climatic ranges, restricted habitat requirements, long generation times, and small breeding populations.

Box 4. Adaptation options for inland wetlands, mountains and marine and coastal systems

Source: CBD 2003

Marine and coastal. Options may include: (i) design marine protected areas so that they include reef areas that have demonstrated resilience/resistance to raised sea-temperatures; (ii) conserve and restore coastal ecosystems to protect coastlines from the impacts of climate induced sea-level rise; (iv) aquaculture and mariculture as options to potential climate-change induced decline of wild fisheries need to be undertaken in a sustainable manner, and in the context of integrated marine and coastal area management as unsustainable farming of carnivorous fish species can have further detrimental impacts on wild populations (e.g., use of small fish for food) in addition to current over-harvesting, and because large-scale aquaculture projects that lead to clear cutting coastal forests may reduce the ecosystem's capacity to mitigate floods and sea level rise.

River and lake biota is—within reasonable limits—relatively well adapted to rapid and unpredictable changes in environment. In contrast to many terrestrial ecosystems much of the functions of inland water ecosystems are determined to a large extent by physical features rather than species composition/diversity *per se.* Thus, options may include maintaining near-natural flow patterns, channel morphology, water quality and quantity, and overall physical connectivity.

Mountain ecosystems are under particular stress and threat of degradation due to their high sensitivity and vulnerable characteristics to climate change but few adaptation options are available except for building barriers against coastal erosion. Adaptation activities that best address how mountain ecosystem management leads to adaptation benefits may be those that link upland-lowland management strategies.

4.3.1 Grasslands and rangelands - drylands

Many grasslands and rangelands occur in arid and semi-arid parts of the world or in dry lands.

Many grasslands already face pressures from conversion to agriculture land, overgrazing, changes in frequency and intensity of fires, salinisation, dominance of invasive species and fragmentation. Related to climate variability is the changes in the frequency and intensity of El Nino events that have adversely affected dryland ecosystems. These lead to some degree of degradation in the grasslands of the world. Abundance and diverse composition of native species that provide adequate leaf canopy cover, help in penetration of moisture to the soil, develop native soil biota and rooting system that can go beyond the top soil layer and thus allow the survival of plants during drought, reduce surface flow and thus erosion are characteristics of undegraded grasslands. These are also the basis of adaptation options to deal with climate change and more specifically changes in temperatures, possible seasonality of precipitation as well as total precipitation, changes in extreme climatic events, especially floods and droughts and changes in frequency and intensity of fires and pest and disease outbreaks that would be faced by grasslands in many parts of the world.

One additional effect of increased atmospheric concentration carbon dioxide is the potential effect on the mix between C_3 and C_4 species. Grasslands can be dominated by either of these but CO_2 along with changes in moisture (depending on soil type) and fire regimes, can alter this mix and thus affect the type of herbivores that can be supported by these systems and also the fire regimes.

Specific adaptation measures can be implemented through a landscape mangement approach and would incorporate adaptive management. The suggested option incorporate the inclusion in a protected area of:

- representative grassland and rangeland types across environmental gradients and if possible key species and functional groups important for ecosystem functioning
- relict and native-dominated communities, including climatic refugia from the paleoclimate change
- buffer zones around the desire ecosystems

Others options include:

- reducing fragmentation through land use changes and infrastructure development (roads, urban areas)
- developing corridors and "stepping stones" to improve connectivity between these types of ecosystems in a landscape
- prevention and management of invasive species
- reducing the grazing intensity and restoring "natural fire regimes"
- restoration and rehabilitation of the grasslands and rangelands

many of these assume a good knowledge of the grasslands, their species and functioning including the pre-human fire regime. This is not available or known for different grasslands and rangelands of the world. In addition many of the grasslands are under private management or ownership, which the authors accept poses challenges and would mean the development of incentives or regulations to be implemented as actions. Voluntary retirement of rangelands and grasslands from grazing, as is being practised in some parts of the world, e.g. the US, is an option that can help in adaptation. In addition, the shift from short-term gains to long term view and management is necessary for range and grassland management under climate change. To help in moving towards long-term management, the idea of giving land users some financial assistance to be stewards of the land is being explored (Morton *et al.*, 1995; Pickup, 1998).

4.3.2 Tropical and subtropical broadleaf forests

These forest types are under pressure from land use and land cover change, fires, drought, pests (often associated with changes in El Nino events) and grazing. Air pollution is an additional pressure that may predispose forests to dieback and loss. Fragmentation, non-sustainable logging of mature forests, development of infrastructure add to the pressures and lead to degradation of these forests. Impacts of climate change will be direct and indirect, especially in the frequency and intensity of fires. As with rangelands, there will also be the direct effect of increased concentration of atmospheric carbon dioxide, which affects the productivity of the forests.

Adaptation options include

- the inclusion of representative forest types in conservation areas, especially different age stands, but particularly mature ages and as large an area as possible
- buffer zones for possible spatial shifts in reserve boundaries and practice low-intensity harvesting and site preparation methods
- more importantly, given the human pressures better forest management, including low impact harvesting, agroforestry and perhaps inclusion of plantations in the landscapes to take off the pressure for timber and non-timber products from the native forests

Other more generic adaptation options are:

- Reducing the present pressures from land use and land cover change, fragmentation,
- Improving connectivity between fragmented forest patches in a landscape through plantings or inclusion of corridors where natural regeneration can occur
- prevention and management of invasive species
- restoring “natural” fire regimes
- active management of pest outbreaks.

For forested systems in particular and given the ratification of Kyoto Protocol, there are potential synergies between adaptation and mitigation options and include use of native species for afforestation and reforestation, inclusion of agroecosystems using species that have local and indigenous use and high biodiversity typical of some local/indigenous agroforestry practices that exploit habitat/microhabitat heterogeneity (see also CBD 2003-chapter 4)

4.3.3 Arctic – a vulnerable system

Some ecosystems, such as coral reefs, mangroves, high mountain ecosystems, remnant native grasslands, and ecosystems overlying permafrost, are particularly vulnerable to climate change. Species with limited climatic ranges and/or restricted habitat requirements and/or small populations are typically the most vulnerable to extinction, such as endemic mountain species and biota restricted to islands (e.g., birds), peninsulas or coastal areas (e.g., mangroves, coastal wetlands, and coral reefs). Of these, the arctic systems are probably the most vulnerable to climate change.

The Arctic Climate Impact Assessment (ACIA 2004) indicates a surface temperature increase of 2-3 °C from 1954-2003 (whereas the global average is 0.4 to 0.8) and a cooling in the southern Greenland of 1 °C . Thus the Arctic is on the whole warming two to three times faster than the globe as a whole. Ice in this system is a supporter of life and it is disintegrating and disappearing fast (with the rate and magnitude being greater in the last few decades) affecting both biodiversity and human livelihoods, perhaps to an extent that may not be obvious in other parts of the world till late in the 21st century.

Projected changes in the temperatures are in the 8 to 10 °C range, a lot higher than for other parts of the world. Together with changes in precipitation, sea ice and ice sheets, thresholds in the system are being passed. Given the changes, there are now concerns about the rapid melting of the Greenland ice sheet and the slowing of the thermohaline circulation. This is not just likely to affect the arctic, but a large part of the world and as the report suggests “arctic ecosystem changes will reverberate globally”.

The changes are projected to be in ice, polar deserts, tundra, boreal and temperate forests. Linked to these are challenges to tree establishment due to the unsuitability of soils and industrial pollution (already observed in parts of Russian arctic). Other challenges include multiple outbreaks from pests, such as spruce budworm, adding to the challenge of growth of tree species such as spruce. Many of the ice-dependent species are likely to be adversely affected and the presence of persistent organic pollutants (POPs) is likely already an added stress and will become more so. Sea birds both due to the availability of nesting sites and feeding grounds.

From human perspective, some areas will be able to support agriculture, aquaculture (salmon being farmed now) and perhaps mariculture. The projected changes in the frequency and intensity of pest and disease outbreak will add to the challenge and can also have negative consequences on the environment if chemical controls are used. Much of the infrastructure will be badly affected – especially the case for pipelines carrying oil, which would add to the adverse impacts on the environment.

Apart from learning to live with the changed conditions and/or migrating, it is not clear what the adaptation options are. Any that are being tried have to cope with not just climate change but also many of the other interacting pressures, such as the elevated levels of POPs, other industrial pollution, high levels of UV.

5. Tools for incorporating adaptation options into national development planning

National development planning already uses frameworks and tools that can be adopted to incorporate biodiversity consideration of adaptation activities. These include a range of tools and processes that assess the economic, environmental and social implications of different adaptation activities (projects and policies) within the broader context of sustainable development. Examples include: environmental impact assessments (EIAs), strategic environmental assessments (SEAs), decision analytical frameworks, valuation techniques, and criteria and indicators. Decision analytical frameworks, valuation techniques, and criteria and indicators are tools that can be applied within the environmental impact and strategic environmental assessment processes (CBD 2003 – chapter 5).

In this section, after presenting the commonly used tools or methods for adaptation, a checklist or a design tool that can be easily incorporated into strategic environmental assessment and/or environmental impact assessment is introduced. Essentially, it is a series of questions that a project developer or a policy planner can use. It is primarily aimed at project level rather than at the policy level, but can be modified to be incorporated at the policy level. These type of checklist are component of the Lim et al's guidebook, STAP's guidance to the GEF (STAP 2004) and of a design/screening tool being developed in the World Bank (see Box 5). The emphasis is on systems as a whole, the analysis of what options can be implemented, but not necessarily how to implement these actions on the ground. The World Bank moves a little further in that direction with its design/screening tool and has the advantage that it brings together a huge database of literature, published and grey literature, practitioner and experts knowledge. More importantly, it breaks a project into a series of activities so that the planners can see the critical subcomponents where the need to address the impacts of climate change is necessary. These additional steps can also increase the adaptive capacity and resiliency of the planners including the local and indigenous cultures, enabling them to share information and then cope with the present climatic extremes. Some of the tools and checklists can be incorporated in a risk management framework as in many ways adaptation can really mean the minimisation of adverse risk to systems.

Box 5: The World Bank screening/design tool for incorporating climate change into planning process

Objective: *To reduce the vulnerabilities of poor people to the impacts of climate variability and change*.

The World Bank is developing a screening and design tool for projects to help raise the awareness of its staff and clients to the risks to projects arising from climate variability and change. This work seeks to identify climate related risks early in project design so that appropriate adaptive options can be incorporated. The project will assist in bringing the rapidly developing knowledge base of community and local responses to current climate variability (including early climate change) into the wider development planning process. This will assist the Bank in its goal, recognized in the Environmental Strategy, of supporting better vulnerability assessments and mainstreaming adaptation into the Bank's activities.

The screening/design tool will be web and CD based and will not requires detailed technical knowledge of climate related issues by the user. The user will describe the nature of the project and its location and the tool will provide an initial assessment of any climate risks and guidance on how to deal with such risks.

It is expected that the tool will have value to the GEF, bilateral donors and regional Banks. The design is open ended and flexible and will be shared widely with other interested parties.

The project will include:

- A consistent set of **assessments** across selected regions of the vulnerabilities of different sectors and groups within a country to climate change.
- The creation of a **screening tool** for projects that will indicate which activities might be subject to high risk from climate change and a **design tool** to help identify the elements of best practice in avoiding or adapting to these risks.
- **Awareness raising** within the Bank, and across client countries and other donor organizations, of the importance of adaptation to climate change.

5.1. General tools for developing adaptation options

Typically the tools for carrying out impact and adaptation for climate change have been very top down and included (see also AIACC project, IPCC TAR Chapter 19, Biringer et al in press):

- *Modelling climate change* with many involving downscaling exercises since adaptation action is often at very local level. Often this has just been the extraction of the general circulation model outputs for that particular cell or area. There has been little inclusion of past climate data.
- *Assessing impact on species or ecosystems*: From the physiological response of species and the distribution of ecosystems in relation to present climate, use coarse changes in temperature to project the changes in distribution of species or ecosystems. This is the basis of BIOCLIM developed by Nix et al in 1970 and is being widely used for conservation and reserve design and can use a range of information including climatic, soil properties etc. Recent developments have incorporated some dynamic properties such as dispersal ranges of species and information on the potential rather than realised niche. Most of these do not include present land use and land cover change and thus the barriers to dispersal and migration (see IPCC 2002 for more detail). They are also heavily dependent on data availability since many of them use empirical relationships between climatic variables and distribution or a biological response.

- *Developing adaptation options*, many are management options either aimed at reducing the impact or reducing its potential magnitude (see section 4). A decision support system and analytical frameworks can help in prioritising the objectives, evaluating the options (see also CBD 2003 Chapter 5)

Lim et al (2004) summarise a range of more detailed tools that can be used as part of assessing adaptation options. They use quantitative and qualitative data and can be used for assessing present vulnerability as well as planning and evaluating future options and build on those listed by Downing and Doherty (Figure 1)

- Agent-based simulation modelling
- Bayesian or statistical analysis
- Monte-carlo simulation
- Brainstorming
- Checklist or matrix
- Econometric techniques such as cost benefit and cost effectiveness analysis
- Cross-impact analysis to assess the risk of climatic events that are linked/interdependent
- Decision conferencing which can incorporate uncertainties both in impacts and outcomes
- Decision probability trees
- Multi-criteria analysis
- Risk analysis
- Scenario development
- Expert judgement, focus groups
- Indicators of impacts and outcomes from adaptation actions
- Vulnerability profiles

These tools are dependent on data availability as well as expertise. It is not clear how helpful they may be for ecological systems in different parts of the world.

5.2 Checklist type of approach

A series of questions can consider the pressures facing the system, given their present condition and then try to minimise the risk of adverse effects of the activities planned in the project. It is parallel to the WWF manual and uses the state-pressure-response concept. A key component is the need to consider the trade-offs that may be needed to meet the primary objectives of the project and minimisation of the risks to other areas including the needs of the local and indigenous peoples.

Modified check list of questions from Lim et al (2004) that guide the different approaches that can be taken include (see table 2)

- Is the study team’s understanding of the system under investigation well-established?
- Is that understanding shared by all participants?
- Are the climate hazards well-understood?

- Are the vulnerabilities of the system well-understood?
- Is the relationship between climate and impacts well-understood?
- Is the relationship between impacts and vulnerability well understood?
- Is the relationship between climate hazard and vulnerability well understood?
- Are historical adaptive responses (or coping capacity) known, understood and can be used for developing future options?

A modified checklist from STAP 2004 is at project level and includes:

- Have relevant climate change scenarios been considered in project area?
- Have altitudinal and latitudinal gradients been incorporated in consideration of projected climate change?
- Has the vulnerability to invasive species been considered in context of climate change?
- Has the potential for disturbance in surrounding areas following protected area establishment been included?
- Have trade-offs between livelihood needs (e.g. firewood), biodiversity goals and reduction in land degradation been considered?
- Has watershed management (including any potential land degradation) within surrounding and upstream areas been included in the design and management of the protected area?
- Have corridors (and perhaps restoration of intervening land) been considered as ways to link protected areas in the system design?
- Will management interventions be needed to maintain ecosystem structure and function in response to interlinkages?
- If there are any rehabilitation and restoration activities, have multi-species plantings and natural regeneration being encouraged;
- Have costs, benefits, incentives and alternative livelihoods for local communities been incorporated?

5.3. Risk management

Another approach that can move towards the integration of adaptation activities into national planning and policies is to look at it in terms of risk management. Risk management is widely used as a tool within EIA even not specifically stated. It can potentially cover policies and projects.

The concept of risk identification and risk management, the idea being that by managing risk, the system would become less vulnerable. Ramsar has used a risk assessment and risk management framework for a number of years and is in the process of developing a vulnerability assessment framework which is a combination of the former two linked with adaptive management. There have been numerous attempts at developing vulnerability assessment with the key components being able to predict the extent of climatic change and to examine the likelihood that a given system or species will be able to adapt or migrate, taking into account existing non-climatic stresses affecting its survival (Biringer et al in press). Ramsar, in developing a practical approach has suggested combining their existing frameworks. Steps that are suggested to include in the vulnerability assessment are (Ramsar in prep):

- ***Risk assessment*** (including risk perception)
  - *Delimiting the boundaries* of the social and biophysical system to be considered and explicitly including spatial, temporal limits
  - *Identification of past and present drivers of change and existing hazards*
  - *Assessing the present condition and recent trends* in the ecological character of the wetlands (using metrics such as indicator species, functional groups etc)
  - *Carrying out a stakeholders analysis* – the people involved in evaluating the potential responses and also affected by the potential changes in the system
  - *Determining the sensitivity and resiliency* including adaptive capacity of the system
  - *Identifying the wetlands and groups of people* that are particularly sensitive to different pressures
  - Developing scenarios and storylines with the involvement of the stakeholders to the risk of possible drivers of change and the interaction between them that could lead to future changes,
- **Risk minimisation or management**
  - Identifying the wetlands and groups of people that would not have the ability to cope with the changes, often adverse, given their low present adaptive capacity and/or sensitivity
  - developing response options that can minimise the risk of abrupt and/or large changes in the ecological character of wetlands (and thus maintaining their ability to provide the ecosystem services that humans depend on). These can include: regulations, strategic environmental planning, infrastructure/engineering works, rehabilitation/restoration, developing education material, improving community awareness, developing integrated management plans. In some case, given the adaptive capacity, sensitivity and resiliency of the system, no further management response may be needed.
  - *tradeoff analysis* to choose between potential response options and overcoming constraints such as instituional capacity, information/data availability and often finanancial
  - Specifying the desired outcomes for the system
- **Monitoring and adaptive management** throughout the process. This would include a means of measuring the path to the desired outcomes.

6. Adaptation activities under implementation - case studies

Much of the framework and literature, including that in the GEF, is at the planning stage with little work on policies or projects to deal with adaptation on the ground. There is thus a need to move from planning to implementation fairly rapidly, both as adaptation measures for biodiversity and general adaptation options to safeguard human well-being.

Successful implementation of adaptation options requires the presence of an enabling environment, the development of which is an important objective of national and international climate policy. Using this enabling environment, the actual implementation of options—be they technical, institutional, legal, or behavioural—is best done by sectoral planning and management agencies "on the ground" (for example, water companies, agricultural planners, coastal management agencies), as well as private companies and individuals.

At the national planning level, the main challenges to effective adaptation are associated with the coordination of multiple sustainability strategies with budgetary processes, including international assistance. In most countries, developed and developing, climate change issues are the responsibility of departments and agencies that are at the periphery of government planning and, in particular, of financial decision- making. A recent view of 19 developing and developed countries (Swanson 2004) identified this disconnect to be a major impediment to sustainable development.

International negotiations over climate change are paying increasing attention to adaptation issues. It is generally accepted that the need to adapt is an additional impediment to development imposed on developing countries largely through the activities of others. Adaptation to climate change must, therefore, be firmly rooted in ongoing, broader development efforts and should build upon lessons from other activities such as disaster risk reduction, poverty reduction, and natural resource management (Hammill 2004). The immediate challenges are to explore ways to mainstream adaptation issues in the development agenda and to negotiate, both bilaterally and multilaterally, responsibilities for support through technology transfer, aid, lending arrangements, and other innovative arrangements such as disaster prevention and risk transfer.

A few examples are being summarised here, some addressing the mainstreaming of adaptation into national planning, some more sector specific. CBD (2003 – chapter 6) also included case studies two of which include adaptation objectives or components:

- Belize and the U.S. A.: Rio Bravo Climate Action Project, Adaptation to climate change component included. Projected impacts were used to develop conservation and sustainable use of corridors in the Rio Bravo forests and was also advocated as a means of increased resiliency and connectivity. Experiments with innovative sustainable forest-management have assisted local residents find sustainable economic alternatives to destructive logging practices
- Britain and Ireland: Climate change and nature conservation. Use of a scientific modelling based approach to inform the adaptation of nature conservation policy and management practice to climate change impacts. Results from the first phase indicate the need for a flexible and forward looking approach, with objectives set within a dynamic framework that can adjust to the changing distribution of species and habitat types and to the rate of this change. For the next phase of research, downscaled versions of the models will be used together with dispersal models and predictions for land cover change to assess the likelihood of species keeping pace with potential climate change and occupying their future climate space. The inclusive approach to the research,

undertaken by a consortium of government agencies, NGOs and research institutes has the added strength of bringing diverse views, concerns and perspectives into the analysis from the outset and influencing policy.

It is worth noting the lesson learned from these. This is an essential component for developing effective adaptation options and should be included as part of a future exercise, perhaps under UNFCCC and or joint work program of the MEAs.

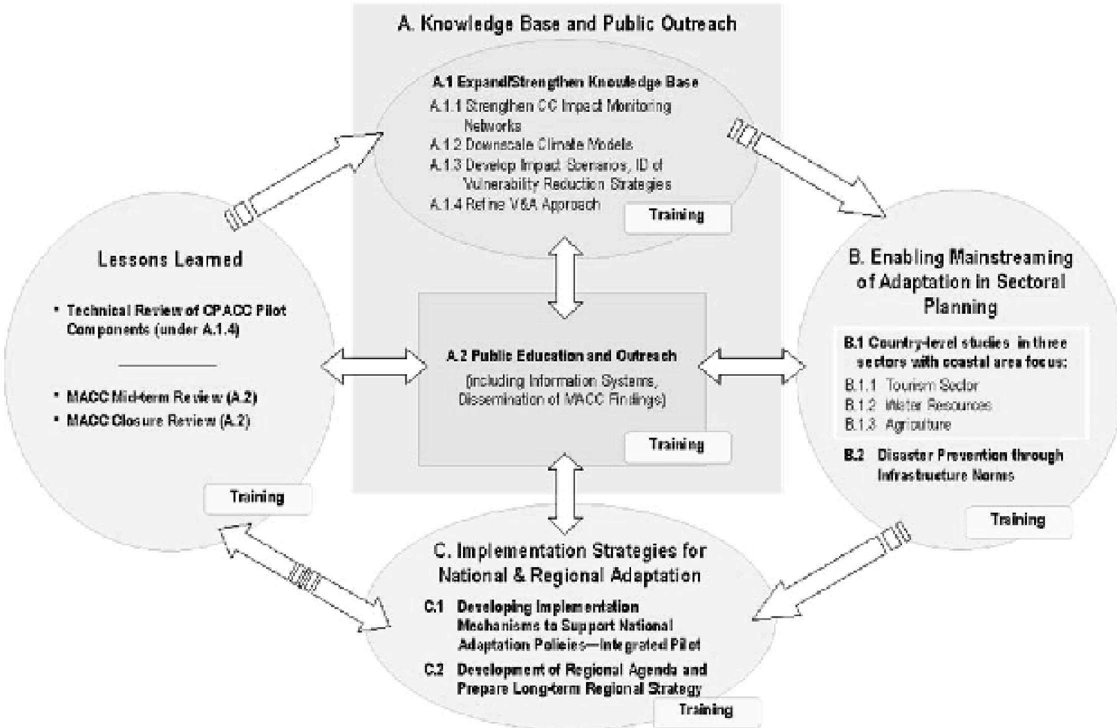
6.1. Mainstreaming Adaptation to Climate Change; MACC project

As stated above, mainstreaming adaptation makes more efficient and effective use of financial and human resources by incorporating, implementing and managing climate policy as an integral component of ongoing activities, rather than treating adaptation as a series of stand-alone actions. In the Caribbean, a series of projects supported through local resources, GEF and bilateral agencies (such as Mainstreaming Adaptation to Climate Change; MACC – see Box 3) aim to build national and regional capacity and facilitate governments' efforts to incorporate climate change considerations into planning and policy-making.

Another approach that is being taken by The Caribbean Community Secretariat 2003 is to integrate climate change into current environmental impact assessment procedures (Caribbean Community Secretariat 2003).

Box 6: Example of adaptation project in the Caribbean

Mainstreaming Adaptation to Global Change (MACC – see http://www.oas.org/macc/; http://www.gefonline.org/projectDetails.cfm?projID=1084)) is a five-year regional project covering 12 countries. It is designed to increase national and regional capacity to monitor sea level and key climatic indicators and to plan for adapting to the effects of global climate change on coastal and marine resources. It specifically aims to integrate climate change and variability into the agendas of the tourism, agriculture, fisheries and infrastructure sectors. It was developed through a consultative process in the region in 2001-2002. As illustrated in their structural diagram, public education, outreach, capacity building, creation of enabling conditions and implementation of the activities in the various sectors are pivotal to the project. This is essentially a second phase of the project with the first being very much at the planning level, emphasising the need for 5-10 year time frames needed for adaptation activities and more if they are to be implemented as part of national development planning and in multiple countries.



6.2. Community based approaches

Many of the Pacific islands are facing inundation from storm surges. Adaptation activities thus include moving the people to higher ground but also rain water harvesting and storage techniques. Others that rely on community-involvement and have taken an adaptive management approach include sea wall constructions and revegetation of the coastal dunes. Initial attempts at revegetation of coastal beach fronts failed as the erosion was too great and the plants got uprooted. Recent attempt include a combination of sea wall and then revegetating the protected areas behind thus improving biodiversity and protecting the community from storm surges (Nakalevu 2005). There are also a series of projects that are designed to address some ecosystem management approaches and include a component of capacity building (see Box 4)

Box 7: Adaptation Measures in Pacific Island Countries

1. As with many countries, the Pacific region contureis concentrate on capacity building initiative. This project (see http://www.sprep.org.ws/climate_change/cdbmpic.htm) concentrates on improving the livelihood of Pacific Island people by increasing their adaptive capacity to climate-related risks. As with the Caribbean project, it firstly aims to mainstream adaptation into national and sectoral planning and in budgets. It then has various activities that are aimed at increasing the capabilities of Pacific Island government insititutions and communities to deal with vulnerabilities to climate change and climatic extremes. The latter include housing design (building houses on stilts as was the case), farming (small garden) practices and the use of historical informal knowledge to deal with the climatic extremes and sea water intrusion into the fresh water lens.
2. Another project (http://www.sprep.org.ws/climate_change/arms.htm) aims to:

- enhance transboundary management mechanisms
- enhance conservation and sustainable use of coastal and watershed resources.
- enable the conservation and sustainable yield of ocean living resources and
- maximise regional benefits from lessons learned through community-based participation and to catalyse donor participation

6.3. Addressing research gaps and capacity building

The AIACC project funded by the GEF includes about 20 on-going projects that assess the impacts of climate change and develop potential adaptation options for different ecosystems and sectors in developing countries. Many incorporate basic research, develop or modify the climate scenarios and collect information about climate change and impacts as much of this is lacking especially in developing parts of the world (AIACC web site)

There are a number of national action plans for adaptation (NAPAs) being conducted for the least developed countries under the United Nations Framework Convention on Climate Change requirement and funded by the GEF. Some of these reports have been finalised and are being sought from UNDP, UNEP and the World Bank that are coordinating this work.

7. Challenges: research and information gaps

There are a number of challenges that have arisen in various works and can be summarised as follows:

Space and time specificity challenge:

- Challenges to deal with “multiple” drivers or pressures affecting a system
- Vulnerability and adaptation are location, time specific and system specific – depending on the resistance and resilience of the system. Lack of clear understanding of attributes that determine the resiliency of an ecosystem and the potential thresholds in its dynamics
- limited understanding of ecosystem/species adaptations to *current* environmental change (it can provide important information for designing future options)
- Ecosystems and species go across political boundaries thus adaptation options have to go across these boundaries

Data, information and scenario development

- Reliable present land use and land cover and changes in these, including data on distribution and extent of ecosystems and the condition of the landscape
- Long-term monitoring of key biophysical parameters thus providing time series data for developing bench marks or baselines
- Challenges in downscaling climate and other models
- Modelling the changes in biodiversity in response to climate change - data and models needed to project the extent and nature of future ecosystem changes and changes in the geographical distribution of species are incomplete, and thus these effects can only be partially quantified*.*
- Developing scenarios that would give the likely future changes in drivers, status and condition of the system, given the lack of knowledge in the present
- cost/benefit analysis for deciding between different options
- There is a need for case studies of autonomous adaptation in ecosystems and their limits in conjunction of the records of the present climate variability. This can be used as a basis for adaptation options future changes.

Perceptions of the need to develop and implement adaptation options

- there is a perception that the system is able to cope with slow changes (e.g., slow increases in temperature, precipitation) and less likely to deal with abrupt changes, such as the ones associated with large scale changes in land use, thermohaline circulation

Collation of lessons learned from adaptation activities and dissemination of information

- An important determinant of success for developing adaptation options will be dissemination of information and extracting any generalities given the specificity of adaptation actions that might be developed.
- This has to include the human resources and finance to make changes in management as needed.

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Annex 1 Summary of observed and projected impacts of climate change on biodiversity

Climate change has already impacted biodiversity and socio-economic systems. Here, a summary is provided on the observed and projected impacts on biodiversity in particular.

Observed changes in climate and the observed impacts on biodiversity

IPCC concluded that the atmospheric concentrations of greenhouse gases have increased since the pre-industrial era. These and natural forces have contributed to changes in the Earth's climate over the 20th century; land and ocean surface temperatures have warmed by 0.4 to 0.8 °C, the spatial and temporal patterns of precipitation have changed, sea level has risen between 0.1 and 0.25m, most non-polar glaciers are retreating, and the extent and thickness of Arctic sea ice in summer are decreasing, and the frequency and intensity of El Niño events have increased. Most of the observed warming of the past 50 years can be attributed to human activities, increasing the atmospheric concentrations of greenhouse gases and aerosols, rather than changes in solar radiation or other natural factors. Changes in sea level, snow cover, ice extent, and precipitation are consistent with a warmer climate (IPCC 2001a).

These changes, particularly the warmer regional temperatures, have affected many aspects of species and ecosystems including the timing of reproduction of animals and plants and/or migration of animals, the length of the growing season, species distributions and population sizes, and the frequency of pest and disease outbreaks. Some coastal, high latitude and altitude ecosystems have also been affected by changes in regional climatic factors. Many coral reefs have undergone major, although often reversible or partially reversible, bleaching episodes, when sea surface temperatures have increased by 1^{o}C during a single season, with extensive mortality occurring with observed increases in temperature of 3^{o}C. Changes in fish populations have been linked to large-scale climate oscillations. For example, El Nino events have impacted fisheries off the coasts of South America and Africa, and decadal oscillations in the Pacific have impacted fisheries off the west coast of North America (IPCC 2001b, CBD 2003

Projected changes in climate and potential impacts on biodiversity

For the wide range of Intergovernmental Panel on Climate Change (IPCC) emission scenarios, the Earth's mean surface temperature is projected to warm 1.4 to 5.8°C by the end of the 21st century, with land areas warming more than the oceans, and the high latitudes warming more than the tropics. The associated sea-level rise is projected to be 0.09 to 0.88m. In general, precipitation is projected to increase in high latitude and equatorial areas and decrease in the subtropics, with an increase in heavy precipitation events. Climate change is projected to affect individual organisms, populations, species distributions, and ecosystem composition and function both directly (e.g., through increases in temperature and changes in precipitation and in the case of marine and coastal ecosystems also changes in sea level and storm surges) and indirectly (e.g., through climate changing the intensity and frequency of disturbances such as wildfires). Processes such as habitat loss, modification and fragmentation, and the introduction and spread of non-native species will affect the impacts of climate change. A realistic projection of the future state of the Earth's ecosystems would need to take into account human land- and water-use patterns, which will greatly affect the ability of organisms to respond to climate change via migration. Species will be affected differently by climate change; they will migrate at different rates through fragmented landscapes, and ecosystems dominated by long-lived species (e.g., long-lived trees) will often be slow to show evidence of change. Thus, the composition of most current ecosystems is likely to change, as species that make up an ecosystem are unlikely to shift together. The most rapid changes are expected where they are accelerated by changes in natural and anthropogenic non-climatic disturbance patterns. (IPCC 2001a, 2002, CBD 2003)

Changes in the frequency, intensity, extent, and locations of disturbances will affect whether, how and at which rate the existing ecosystems will be replaced by new plant and animal assemblages. Disturbances can increase the rate of species loss and create opportunities for the establishment of new species.

The impact of sea-level rise on coastal ecosystems (e.g., mangrove/coastal wetlands, seagrasses) will vary regionally and will depend on erosion processes from the sea and depositional processes from land. Some mangroves in low-island coastal regions where sedimentation loads are high and erosion processes are low may not be particularly vulnerable to sea-level rise

Where significant ecosystem disruption occurs (e.g., loss of dominant species or a high proportion of species, thus much of the redundancy), there may be losses in net ecosystem productivity at least during the transition period. However, in many cases, loss of biodiversity from diverse and extensive ecosystems due to climate change does not necessarily imply loss of productivity as there is a degree of redundancy in most ecosystems. The contribution to production by a species that is lost from an ecosystem may be replaced by another species. Globally, the impacts of climate change on biodiversity and the subsequent effects on productivity have not been estimated.

Annex 2: Global Environmental Facility's Strategic Priority on Adaptation-operational guidelines

- Pilot or demonstration projects to show how adaptation planning and assessment can be practically translated into national policy and sustainable development planning"
- Iintegrated into national sustainable development and poverty-reduction strategies
- Portfolio designed to maximize the opportunity for learning and capacity building and will be representative of particularly vulnerable regions, sectors, geographic areas, ecosystems, communities.
- Use experience from the SPA to develop good practices and estimates of the costs of adaptation to better mainstream adaptation into the full range of GEF activities

Source:http://www.thegef.org/Documents/Council_Documents/GEF_C23/C.23.Inf.8.Rev.1_Adaptation_Council_paper_FINAL.doc