The littoral rainforests of south eastern Madagascar © Terence P. Dawson

ECTF Thematic Review of Climate Change and Biodiversity

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Contents

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Acronyms

ACIA	Arctic Climate Impact Assessment
AHTEG	Ad Hoc Technical Expert Group
AMD	Asian Megadelta
BP	Before Present
CBD	Convention on Biological Diversity
CDF	Charles Darwin Foundation
COP	Conference of Parties
DEFRA	Department for Environment, Food & Rural Affairs
DGVM	Dynamic Global Vegetation Model
DI	Darwin Initiative
ECTF	Edinburgh Centre for Tropical Forests
ENSO	El Niño / Southern Oscillation
IBA	Important Bird (Biodiversity) Areas
IGBP	International Geosphere-Biosphere Programme
IOC/UNESCO	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization
IPCC	Intergovernmental Panel on Climate Change
IUCN	The World Conservation Union
MEA	Millennium Ecosystem Assessment
NDVI	Normalised Difference Vegetation Index
NGO	Non-Governmental Organisation
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice
SES	Social-Ecological System
SIDS	Small Island Developing States
SRES	Special Report on Emissions Scenarios
SST	Sea Surface Temperature
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
WCMC	World Conservation Monitoring Centre
WG2	Working Group Two
WWF	World Wildlife Fund for Nature

Glossary

Climate change mitigation: Taking actions aimed at reducing the extent of global warming through emissions reduction.

Climate change adaptation: Enabling living organisms (biodiversity) to cope with and survive through climate change.

Executive summary

This Darwin Initiative thematic review is slightly different than previous thematic reviews. Earlier reviews have aimed, primarily, to analyse the evidence from DI projects relating to the theme, with a focus on performance. This review, because few DI projects have so far focused on climate change, placed equal emphasis on a synthesis of the wider current knowledge about the theme, and what that means for existing and future DI projects. The objectives of this Thematic Review are therefore to:

a) Summarise current knowledge regarding climate change and biodiversity to inform the wider Darwin Initiative community;

b) Assess the extent and degree of success of 245 Darwin Initiative projects in identifying and addressing climate change impacts, adaptation and mitigation;

c) Development of more guidance on how climate change issues can be integrated, where appropriate, in future Darwin Initiative projects. This will serve to strengthen the Darwin Initiative's contribution to reducing the impact of climate change on biodiversity.

The introduction (Section 1) provides a brief **overview of the current knowledge**, whilst Section 6 gives further detail and Section 7 provides a bibliography. This highlights some of the key climate change predictions and looks at the impacts of climate change on vulnerable habitats, ecosystems, and regions.

Section 2 analyses **the contribution of past and current Darwin Initiative projects** to the mitigation of, adaptation to and monitoring of climate change, with a focus on projects in the most vulnerable habitats, ecosystems and regions. Analysis shows that 70% of the projects examined were in habitats vulnerable to climate change. Forests are very well represented (33%), whilst arctic and boreal habitats received little attention from Darwin. Less than 10 projects (4% of the 245 analysed) have focused explicitly on climate change issues, and consequently the DI has to date made relatively minor contribution to our understanding of climate change and biodiversity. However, a much greater number of projects have promoted activities that contribute to adaptation to (20%) and mitigation of (14%) climate change, even though the contribution is often not clearly recognized by the project. Typical adaptation activities include: habitat restoration, *ex-situ* conservation of species, connectivity and corridors. Typical mitigation activities relate to carbon sequestration through habitat protection.

Section 3 observes some of the **key linkages between climate change, livelihoods and biodiversity** within Darwin Initiative projects. Prediction of the impacts of climate change on human livelihoods and well-being remains challenging. However, developing countries in the lower latitudes are expected to suffer most, through the weak adaptive capacity of the human, institutional and financial systems to respond to the probably significant changes. It is considered to be crucial that strategies are devised and implemented for increasing the resilience of the social-ecological-systems on which many poor people (especially in sub-Saharan Africa) rely. Livelihoods activities can work either to support or worsen adaptation potentials. Around 38% of Darwin Initiative projects include livelihood activities. Care is needed to ensure that these help local people to adapt to their future.

Section 4 proposes a set of **recommendations** for the future and potential contributions of Darwin Initiative projects to climate change issues. Recommendations are offered for the consideration of both projects/project leaders and the Darwin Secretariat.

Recommendations for projects:	
The following actions could be incorporated into new project designs that could focus specifically on climate change or become components of projects which have other non climate change objectives.	
For adaptation for climate change	• Re-evaluate protected area strategies to allow species mobility. • Strengthen populations of rare and endangered species. • Adopt the ecosystem approach for conservation action. • Maintain maximum genetic diversity especially in leading and trailing edge ranges. • Promote landscape connectivity. • Explore climate change synergies in clusters of DI projects. • Contribute to National Adaptation Programmes of Action. • Incorporate climate change into biodiversity threat analyses.
For mitigation of climate change	• Promote the conservation and restoration of forests, and wetlands, and especially peatlands. • Use Clean Development Mechanism where possible. • Encourage low or neutral carbon energy sources. • Off-set project emissions.
For monitoring for climate change	• Deposit climate change data sets nationally. • Ensure continuity of monitoring effort where possible. • Select climate sensitive taxa for monitoring. • Record weather so this data can be linked to biological data.
Recommendations for the Darwin Initiative Secretariat:	
• *Vulnerable habitats and regions:* Encourage the establishments of projects in vulnerable or sensitive under-represented habitats or regions. • *Long-term data sets:* Encourage projects to build upon any national or regional long-term ecological datasets where already available, or to establish baseline datasets. • *Provide guidance:* Provide guidelines along with details of grant application on how climate change could be incorporated into projects. • *Planning:* Ensure that management plans take into account projected changes and their potential impacts. • *Knowledge gaps:* DI projects can contribute to building up the knowledge base and to filling knowledge gaps identified by the IPCC.	

Section 5 highlights the **main conclusions** of the review, which include:

- Although very few DI projects have considered explicitly the impacts of climate change on their strategies and objectives, a significant number of projects are undertaking useful activities which can be described as contributing to the mitigation, adaptation and monitoring of climate change impacts. These activities need to be explicitly recognised and their potential assessed.
- Future projects could make a much greater contribution to reducing the impacts of climate change on biodiversity conservation. This would not take a large shift in activities undertaken, but a better realization of the climate change potential of certain activities, and re-focusing around these.
- Climate change issues need to be made integral to DI project proposals. This will enable cutting-edge science partnerships to better contribute to international efforts and strengthen the future of many projects.

1. Introduction

The Darwin Initiative (DI) has funded over 460 main projects since 1992, centred on supporting biodiversity conservation in countries rich in biodiversity but poor in resources. The impacts of climate change on biodiversity and the potential of biodiversity to mitigate some impacts of climate change are increasingly being recognised. In general, climate change issues have not formed a core part of Darwin Initiative project activities, and awareness of climate change issues is low amongst DI project institutions. Only a small number of DI projects have specifically addressed climate change. A larger number of projects have, however, been engaged in activities related to climate change.

The objectives of this thematic review are to;

a) Summarise current knowledge regarding climate change and biodiversity to inform the wider Darwin Initiative community.

b) Assess the extent and degree of success of 245 Darwin Initiative projects in identifying and addressing climate change impacts, adaptation and mitigation.

c) Development of more guidance on how climate change issues can be integrated, where appropriate, in future Darwin Initiative projects. This will serve to strengthen the Darwin Initiative's contribution to reducing the impact of climate change on biodiversity.

a) While discussions on global warming and climate change have been ongoing for some time, impacts on biodiversity and implications for conservation practice have not been well understood outside specialist institutions. The increasingly obvious climate effects, as well as measurable changes in biological responses have, however, increased the attention of the biodiversity community to the phenomena. Recent political acceptance of global climate change as a reality has significantly heightened awareness and interest. As a result, theory and evidence have developed rapidly over recent years and there are now a number of recent and useful texts, with many online, that have evaluated climate change impacts on biodiversity and habitats at the global, national or regional levels or are targeted specifically at habitat types.

The review draws upon this information and provides a synthesis of the main points from these and other relevant literature. It is hoped that this will help give the wider Darwin Community greater accessibly to the subject of climate change and biodiversity (summarised in this introduction and detailed in section 6). The reader is advised to examine the bibliography at the end of this review document for more detailed information.

b) This review then evaluates the contribution of selected 245 Darwin Initiative projects to deliberately or inadvertently mitigating climate change, and to supporting the adaptation of species and habitats to better cope with climate change effects (section 2). Two classes of habitat or region are considered vulnerable and form the basis of the review, these are as follows:

i) Regions and habitats with low adaptive capacity;

ii) Regions and habitats with high climate change variability.

c) In addition, the review looks at conservation and habitat management activities and monitoring protocols that can improve our knowledge of the effects and impacts of climate change on biodiversity. The review concludes with a number of recommendations for both DI project leaders and the DI secretariat to consider to strengthen the links between the biodiversity protection, management and conservation objectives of DI and the projected global impacts of climate change on biodiversity and natural resources.

1.1 Climate Change and Biodiversity – an overview

For the purposes of this report, the term climate change is used as defined by the United Nations Framework Convention on Climate Change (UNFCCC):

"A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

Summary information related to climate change and biodiversity is presented in the following pages as points. For those that want further information these points are described and fully referenced in section 6. The bibliography provides sources for further reading.

- The expected mean global warming over the 21st century is 'very likely' to be greater than 1.5°C and 'likely' to lie between 2°C and 4.5°C;
- Greatest temperature increase is projected to occur over land at high latitudes in the northern hemisphere. Fewer low temperature spells are expected;
- Precipitation likely to increase in areas of regional tropical monsoon regimes with a general decrease in rainfall in the subtropics;
- Extreme weather events such as heat waves are 'very likely' to be more intense and frequent.

1.1.1 Climate change and impacts on biodiversity

- Significant impacts on biodiversity and ecosystems are predicted but their nature is poorly understood;
- Many ecosystems and species are very likely to be adversely affected by increases in global mean temperatures of 1°C to 2°C, in relation to both their range or existence, and also their ability to deliver various services to humans;
- A temperature increase greater than 2°C may be beyond the tolerances of many species and ecosystems;
- Actions are needed to avoid such temperature increases through **climate change mitigation**;
- While in the past species and ecosystems have adapted to changes in climate, the current fragmented and reduced levels of biodiversity means greatly reduced ability to adapt to changes in climate;
- Actions are needed to maintain or increase populations and genetic variation through **climate change adaptation** strategies;
- Adaptation strategies to reduce vulnerability to climate change are likely to resemble other activities for improving natural resources management.

1.1.2 Habitats, ecosystems and regions most vulnerable to climate change impacts

- Habitats and ecosystems most vulnerable to climate change have been identified;
- Two classes of habitat or region are considered vulnerable and form the basis of the review, as follows:

  a) Regions and habitats with low adaptive capacity;

  b) Regions and habitats with high climate change variability.

Vulnerability of terrestrial ecosystems

- There is very high confidence that recent warming is strongly affecting terrestrial biological systems;
- **Mountains** are highly significant for biodiversity and already some climate change impacts are apparent. Adaptive capacities in montane regions are generally limited, with a disproportionately high risk of extinction for many endemic species in various mountain ecosystems;
- Predicted increases in temperature are likely to have greatest effect on **forests** in boreal regions, while some regions are expected to experience significant changes in precipitation and water availability (e.g. Amazon drought). Some scenarios show significant forest dieback in tropical, boreal and mountain areas towards the end of this century and beyond, with a concomitant loss of key services;
- The physical processes of land degradation, biodiversity, and climate change are intimately inter-twined, especially in **drylands.** The CBD sees wetlands, drylands, remnant grasslands, prairies, Mediterranean forests, and desert margins as particularly vulnerable to the impacts of climate change.

Vulnerability of marine and coastal habitats

- Marine and coastal habitats provide globally significant ecological services;
- Global warming is likely to lead to an increase in coral reef bleaching and mortality as well as more frequent algal blooms;
- Sea level rise and an altered hydrological cycle will affect the geographical distribution and extent of many coastal and marine habitats;
- A further likely negative impact of increased atmospheric carbon dioxide will be by changes in ocean chemistry through acidification.

Vulnerability of wetlands

- Wetlands support significant biodiversity as well as significant social, economic and ecological benefits to societies;
- Climate change will have a significant effect on the hydrological regime and the ecological processes of wetland habitats, and this will essentially be regionally determined;
- Wetland management strategies should incorporate projected precipitation changes in their biodiversity conservation activities;
- Climate change is already having measurable, primarily negative, impacts on wetland biodiversity due to increased invasions from non-native species and decreased water availability in many arid- and semi-arid regions;
- Increased concentrations of pollutants and frequent and more extreme weather events are potentially detrimental to wetland biodiversity.

Vulnerable regions and climate change

- These regions encompass many of the vulnerable habitats described above, but have been highlighted because they are extensive, both geographically (e.g. the Arctic region, Africa) and in the number of localities which share the same issues and exposure to climate impacts (e.g. the Asian Megadeltas, small islands);
- Impacts and adaptation strategies are likely to be similar to those discussed in the habitats discussions, notwithstanding the greater challenges of scale and sheer numbers of people involved.

Arctic vulnerability

- The arctic region is experiencing rapid climate change with melting ice and rising sea levels;
- Climate change is projected to cause a pole-ward shift and reduction of area of the polar desert vegetation zones.

Sub-Saharan African vulnerability

- Africa, especially the sub-Saharan region, is identified as being particularly vulnerable to climate change;
- Vulnerability to climate change is due to the sensitivity to the projected impacts and the weak socio-economic status of many societies, which limits the adaptive capacity of institutions and communities;
- Sustained global warming and temperature increases will result in significant changes in forest and rangeland cover; species distribution, composition, and migration patterns; and biome distribution;
- Many organisms in arid and semi-arid zones are already close to their tolerance limits, and some may not be able to adapt further under warmer conditions.

Small island vulnerability

- Small island developing states (SIDS) have been identified as likely to be highly vulnerable to climate change;
- SIDS are already experience adverse effects of climate change (sea-level rise with tropical cyclones and hurricanes, storm surges, coastal erosion and increasing sea surface temperatures resulting in coral bleaching events).

Asian Megadelta vulnerability

- Eleven megadeltas contribute about 40% to 50% of the world's sediment flux from the land to the ocean;
- The resulting alluvial soils have created some of the most fertile plains in the world supporting the livelihoods of millions of people, mainly located in seven megacities in the region;
- Human activities have resulted in severe coastal erosion of the megadeltas in Asia with climate change expected to enhance erosion through increased frequency and level of inundation;
- Megadeltas are highlighted as one of most vulnerable regions due to global climate changes.

1.1.3 Climate change and the Convention on Biological Diversity

- The CBD has established **7 thematic programmes** which correspond to some of the major biomes on the planet, as well as initiated work on key matters of relevance to all thematic areas. There are **17 cross-cutting issues** of which **climate change and biodiversity** is one;
- **Mountain biodiversity** is a thematic programme with a programme of work which refers to global climate change;
- The relationship between **forest biodiversity** climate change has a clear focus in the forest biodiversity thematic programme. The CBD has also urged the UNFCCC, to ensure that its future activities, including forest and carbon sequestration, are consistent with and supportive of the conservation and sustainable use of biological diversity;

- **Marine and coastal biodiversity** is a CBD thematic programme and global climate change is seen as a major impact. The increasing severity of climate change-induced coral bleaching events is also a cause of concern. One of the goals of the programme is the establishment and maintenance of marine and coastal protected areas;
- Inland waters was adopted as a CBD thematic area and the RAMSAR definition of **wetlands** has been included. The CBD recognises that climate change is the driver of wetlands change. Removing the existing pressures on wetlands and improving their resilience is considered the most effective method of coping with the adverse effects;
- Much of **Sub-Sahara Africa** is included in the dry and sub-humid lands biodiversity theme and programme. A joint work programme with the United Nations Convention to Combat Desertification seeks to address multiple and increasing threats, including from climate change.

1.2 Climate Change, Mitigation and Biodiversity

- The climate change **mitigation** action that is most relevant to biodiversity conservation is the protection and promotion of land-uses and habitats that act as **carbon sinks**;
- Two important habitats that can make a significant contribution to carbon sequestration and storage are **forests** and **wetlands**;
- **Forests** are important in climate change and climate change mitigation because of their role in the carbon cycle;
- The world's forests contain significant carbon, with about 1.5 times as much in soil as in the vegetation;
- The **boreal** forest ecosystem is the world's largest and most important carbon sink largely because, in boreal climates, the colder temperatures reduce decomposition rates, resulting in deep organic soils that are thousands of years old;
- Increases in temperature, precipitation and water availability could significantly affect the carbon sequestration potential of forests, especially in some regions (e.g. Amazon drought);
- Climate change has raised the value of **wetlands** as stores and sinks of carbon. **Peatlands** are estimated to store over 25% of the soil carbon pool even though they cover only 3% of the world's land area;
- **Coastal wetlands** play an important role in reducing impacts from climate change by acting as buffer zones and sea defences against storm surges and extreme storm events.

1.3 Climate Change, Adaptation and Biodiversity

- **Climate change adaptation** is the enabling of biodiversity to cope with and survive through climate change;
- There are limits to adaptation in natural ecosystems, small changes in climate may be disruptive and, beyond certain thresholds, natural systems may be unable to adapt at all;
- For biodiversity conservation adaptation, strategies should enable the maximum biodiversity resource to persist;
- Planned adaptation involves active intervention and management, for example the development of habitat "corridors" or the more strategic design of landscapes to facilitate the movement of species;
- Adaptation **principles** include promoting activities to reduce direct and indirect impacts, increase resilience and accommodate change;

- **Measures** that support these principles include: direct management; promoting dispersal of species; increasing available habitat, promoting ecosystem functioning; optimising sectoral responses, and continuing to reduce pressures not linked to climate change;
- In order to implement these measures it is necessary to conduct monitoring, develop an evidence base, and communicate and transfer knowledge.

1.4 Climate Change, Monitoring and Biodiversity

- Good scientific monitoring allows biodiversity changes to be detected and quantified and provides an objective basis for assessing the nature and seriousness of threats to biodiversity and improves the understanding of the processes causing change, including that attributed to climate;
- The CBD has a theme on the Identification, Monitoring, Indicators and Assessment. Multiple indicators are required to derive trends and greater understanding of the detailed responses of biodiversity to climate change.

2. Climate Change and Darwin Initiative Projects

2.1 The Darwin Initiative

The Darwin Initiative was established in 1992 by the UK Government to assist countries rich in biodiversity but poor in resources to meet their obligations under the CBD. Projects supported from Darwin Initiative funding link together UK based institutions with public and voluntary sector institutions in partner countries. Occasionally, there are also commercial sector partners. Since its inception, the Initiative has supported over 460 projects.

Box 1 Goal of the Darwin Initiative

To draw on expertise relevant to biodiversity from within the United Kingdom to work with local partners in countries rich in biodiversity but poor in resources, to achieve:

- The conservation of biodiversity;
- The sustainable management of its components; and
- The fair and equitable sharing of benefits arising out of the utilisation of genetic resources.

More details can be found at www.defra.darwin.gov.uk

Most Darwin projects last for 2 to 3 years and have a budget of less than £200,000 (US$ 400,000). Many projects successfully lever additional funds from sponsors, or secure co-funding from other initiatives, and there is nearly always support in kind from local partners.

Darwin projects, which can be on any topic relevant to the overall goals of the Initiative, are approved on the basis of merit only; there is no deliberate strategic or geographical focus. The quality of applications is such that available funding is exhausted each year before all proposals of significant merit in the application round are approved. Applications go though a two-stage elimination process with the final ranking being given by the Darwin Advisory Committee.

2.1.1 Purpose of the Thematic Review

In addition to monitoring and evaluation of individual projects, the Darwin Secretariat has commissioned a number of DI-wide reviews addressing CBD Programme Themes or Cross-cutting Issues. The first of these looked at the contribution of the Initiative to the Global Taxonomy Initiative. In 2006 there were Thematic Reviews on Awareness Raising and on Islands, while in 2007 Forest Biodiversity and Climate Change were chosen. The full Terms of Reference for this review are attached as Appendix 1.

The aim of Thematic Reviews is to look globally at the contribution the Initiative has made to improved delivery of obligations under the CBD. As a consequence, the details of individual activity are not so relevant, other than in the extent to which they point to impact, legacy and lessons learned. At the same time, the Thematic Review looks at geographical spread and the range of targets under the CBD Programme of Work that have been addressed.

Again, it is emphasised that Darwin funding is allocated on merit rather than strategically. Consequently, thematic gains are those that have arisen through this approach not as a result of a deliberate focus. Despite this, it is evident that the initiative has made a significant contribution.

2.1.2 Methodology and process

Although the DI has to date supported over 460 projects in more than 100 countries, detailed information relating to climate change mitigation activities and adaptation was not always available in the records. Therefore only those projects where completed final and interim reports were available were included in this review. A spreadsheet was then produced listing the projects and flagging those activities undertaken by the project which could be identified as having a climate change adaptation, mitigation or monitoring contribution. This resulted in a total of 245 project records for subsequent analysis.

Projects developed before the year 2000 seldom had a logical framework, as it was not mandatory and this makes them more time consuming to summarise. For older projects, those that started in 1998 or earlier, there is seldom much detail available as relatively little information was kept at that time other than the final report. This means that the level of information from which the projects can be categorised varies, with significantly more information being available from recent and current projects.

The following sections group and summarise the 245 DI projects that were selected for analysis as part of this review.

2.2 Habitats Vulnerable to Climate Change

The primary habitat was determined for each project. The following habitat types were used as classes: arctic, boreal, coastal and marine, forest, mountains, semi-arid and wetlands. It was also necessary to include the classes ‘mixed’ and ‘other’ to allow all projects to be classified.

For many projects the habitat information was contained in the stated title, purpose, activities and outputs. Where the habitat type was not apparent the location of the project was investigated. Most projects were based in a particular region, national park or reserve. The primary habitat type of these parks and reserves was determined from park and geo-climatic information on the internet. Where parks or reserves contained a mixture of habitat types, projects were assigned to several habitat classes. These are included in the habitat summary data as having mixed habitats. Where the habitat was not made explicit but the location was clearly within a region predominated by a particular habitat type of interest, the most likely habitat type was assigned. For example, projects based in the Amazon or Borneo were assigned as having a forest habitat; those in East and Southern Africa were assigned as semi-arid and so on.

Projects based in areas of mangroves were assigned to the coastal and marine habitat class. Those dealing with a variety of habitats in mountainous areas were assigned to the mountains class. A few projects gave very specific types of mixed habitat, e.g. cloud forest was assigned to both forest and mountain classes and so is summarised into the mixed class; coastal woodland was assigned to both appropriate classes. The ‘other’ habitat class was used where projects were concerned with a habitat type, such as riverine, which was not included in the priority class list. This ‘other’ category also covers projects which involved training which would likely be applicable to a range of habitat types.

The total number of projects in each habitat class were counted, and a table and pie chart produced, see Tables 1 and 2 and Figure 1.

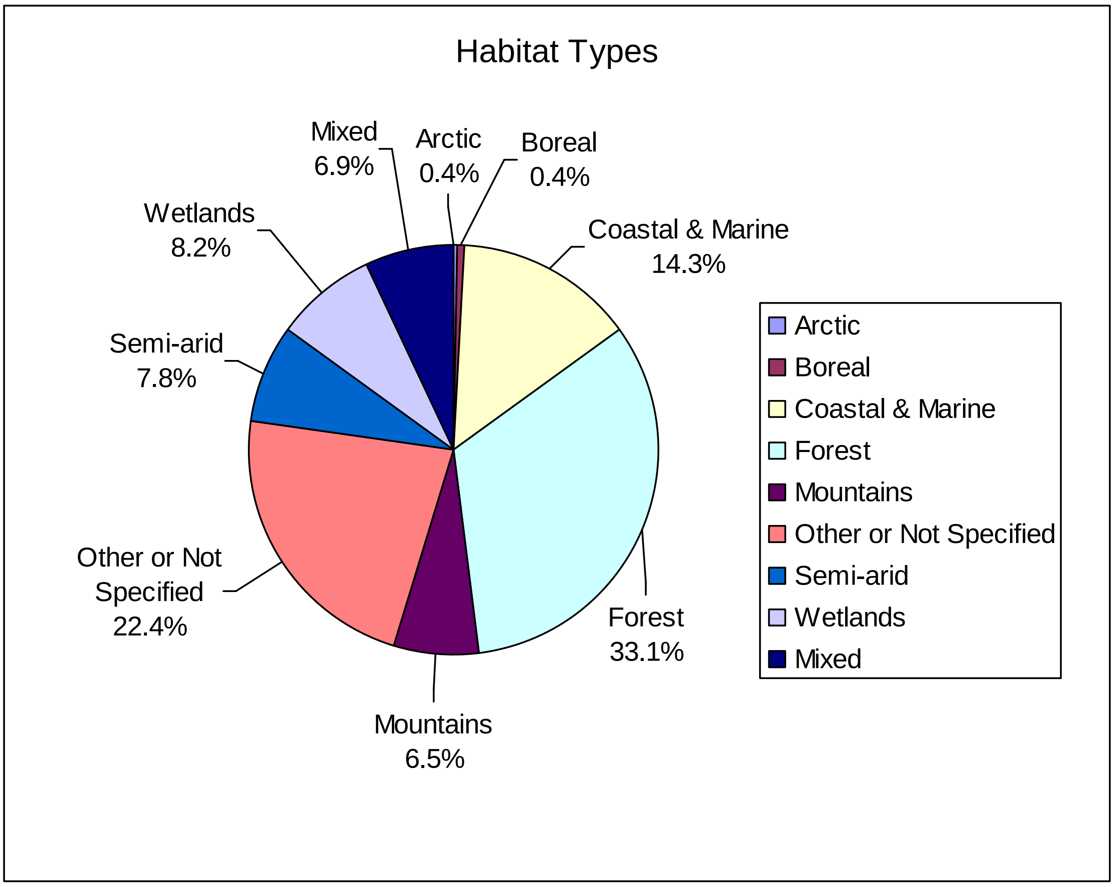

Figure 1 **Project Habitat Types**

Habitat Type	Total	%
Arctic	1	0.4
Boreal	1	0.4
Coastal & Marine	35	14.3
Forest	81	33.1
Mountains	16	6.5
Other or Not Specified	55	22.4
Semi-arid	19	7.8
Wetlands	20	8.2
Mixed	17	6.9
Grand Total	**245**	**100.0**

Table 1 Project Habitat Types

Habitat Type	Total Count
Arctic	1
Boreal	1
Coastal & Marine	40
Forest	92
Mountains	22
Other or Not Specified	55
Semi-arid	20
Wetlands	26

Table 2 Total Projects for each Habitat Type (counting mixed projects in all relevant classes)

This analysis showed that 70% of the projects examined were situated in habitats vulnerable to climate change. The distribution was not even with the largest number of projects located in forest habitats (33%), followed by coastal and marine (14%) wetlands (8%), semi-arid (8%) and mountains (7%). Arctic and boreal habitats have received little DI attention with only 1 project each. Undoubtedly a large part of the reason for this focus is the habitats found in typical DI host countries and the traditional habitat experiences of UK institutions.

2.3 Regions Vulnerable to Climate Change

The region was determined from the geographical location of the project. The classes of interest were Arctic, small islands, sub-Saharan Africa and Asian megadeltas; all other regions were classed as other. Small islands were classed as such even if they were in sub-Saharan Africa. The determination of whether a project concerned an Asian megadelta was difficult. Only a few projects specifically mention a megadelta listed by the Asian-Pacific Network project website at http://www.megadelta.ecnu.edu.cn/main/. A number of projects that were geographically located in megadelta regions (or where no region was specified) were flagged up as possible Asian megadelta projects. These data were counted and summarised as a table and a pie chart, see Table 3 and Figure 2, Project Regions.

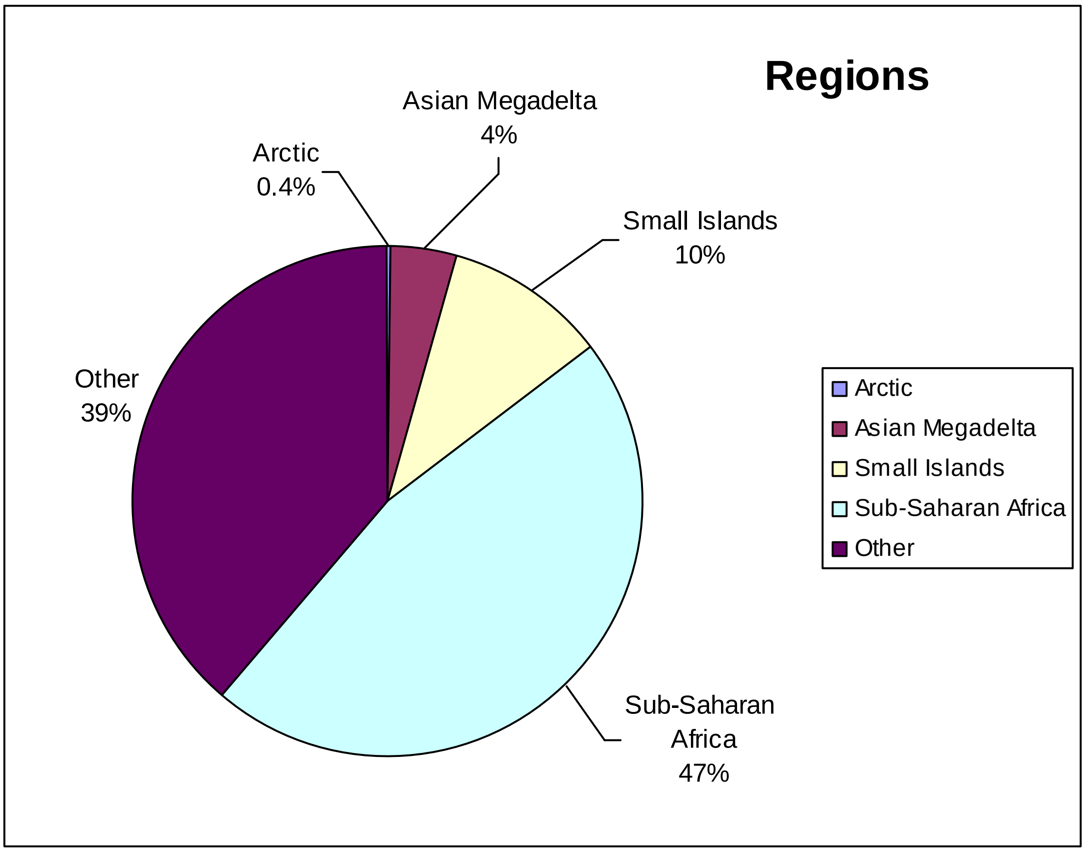

Figure 2 **Project Regions**

Region	Total	%
Arctic	1	0.4
Asian Megadelta	10	4.1
Small Islands	25	10.2
Sub-Saharan Africa	114	46.5
Other	95	38.8
Grand Total	**245**	**100.0**

Table 3 Project Regions

These data show that nearly half the projects reviewed were based in sub-Saharan Africa, 10% were on small islands but only 4% of projects were in the Asian megadeltas. For a full review of all Darwin Initiative activities on islands refer to an earlier FDTF review (van Gardingen and Wild, 2007)

2.4 Mitigation and Adaptation

Projects were reviewed to see if they contained any measures or practices which could be considered as helping a habitat or species adapt to climate change. **The results show that 20% of projects were undertaking activities that involved adaptation strategies drawn from the list in section 1.3.**

For the projects which did involve some activities to assist in adaptation to climate change, the type of adaptation was further broken down into the classes: translocation, *ex-situ* conservation, habitat restoration, habitat recreation, improving habitat connectivity and migration corridors, see Figure 3 and Table 4. Some projects include more than one type of adaptation and these activities are all counted in Figure 3 and Table 4 and are discussed further below.

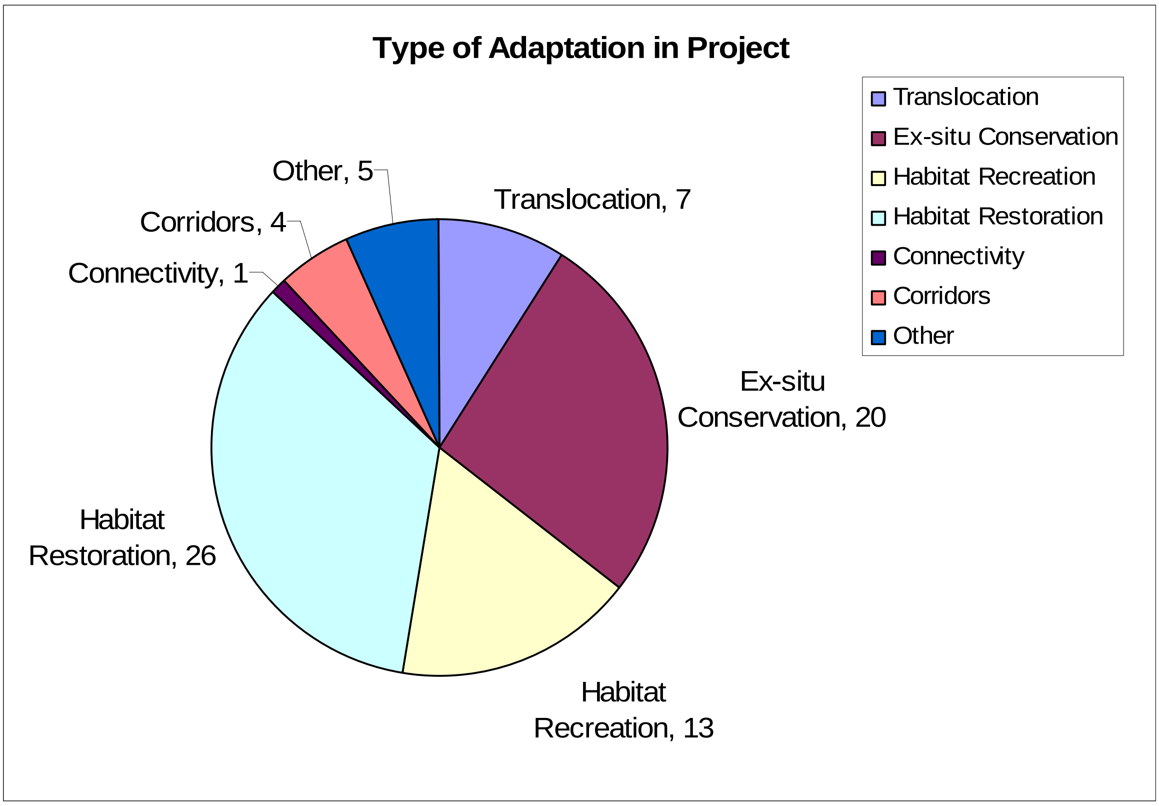

Figure 3 **Types of Adaptation used in Projects**

	Habitat Restoration	*Ex-situ* Conservation	Habitat Recreation	Translocation	Connectivity	Corridors	Other	Total
Count	26	20	13	7	1	0.4	5	76

Table 4 Types of Adaptation used in Projects

Most of the adaptation activities are related to habitat restoration and recreation and *ex-situ* conservation of species. A very few look at the spatial connectivity and corridors to other habitat areas.

The projects were reviewed to find any that incorporated any measures and activities that can be considered as helping to mitigate climate change. **The results showed that 14% of projects involved some activities which might help to mitigate climate change**. The analysis showed that all activities classed as mitigation involved carbon sequestration and that there were no other mitigation activities. Similarly, projects were reviewed for management or capacity building activities. Results show that most projects do include these activities (Table 5).

Management	Total	%
Yes	151	61.6
No	94	38.4
Total	**245**	**100.0**

Table 5 Projects Involving Management or Capacity Building Activities

2.4.1 Terrestrial

Mountain projects

There are 22 DI projects associated with mountains, nine in Africa, four in Central and South America, two in Europe and seven in Asia. Of these, 17 are wholly or partly in tropical regions. Most of the projects are associated with areas below the tree-line and thus do not encompass the habitats most sensitive to climate change. A number of projects are concerned with monitoring, management and livelihoods. Four projects contained elements associated with adaptation and six projects involved mitigation in the form of carbon sequestration.

One project was concerned with *ex-situ* conservation in that an aim of project 3-063 was "To increase the expertise of the staff of the existing Limbe Botanic Garden and Genetic Resources Conservation Project in modern scientific conservation methods by providing a formal link with UK expertise at Bangor and Kew". Unfortunately no further information was available for this project, but this form of capacity building can be important for the conservation of endangered species in conjunction with other forms of adaptation or where such actions are not proving successful. The project 10-011, Community based conservation of Hoang Lien Mountain Ecosystem, Vietnam, helped the Vietnam government to meet its Biodiversity Action Plan objectives and the need for *ex-situ* conservation was recognised in the Plan. This project additionally used habitat restoration and recreation and mitigation in the form of carbon sequestration. A project (11-024) based in Kyrgyzstan also implemented a habitat recreation scheme. The only other adaptation option associated with mountains is related to corridors, as the Parque Nacional La Amistad, Costa Rica (15-027) has a strategic position in the Mesoamerican Biological Corridor.

Project No.	Title	Adaptation & Mitigation	Comments
3-063	Tree Regeneration, Vegetation Dynamics and the Maintenance of Biodiversity on Mount Cameroon: The Relative Impact of Natural and Human Disturbance	Ex-situ conservation	SSA Also monitoring and livelihoods activities
3-064	The Effect of an Invasive Tree Species on Biodiversity in Primary Montane Rainforests in Jamaica	Carbon sequestration	
10-011	Community based conservation of Hoang Lien Mountain Ecosystem, Vietnam	Ex-situ conservation: propagation of endangered plants and /or development of more sustainable systems of NTFP extraction Habitat recreation and restoration Carbon sequestration	Also monitoring and livelihoods activities

Project No.	Title	Adaptation & Mitigation	Comments
11-024	School Green Land – Community Biodiversity Awareness in Kyrgyzstan; EIDPO11 Biodiversity Education and Teacher Training	Habitat recreation	
13-033	Combating Invasive Alien Plants Threatening the East Usambara Mountains in Tanzania	Carbon sequestration	SSA Also monitoring activities
14-009	Biodiversity Monitoring in Forest Ecosystems in Bale Mountains National Park, Ethiopia	Carbon sequestration	SSA Also monitoring and livelihoods activities
15-027	Baseline Tools for Management of PN La Amistad	Corridors Carbon sequestration	Also monitoring and livelihoods activities
16-014	Co-management of Forests and Wildlife in Bi Doup-Nui Ba Nature Reserve, Vietnam	Carbon sequestration	Also livelihoods activities

Table 6 Mountain Projects Including Adaptation and Mitigation Activities

Management is implicit in most of the projects, although it is only explicit in six (3-063; 12-007; 13-003; 14-009; 15-001; 15-027). The management may be primarily for conservation objectives or involve the management of ecosystems as part of livelihoods and sustainable development. More specifically it relates to Tree Regeneration, Vegetation Dynamics and the Maintenance of Biodiversity on Mount Cameroon (3-063), independent local management of forests for gorillas in the Afi Mountain Wildlife Sanctuary, Nigeria (12-007), management to prevent invasive alien plants in the East Usambara Mountains, Tanzania (13-033), protection of native forest species of plants and animals in Bale Mountain National Park, Ethiopia (14-009), bees, biodiversity and forest livelihoods in the Nilgiri Biosphere Reserve, India (15-001) and a sustainable management plan for the bi-national Parque Nacional La Amistad (PILA), Costa Rica (15-027).

One of the aims of project 3-063 was to carry out background work essential for the development of management practices for sustainable forest use by local people and for conservation of biodiversity in the proposed Mount Cameroon Forest Reserve, by determining whether natural regeneration following the disturbance created by extraction of products from the forest by local people is leading to the maintenance of biodiversity or its decline. There was also a desire to involve local people in the development of the management policies for the new Forest Reserve to ensure they incorporate their interests as well as the conservation of biodiversity. The Afi Mountain Wildlife Sanctuary Gorilla Research and Conservation Project, Nigeria (12-007) had a greater focus on species conservation and ecosystem functioning, but still involved the cooperation of local people.

Project 15-027 possibly has the strongest focus on management, as it aims to provide baseline data, tools and training to underpin the development of a conservation plan for the sustainable management of the bi-national Parque Nacional La Amistad. This is a project in progress and the management plan is an end point, so there are no details available as yet, but it is based on a life-zone map of the Costa Rican component of PILA and includes a prioritised strategy for the life-zones. There is, in theory, therefore, a potential to identify climate change sensitive areas and to ensure that they are given priority.

None of the projects explicitly mention management for adaptation to climate change and it would be important to ensure that management plans took into account any such projected changes and their potential impacts.

Forest projects

Of the 92 projects associated with forests[1] (excluding boreal but including all forest projects in the mixed class) examined in this review, 32 have been flagged as including adaptation or mitigation activities, with only two of those reviewed explicitly mentioning climate change. Project 14-022 has as one of its goal to "prioritise the biological importance of forest reserves for maximising biodiversity, and to provide clear practical advice on biodiversity consequences of changes in climate and land-use." It uses computer modelling to predict the current and potential future distribution of selected families of butterflies in relation to climate and land cover. The modelling is then to be used to quantify conservation status of protected areas and enable effective long-term conservation planning. Another project (15-016), which included evaluating the capacity for increased production of native forest products (*Prosopis* pod flour and syrup), stated that "climate change is potentially a significant issue in this hyper-arid region, and it is not known to what extent this is a factor in the insect infestations and die-back observed in some relic patches of Huarango forest. However, to compensate for this possibility, species with economic potential that do not appear to be suffering such problems have been included in the community-based habitat restoration trials."

Ex-situ conservation is only mentioned in five projects and it is targeted at the *ex-situ* propagation of endangered plants. Project 4-190 trained Chilean scientists in seed storage and germination, macro- and micro-propagation. Other projects with *ex-situ* conservation are 10-011; 10-029; 11-012; and 11-014.

Nine projects (4-190; 7-149; 9-001; 10-011; 11-012; 11-014; 11-023; 14-010; 15-016) included an element of habitat restoration. The aims of these restoration schemes included the reversing of habitat degradation and the conservation of the habitat and/or species, with some links to livelihoods (56%), but all involved the local communities. In most cases, the propagation of native species in local gardens or nurseries formed part of the strategy and thus the species, once planted out, enhanced the local species populations and increased its resilience to change.

An ongoing project (Habitat restoration and sustainable management of southern Peruvian dry forest- 15-016) provides an example of restoration of dry forest vegetation highly susceptible to degradation and desertification, with very infrequent natural regeneration. Huarango (*Prosopis pallida*), originally the dominant tree species in the region, provides many food and forage products that potentially offer lucrative sustainable livelihoods. During the last 30 years there has been an estimated loss of 50,000 hectares of Huarango forest in the Ica region, with less than 1000 ha remaining (of which the majority is secondary forest). Huarango forest is a threatened ecosystem and there are increasing levels of concern among the regional governments for its conservation.

The project sought, amongst other objectives, to develop and disseminate technology for habitat restoration to protect biodiversity and combat desertification. Seed collection from the relict vegetation was undertaken in order to have a sufficient and representative selection of perennial and annual plants for both the habitat restoration and education planting programme and a tree nursery was established for germination and propagation trials. Four habitat restoration trials were established and monitored monthly. Observations included plant height, stem width, canopy area, health, mortality and other observations. In order to maximise the likelihood of long-term management of restored areas and uptake of restoration techniques, the trials have been modified to match local necessities and priorities (e.g. inclusion of species of economic value, woodlots), and the species composition broadened to maximise the likelihood of survival in what appears to be a changing environment.

[1] A slightly broader set of 106 projects was examined in the Forest biodiversity thematic review.

Water supply may be an issue that could affect the success of the restoration trials and be exacerbated under climate change, although this is not explicitly considered. Also an ephemeral stream habitat restoration site was inundated due to an exceptional year and such risks need to be assessed especially in the light of climate change. The restorations proposed would improve the conservation status of the habitat and its species, thus making it more resilient to climate change, but often the areas involved are rather small and thus it is of more local significance. Nevertheless, the projects are often (incidentally) targeted at habitats and species which could be sensitive to climate change and the restored areas can contribute to movement of species adapting to climate change.

Connectivity was an element of project 7-040, biodiversity of butterflies in tropical rainforests of Sabah, Borneo. This project looked at forest vegetation structure in logged and unlogged forest to elucidate the causal mechanisms of changes in butterfly biodiversity. Corridors were used in project 13-009, Ethnobiology of proposed traditional use zones of Crocker Range Park.

Thirty-five of the forest projects were classified as involving carbon sequestration.

Project No.	Title	Adaptation & Mitigation	Comments
3-064	The Effect of an Invasive Tree Species on Biodiversity in Primary Montane Rainforests in Jamaica	Carbon sequestration	
4-190	The Senda Darwin Forest Conservation and Training Project	*Ex-situ* conservation: seed storage and germination, macro- and micro-propagation Habitat restoration and recreation Carbon sequestration	Also monitoring activities
6-046	Rattan Diversity and Sustainable Management in Lao PDR	Carbon sequestration	Also monitoring activities
6-159	Conservation of Seed and Microsymbionts of Albizia tree species in Ghana	Carbon sequestration	SSA
7-040	Biodiversity of butterflies in tropical rainforests of Sabah, Borneo	Connectivity	Also monitoring and livelihoods activities
7-149	Tabunan Forest Biodiversity Conservation	Habitat restoration Carbon sequestration	Also monitoring activities
8-044	Conservation Biology & Genetics of the western lowland gorilla in Gabon	Carbon sequestration	Also monitoring activities
8-154	Biodiversity conservation and sustainable use in Mexican cloud forest	Carbon sequestration	Also livelihoods activities
9-001	Renewing management of Sapo National Park and creation of the Liberian protected areas system	Habitat restoration: capacity building Carbon sequestration	SSA Also livelihoods activities
9-012	Conservation of the Paguyaman forest in North Sulawesi, Indonesia	Carbon sequestration	Also livelihoods activities
9-014	Huemul ecology research for conservation planning, Southern Chile	Carbon sequestration	Also monitoring activities
9-016	Conservation of the orang-utan in Kinbatangan Wildlife Sanctuary, Sabah	Other adaptation activity: using non-invasive population molecular genetic techniques	Also monitoring activities
10-011	Community based conservation of Hoang Lien Mountain Ecosystem, Vietnam	*Ex-situ* conservation Habitat restoration and recreation Carbon sequestration	Mixed (also mountain) Also monitoring and livelihoods activities
10-029	Training of Vietnamese Scientists in tree science and technology	*Ex-situ* conservation	AMD

Project No.	Title	Adaptation & Mitigation	Comments
11-004	Conserving Kenya's indigenous forests through certification of sustainably sourced woodcarvings	Carbon sequestration	SSA Also livelihoods activities
11-012	An integrated conservation programme for threatened endemic forest species in Chile	*Ex-situ* conservation Habitat restoration Carbon sequestration	Also livelihoods activities
11-014	Biodiversity and Colombian Coffee Farmers: Capacity building for added value	*Ex-situ* conservation Habitat restoration: capacity building	Also monitoring and livelihoods activities
11-021	Institutionalising Participatory Integrated Forest Management Assessment in Nepal	Carbon sequestration	Also monitoring and livelihoods activities
11-023	Education and training for restoring tropical forest biodiversity in Thailand	Habitat restoration: Restoring degraded forest for biological conservation Carbon sequestration	
12-014	Biodiversity and functional value of Amazonian primary, secondary and plantation forests/ EIDPO14 - Devising Strategies to Integrate Biodiversity Conservation in Plantation Dominated Landscapes	Carbon sequestration	
13-005	Community Conservation and Sustainable Development in the Awacachi Corridor, NW Ecuador	Carbon sequestration	Also livelihoods activities
13-008	Establishing community-based forest biodiversity management around Sapo Park, Liberia	Carbon sequestration	SSA Also livelihoods activities
13-009	Ethnobiology of proposed traditional use zones of Crocker Range Park	Corridors Carbon sequestration	Also livelihoods activities
13-028	Establishment & Management of Nantu National Park, Gorontalo Province, Sulawesi	Carbon sequestration	Also livelihoods activities
13-031	Pioneering an innovative conservation approach in Sierra Leone's Gola Forest	Other adaptation activity: participatory management programme using a conservation concession strategy	SSA Also monitoring and livelihoods activities
14-010	Facilitating Forest Restoration for Biodiversity Recovery in Indochina	Habitat restoration: Restoring sites through framework species	AMD
14-013	Community Management of NTFPs in Kangchenjunga Conservation Area, Nepal	Carbon sequestration	Also livelihoods activities
14-016	Assessing and Conserving Plant Diversity in Commercially Managed Tropical Rainforests, Sabah	Carbon sequestration	Also monitoring activities
14-018	Capacity Building for Managing Eastern European High-Conservation Value Forests	Other adaptation activity	
14-022	Predictive Tools for Targeting Conservation Effort in Bornean Forest Reserves, Sabah	Carbon sequestration: Areas most in need can be targeted	Also monitoring and livelihoods activities
14-034	A Biodiversity Conservation Training Programme for the Yaboti Biosphere Reserve	Carbon sequestration	Also monitoring and livelihoods activities

Project No.	Title	Adaptation & Mitigation	Comments
14-049	Participatory Management of Priority Biodiversity Sites in Taraba State, Nigeria	Carbon sequestration	SSA Also monitoring and livelihoods activities
15-016	Habitat Restoration and Sustainable Use of Southern Peruvian Dry Forest	Habitat restoration Carbon sequestration	Also monitoring and livelihoods activities
15-023	Conservation of Endangered Coastal Biodiversity Hotspots of Central Chile	Carbon sequestration	Also monitoring activities
15-041	The Waria Valley Community Conservation and Sustainable Livelihoods Programme	Carbon sequestration	Also livelihoods activities
16-014	Co-management of Forests and Wildlife in Bi Doup-Nui Ba Nature Reserve, Vietnam	Carbon sequestration	Also livelihoods activities

Table 7 Forest Projects Involving Adaptation and Mitigation Activities

2.4.2 Marine and coastal zones

Of the DI projects reviewed seven involve activities which could help ecosystems adapt to climate change (see Table 8). Some of these projects involve more than one of the activities classed as adaptation.

Project No.	Title	Adaptation	Comments
3-067	Field Collection, Molecular Characterisation and In Vitro Conservation of Porteresia Coarctata	*Ex-situ* conservation: Collect and study the genetic diversity of Porteresia coarctata and establish a reliable propagation system	AMD
10-006	Propagation, nursery and establishment protocols for Seychelles endemic plants	Translocation: storage and propagation of many endangered endemics in a new biodiversity centre. Propagation trials to establish protocols	SI
12-033	Blue Forests: Sustainable Farming of Coral Reefs, Fiji, Solomon Islands	Habitat recreation: Restocking of giant clams and Ark shells. Setting up Coral Farming Experiments Habitat restoration: Assist Communities Demarcate their No fishing Zones	SI Also monitoring and livelihoods
12-034	The Darwin Southeast Asian Wetland Restoration Initiative, Vietnam	Habitat restoration: establishment of demonstration sites	AMD Also wetland Also livelihoods
14-048	Galápagos Coral Conservation: Impact Mitigation, Mapping and Monitoring	Habitat restoration and recreation: reduced coral damage due to the use of permanent moorings	SI Also monitoring
15-005	Conservation of the Mangrove Finch (Cactospiza heliobates)	*Ex-situ* conservation: captive rearing programme. Habitat restoration: invasive species control methods tested.	Also monitoring
15-038	Restoring Island Biodiversity: the Reintroduction of Endemic Mauritian Reptile Communities	Translocation and habitat restoration	SI

Table 8 Coastal and marine projects with adaptation activities

Ex-situ conservation is included in two projects. In project 3-067 (Field Collection, Molecular Characterisation and In Vitro Conservation of *Porteresia coarctata*), a mangrove-associated, salt tolerant, wild relative of rice was collected from diverse mangrove ecosystems in India, Bangladesh and Pakistan, its genetic diversity was studied using molecular fingerprinting and a reliable propagation system established.

For project 15-005 (Conservation of the Mangrove Finch, *Cactospiza heliobates*, Ecuador) a captive rearing programme was set up. This project also included habitat restoration by testing methods to control invasive species.

Translocation was used in two projects. In project 10-006 (Propagation, nursery and establishment protocols for Seychelles endemic plants) the aim was to recover many endangered endemics among Seychelles flora by improved storage and propagation in a new biodiversity centre. A nursery was established for species recovery in degraded conditions. A database of propagation protocols for 90% of endemic flora, incorporating review of known success and species recovery procedures for the endemic flora and results of trials on propagation methods was created and a handbook of best nursery practice compiled. Training courses in plant conservation were given. Project 15-038 (Restoring Island Biodiversity: the Reintroduction of Endemic Mauritian Reptile Communities) translocated and re-established sustainable reptile communities (Telfair's skinks on Gunners Quoin and Ile aux Aigrettes; Bojer's skinks on Ile aux Fouquet and night geckos on Ilot Chat) in Mauritius to secure future reptile populations and restore functional island ecosystems. The impact of translocations was assessed and established populations monitored. Habitats were restored as part of this project.

Habitat recreation was included in the adaptation activities of two projects. For more information on project 14-048 (Galápagos Coral Conservation: Impact Mitigation, Mapping and Monitoring) see the boxed case study.

Habitat restoration is included in five projects: 12-033, 14-048, 15-005 and 15-038 are mentioned in the section above; project 12-034 (The Darwin Southeast Asian Wetland Restoration Initiative, Vietnam) which is dealt with under the wetlands section.

Extended case study – Establishment of a marine corridor project in the Eastern Tropical Pacific

The Eastern Tropical Pacific Seascape Project (ETPSP) is an excellent example of an international marine protection initiative that involves two currently-active Darwin Initiative projects for the creation of a trans-boundary corridor scheme. The Panamá Bight, a designated World Wildlife Fund for Nature (WWF) Global 200 priority ecoregion for conservation (Dinerstein *et al*., 1995; Olson and Dinerstein, 1998) extends eastwards from the Azuero Peninsula in Panamá along Gulf of Panamá and Archipelago de las Perlas and continues south along the entire Pacific coast of Colombia to the coast of northern Ecuador. Its islands and the seas surrounding them offshore from Costa Rica, Panamá, Colombia, and Ecuador are one of the most productive areas of the Eastern Tropical Pacific and belong to one of the world's most biological diverse geographical provinces.

This region has a high degree of ecological interconnection and complex oceanographic characteristics, mainly due to the convergence of major marine currents, which facilitate the dispersal of marine larvae (e.g., from corals, crustaceans, molluscs, fish) and affect the migrations, movements and distribution of many species of regional and global significance. The Humboldt Current, the Equatorial Current, the Panamá Current, the Costa Rica Coastal Current, the Cromwell Current and the Panamá Bight Gyre converge and mix in this region. This complex system results in an upwelling of nutrients from the deep ocean, providing food for many species, and facilitates dispersal of fish larvae, corals, crustaceans, molluscs and echinoderms which affect species migrations, resulting in a wide ecological connectivity throughout the region.

The protected islands currently within the ETPSP include Ecuador's Galápagos Archipelago, Colombia's Malpelo and Gorgona islands, Panamá's Coiba and Costa Rica's Cocos islands. One of the current DI projects (Marine biodiversity assessment and development in Perlas Archipelago, Panamá, No 12-021) is actively engaged in advocating for Las Perlas Archipelago to be included in the Eastern Tropical Pacific Seascape Project as a result of recent studies undertaking by the DI host-country partner, the Smithsonian Tropical Research Institute (STRI), Panamá. Several studies were conducted in Las Perlas to provide support to the legal process that has culminated with the designation of special management zoning throughout this important Panamánian marine ecosystem. They have established, in collaboration with Fundación Yubarta, a Colombian non-governmental organization, the Archipelago's importance as a critical habitat for Humpback whale (*Megaptera novaeangliae*) populations in the southeast Pacific. These local conservation organisations, with support from WWF have entered into a bilateral agreement for the establishment of an essential Marine Biological Corridor of the Tropical Eastern Pacific for the protection of Humpbacks and other migratory species.

More recently, shark tagging experiments in the Galápagos Archipelago (Ecuador) using satellite transmitters and underwater loggers have shown that hammerhead sharks are moving to Cocos islands, Costa Rica (CDF, 2007), in addition to earlier evidence that a shark tagged in Malpelo island, Colombia was also observed at Cocos island. Sharks, including whale sharks, and Humpback whales were regularly sighted at Wolf and Darwin islands during the expeditions of the DI project no. 14-048 'Galápagos Coral Conservation: Impact Mitigation, Mapping and Monitoring'.

The coral reefs of the Galápagos Islands play a significant role in species richness and diversity in the Galápagos Marine Reserve (GMR). These ecosystems support tens of thousands of species, including many rare and endemic corals and associated biodiversity. Hermatypic (reef building) corals are sensitive to elevated temperatures, which have been linked to coral bleaching (loss of symbiotic zooxanthellae) and therefore their distribution around the islands has been strongly affected by extreme climatic events over the last 30 years, especially El Niño events where extensive coral reefs were reduced by 95% in 1982-83 with further mortality in 1997-98 (Figure 4).

The Galápagos islands provide an ideal location for evaluating climate impacts on biodiversity due to the significant climate variability recorded there during El Niño periods and it has been suggested the islands can provide early evidence of global warming impacts on biodiversity analogous to the 'canary in the coalmine' approach. This project has established permanent fixed plots on the coral reefs at the northern islands of Marchena, Darwin and Wolf to establish a current ecological baseline as well as for long-term monitoring of change in coral reef communities and structure. They developed a new set of monitoring and mapping protocols, derived from the Internationally-adopted ReefCheck and AGRRA (Atlantic and Gulf Reef Rapid Assessment) rapid assessment methodologies, but specifically adapted for Galápagos marine habitats.

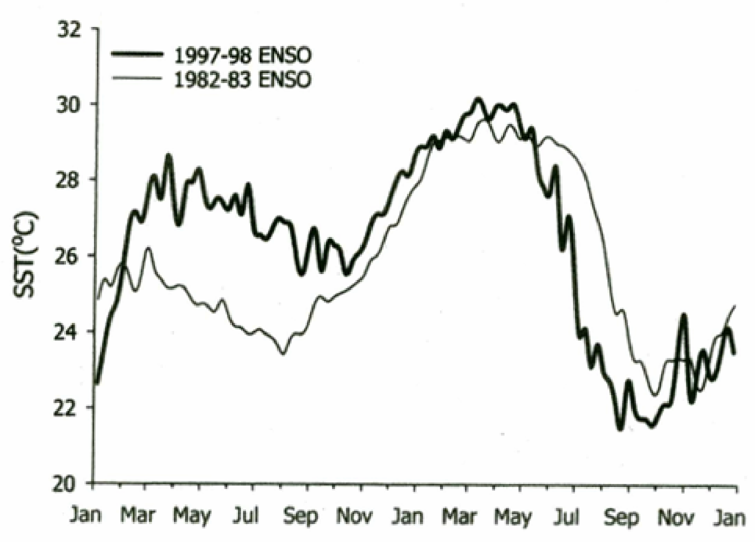

Figure 4 **A comparison of Sea Surface Temperatures (SSTs) in the Galápagos islands during the 1982-83 and 1997-98 El Niño events (from Glynn et al 2001). El Niño impacts had resulted in extensive coral reef decline with over 95% mortality experienced during the 1982-83 and 1997-98 events**

Results to date have shown that, although the Galápagos reefs are isolated in terms of distance, coral and other invertebrate species inventories have confirmed biological connectivity with the reef habitats off the Ecuadorian mainland and with the more northerly islands within the Seascape geographical extent. Other research currently being conducted within this project is demonstrating that the corals are adapting to elevated temperatures through the adoption of more resilient zooxanthellae species, which demonstrates the importance of conservation of genotypes in species.

The development of a working sustainable fisheries and zoning scheme in Galápagos is proving difficult due to the strength of representation of the fishing communities having strong political support and uncompromising attitudes. Indeed, it is now widely recognised by all stakeholders that the lobster and sea cucumber fisheries have effectively collapsed in the islands, and there is now significant increasing illegal shark fishing (shark finning) for the Asian markets, which is proving a challenge to address.

Galápagos is very high on the conservation agenda of the Ecuadorian government, and Wolf and Darwin islands are all the more important given their significant economic importance to dive tourism, which is a rapidly growing subsector of the tourism sector worldwide. For the last 2 years of the project a nine-organization alliance of NGOs has been working with the fishing sector and the Ecuadorian Ministry of the Environment to identify ways to reduce fishing pressure in the Galápagos Marine Reserve. One option that is currently under assessment is the enlargement of the existing No Take zone around the northern islands in exchange for access to cheap credit through a social benefit fund of a value equal to the fishing value of the potential No Take areas at Wolf and Darwin.

The scientific work produced by this project is providing the scientific basis for No Take zone creation. The project has established a successful working relationship with Darwin project No. 12-021 to share knowledge, information and data to support high quality research, and 'best practice' approaches to managing marine protected areas in a region of high climate variability. The recognition and establishment of marine corridors is an excellent example of an adaptation strategy to climate change impacts involving multiple organisations across several countries, and with the active participation of two Darwin Initiative projects.

Only one DI coastal and marine project involves any mitigation activities, project 6-173 Protected Areas Management Planning in the Andaman Islands, India aimed to produce management plans for three protected areas where there is a need to integrate conservation, rural development and tourism.

Case Study - 12-018: Climate change and conservation of Galápagos endemic bird species

The Galápagos penguin (*Spheniscus mendiculus*) is an endangered and endemic species to the Galápagos Islands, with a population of c. 1500 living around the islands. By using data-logger technology the project demonstrated that the volume of ocean apparently usable by them was rather limited (they are restricted to the coasts), in comparison to other penguin species globally. This narrow niche envelope obviously raises the fear that this small and isolated endemic species would be sensitive to climate change. The penguins feed on fish, such as mullet, that depend in turn on the up-welling of equatorial deep ocean currents that deliver macronutrients. During El Niño years these currents are 'switched off'.

The project analysed the survival of the penguins and found that during strong El Niño years, the survival of the penguins plummets by 70-80%. By analysing the pattern of El Niño years, they found that in the more recent period of records the frequency and intensity of El Niño events had increased. They used the data on this new pattern of El Niños to parameterise a Vortex computer simulation. It showed how the risk of extinction was significantly increased if the current pattern of El Niños was to continue (and this risk would be seriously elevated if the frequency of strong El Niños was to increase further, even slightly).

Extending their research to include other species, members of the team found, for example, that on land the Galápagos flamingos redistribute themselves during El Niño years, but their populations are not (cf. penguins) apparently damaged. In very important contrast, on a related project the project demonstrated that El Niño years resulted in a proliferation of invasive Black rats, which in turn imperilled endemic terrestrial species. Overall, the project demonstrated persuasively the importance of exploring on a case by case basis the impact on the behaviour of individuals, and thus on their populations, of changes in weather patterns.

2.4.3 Wetlands

Twenty six of the projects summarized were based in wetland habitats (including those in the mixed category). Only two wetlands projects involved any mitigation activities. These projects were classified as incorporating carbon mitigation: 4-197 (Melaleuca Wetlands Project) and 7-113 (Darwin Madagascar Wetlands Project).

Three of the wetland projects were classified as incorporating adaptation activities. These were all habitat restoration activities. These projects were: 3-224 which looked at Lowland Wet Grasslands in the Czech Republic and Estonia; 12-034, a wetland and coastal habitat project entitled The Darwin Southeast Asian Wetland Restoration Initiative, Vietnam, which involved establishment of demonstration sites for habitat restoration; 13-012 Integrated River Basin Management (IRBM) in the Sepik River, Papua New Guinea, this project produced a gazettal of at least two protected areas established in priority wetland and forest areas. The project assisted the government and local stakeholders to design an integrated river basin management (IRBM) framework for the Sepik River to protect biological diversity and ecological processes while promoting the sustainable management of natural resources supported by a properly implemented water catchment policy.

Project No.	Title	Adaptation & Mitigation	Comments
3-224	Lowland Wet Grasslands in the Czech Republic and Estonia	Habitat restoration: conservation of lowland wet grasslands	
4-197	Melaleuca Wetlands Project (162/04/073)	Mitigation: carbon sequestration	Also livelihoods and monitoring activities
7-113	Darwin Madagascar Wetlands Project	Mitigation: carbon sequestration	SSA Also monitoring activities
12-034	The Darwin Southeast Asian Wetland Restoration Initiative, Vietnam	Habitat restoration: establishment of demonstration sites	Also coastal (mixed) AMD Also livelihoods activities
13-012	Integrated River Basin Management (IRBM) in the Sepik River	Habitat restoration: Gazettal of at least two protected areas established in priority wetland and forest areas	AMD Also livelihoods activities

Table 9 Wetlands Projects Including Adaptation and Mitigation Activities

2.4.4 Projects in Sub-Saharan Africa addressing adaptation and mitigation

Of the 114 Sub-Saharan (inc. Indian Ocean Islands) projects a total of 32 (28%) addressed issues of adaptation and mitigation, Of these 24 related to adaptation including habitat recreation and restoration (13 projects), translocation (7 projects) and mitigation through avoided deforestation or regeneration (9 projects) although none actually mentioned carbon sequestration.

Only 24 (including those involved in capacity building) have any activities categorised as adaptation. Translocation was identified for seven projects, six concerning rare and/or endemic species: Mauritian ferns (3-199) and reptiles (15-038); Seychelles endemics (10-006) and Seychelles Paradise flycatcher (15-009); South African plant genera (12-008); biodiversity in montane ecosystems in SE Africa (15-035). The seventh (8-048) explored conservation and sustainable use of medicinal plants in Ghana, one of its main themes being to promote translocation of medicinal plants to people's home gardens.

These were part of species recovery programmes and involved the re-establishment of communities, sometimes on restored or recreated habitat (15-009). A recently started project (15-038) has the following aims: the re-establishment of sustainable reptile communities in Mauritius to secure future reptile populations and restore functional island ecosystems. It will undertake impact assessment of the translocations, with continued monitoring in donor and translocated populations and ensuring that the lessons learned and protocols established are disseminated for further reptile translocation. Similarly, 15-009 identifies that in the past a lack of technical capacity to implement translocation has hindered the conservation programme for the critically endangered Seychelles Paradise flycatcher. The project seeks to develop an appropriate translocation methodology and to move the species to the now predator free restored Denis island. Further habitat restoration is envisaged, indicating how many conservation/adaptation activities are inter-linked.

Ex-situ conservation is often linked to translocation, as populations for release into new locations may be grown *ex-situ*. Project 3-199 (continued as 5-199), for example, sought to study the rare Mauritian fern *A. asarifolium in situ* and secure its future by collecting spores and growing plants *ex-situ* in Edinburgh, before transferring them back to Mauritius to form an *ex-situ* collection. Surplus plants were planned to be experimentally re-introduced to suitable habitats. The second part of the project aimed to see the horticultural facilities for a long-term pteridophyte programme established in Mauritius. An alternative approach is Project 14-056 which seeks to establish a cryobank in KwaZulu-Natal for the preservation of recalcitrant plant seeds. Already a number of seeds have been screened, but difficulties have been encountered in developing the techniques for the cryoconservation of the genetic resources. Nevertheless progress is being made and it is an important part of *ex-situ* conservation strategy. Altogether, eleven projects in sub-Saharan Africa used *ex-situ* conservation techniques.

Habitat recreation is part of five projects (plus capacity building in one other) and the purposes range from pure conservation to combining this with more direct livelihood benefits. In project 3-199, as described above this is linked to *ex-situ* growth of ferns for such a purpose, while in 15-003 it is concerned with the conservation and sustainable use of indigenous vegetable (IV) species in Mali and Benin. Project 15-031 is seeking to develop practical reclamation and conservation methods for mining enterprises in developing countries that both conserve biodiversity and enhance community livelihoods, using a mining enterprise in Sierra Leone as a case study.

Eight projects are involved in habitat restoration with several focused on capacity building (e.g. 4-186; 5-187). The distinction between this and habitat recreation seems to somewhat arbitrary, with some projects involved in both. Project 15-038, on the re-establishment of sustainable reptile communities in Mauritius, has the clearest focus on habitat restoration. Only one project (4-186) has a possible link to corridors, in that among its actions it seeks to evaluate the policy options for addressing the loss of diversity allowed under the biodiversity Convention and to make recommendations on the optimal regional strategy.

Nine of the projects could be considered as involved in mitigation through aspects of forest conservation, sometimes alongside sustainable rural livelihoods (e.g.13-008: Establishing community-based forest biodiversity management around Sapo Park, Liberia), but none explicitly mention carbon sequestration. This occurs through avoidance of forest loss, although forest restoration could also come in this category. The areas involved may be small, but, depending on the development of carbon markets, this may become important as the conservation of forest may add a new dimension to sustainable livelihoods.

Project No.	Title	Adaptation & Mitigation	Comments
3-063	Tree Regeneration, Vegetation Dynamics and the Maintenance of Biodiversity on Mount Cameroon: The Relative Impact of Natural and Human Disturbance	*Ex-situ* conservation	Also livelihoods and monitoring activities
3-108	Genetic Resource Conservation of Onions in West Africa	*Ex-situ* conservation	
3-170	Domestication of Fruit Trees and Other Non-Timber Economic Species	*Ex-situ* conservation Habitat recreation	
3-199	Mauritius Fern Project (Continued as 05/199).	Translocation *Ex-situ* conservation Habitat recreation	Classed as Small Island
4-186	Implementation of the Biodiversity Convention in Sub-Saharan Africa	Habitat restoration Corridors: - adapting to "biodiversity changes" Other adaptation activity	Also monitoring activities
4-200	Biodiversity Research Training for African Park Staff	Other adaptation activity	
5-187	Capacity Building Through the Wildlife Society of Zimbabwe	Habitat recreation	Also monitoring activities

Project No.	Title	Adaptation & Mitigation	Comments
6-100	Plant Biodiversity Conservation and Sustainable Utilisation Training in West Africa	*Ex-situ* conservation	
6-101	Capacity Building Fellowships in Southern Africa	*Ex-situ* conservation	
6-131	Wildlife and People: Conflict and Conservation In Maasai Mara Kenya	Habitat restoration	Also livelihoods activities
6-159	Conservation of Seed and Microsymbionts of Albizia tree species in Ghana	Carbon sequestration	
7-060	Training for conservation and sustainable use of reptiles in Togo	Habitat restoration	Also monitoring activities
7-113	Darwin Madagascar Wetlands Project	Carbon sequestration	Also livelihoods and monitoring activities
8-048	Conservation and sustainable use of medicinal plants in Ghana	Translocation – main aim of project	Also livelihoods activities
9-001	Renewing management of Sapo National Park and creation of the Liberian protected areas system	Habitat restoration: capacity building - Carbon sequestration	Also livelihoods activities
10-006	Propagation, nursery and establishment protocols for Seychelles endemic plants	Translocation	Classed as Small Island
11-001	Options for supporting on-farm conservation in Eastern and Southern Africa	Habitat recreation	
11-004	Conserving Kenya's indigenous forests through certification of sustainably sourced woodcarvings	Carbon sequestration	Also livelihoods activities
12-008	DNA banking phylogeny and conservation of the South African flora; EIDPO13- Integrating Evolutionary History and Phylogenetic Measures of Biodiversity into Conservation Planning	Translocation *Ex-situ* conservation	Also monitoring activities
13-008	Establishing community-based forest biodiversity management around Sapo Park, Liberia	Carbon sequestration	Also livelihoods activities
13-031	Pioneering an innovative conservation approach in Sierra Leone's Gola Forest	Other adaptation activity: participatory management prog. using a conservation concession strategy	Also livelihoods and monitoring activities
13-033	Combating Invasive Alien Plants Threatening the East Usambara Mountains in Tanzania	Carbon sequestration	Also monitoring activities
14-001	Conservation and Monitoring of Meso-American Orchids	*Ex-situ* conservation	Also monitoring activities
14-009	Biodiversity Monitoring in Forest Ecosystems in Bale Mountains National Park, Ethiopia	Carbon sequestration	Also livelihoods and monitoring activities
14-033	Darwin Training Programmes for Integrated Protected Area Management, Ghana	Carbon sequestration	Also livelihoods activities
14-049	Participatory Management of Priority Biodiversity Sites in Taraba State, Nigeria	Carbon sequestration	Also livelihoods and monitoring activities
14-056	Cryoconservation Centre of Excellence for Sub-Saharan Africa	*Ex-situ* conservation	Also monitoring activities
15-003	Conservation of Biodiversity in Traditional West African Vegetable Species	*Ex-situ* conservation Habitat recreation	Also monitoring activities
15-009	Investing in Island Biodiversity: Restoring the Seychelles Paradise Flycatcher	Translocation Habitat restoration	Classed as Small Island
15-031	Novel and Practical Conservation Strategies Following Mining in Sierra Leone	Habitat recreation and restoration	

Project No.	Title	Adaptation & Mitigation	Comments
15-035	Ex-situ Conservation of the Rare and Threatened Plants of Mauritius	Translocation *Ex-situ* conservation Habitat restoration	Classed as Small Island
15-038	Restoring Island Biodiversity: the Reintroduction of Endemic Mauritian Reptile Communities	Translocation Habitat restoration	Classed as Small Island

Table 10 Sub-Saharan African Projects with Adaptation and Mitigation Activities

2.5 Monitoring

Many DI projects are involved in undertaking baseline surveys. These are an important first step in establishing any longer-term monitoring programmes, which can contribute to the detection and attribution of climate (and other) ecosystem changes (Section 1.4). Given the short-term nature of DI projects it is difficult for them to initiate this longer-term monitoring, but some projects have managed to leave this legacy.

The Darwin projects were assessed to see if they contained monitoring activities. These data showed that 58% of projects do include some monitoring activities (Table 11).

Monitoring	Total	%
Yes	141	57.6
No	104	42.4
Total	**245**	**100.0**

Table 11 Projects Involving Monitoring Activities

Mountains and monitoring

Nine projects (4-213; 8-116; 10-011; 11-025; 12-007; 13-003; 14-009; 14-019; 15-027) include some form of monitoring, although in several cases this seemed to be confined to completing baseline surveys. For example, Project 10-011 objectives were revised when it became apparent that there was little or no baseline information available for the forest resources and biodiversity status of Van Ban District, Vietnam. Therefore the strategy of the project was altered to concentrate on developing good baseline information, including the use of remotely sensed data, which could, in the future, inform the management and monitoring decision making processes. One of the best examples of monitoring is project 14-009 in the Bale Mountain National Park, but as its primary focus is forest ecosystems it is dealt with under this section.

Forests and monitoring

The CBD COP6 Decision VI/22 invited the UNFCCC, IPCC, IGBP and the MEA to enhance collaboration in research and monitoring activities on forest biological diversity and climate change, and to explore the possibilities of establishing an international network to monitor and assess the impact of climate change on forest biological diversity. Goal 3 Objective 3 of this decision (taking account of the work of the AHTEG on Climate Change and Biodiversity) included to “Promote monitoring and research on the impacts of climate change on forest biological diversity and investigate the interface between forest components and the atmosphere”. DI projects could contribute to this if the necessary co-operation across bodies could be achieved, clear monitoring objectives and protocols were established, sites were secure and long-term funding forthcoming.

A number of DI projects mention monitoring, although the details of the monitoring were not always available. Generally it has been undertaken to inform research and conservation needs (14-009), to ascertain the impacts of management (7-040), effectiveness of restoration (11-012; 15-016) and as a means to identify changes from baseline surveys (15-027).

Project 14-009 in the Bale Mountains National Park (BMNP) has an important monitoring component. BMNP is the largest area of Afro-Alpine habitat in Africa and one of the most important centres of biodiversity and endemism on the continent. The Harenna Forest has the most diverse ecosystem within the Park and includes the most extensive tract of intact forest in Ethiopia. It is also one of the most threatened areas, due mainly to conversion to agriculture and removal of timber for construction/fuel for the expanding urban population of the region. The Annual Report points out that to date, monitoring of the park biota has been largely driven by externally funded research projects and so has been opportunistic, fragmented and biased to few taxa. Almost no monitoring has been done in the forest, despite the serious nature of the threats and the presence of many Ethiopian endemics (7 bird species and 7 mammal species), the endangered Bale monkey (*Cercopithecus (a.) djamdjamensis*), forest lions and hunting dogs. The researchers are working with local Park staff to develop protocols for monitoring the forest systems in the park, to prioritise and implement research needed to assess threats in the forest, and to support the development of Sustainable Resource Management agreements with communities living in the Harenna Forest by providing information about the traditional management system that was place in the forest in the past and by providing dissemination material about the forest, its resources and threats to its sustainability. The monitoring programme is seen to be more sustainable because a wider group of stakeholders contributed to it and it is incorporated formally in the park’s management policy and short-term action plans, but given current conditions in Ethiopia, it is unlikely that BMNP will be able to implement its monitoring programme without external financial support.

Project 15-016, mentioned above, is focused on the effectiveness of restoration and is developing and disseminating technology for habitat restoration to protect biodiversity and combat desertification and increase understanding of dry forest ecosystem dynamics and biodiversity. This requires baseline surveys and subsequent monitoring of the habitat restoration areas, including plant recruitment, seedling growth, biodiversity (plants, birds, reptiles and ants). There is also an emphasis on training in monitoring, with workshops to build local capacity, so that the work can be continued independently.

Many projects seek to devise and implement conservation-oriented management plans (7-040; 11-012; 14-025; 15-027) and where livelihoods are concerned too this may involve aspects of sustainable development (15-016). Guides for conservation management may also be produced and these may be in terms of specific actions, such as the management of living conservation plant collections and the propagation of threatened endemic plants (11-102) or the management of the databases generated as a result of data collection.

Project 7-040 was particularly concerned about management and aimed to "evaluate changes in butterfly communities following selective logging, to determine appropriate management responses and to leave a legacy of trained local personnel, thereby promoting ecologically sensitive management and enabling essential long-term monitoring." Also it sought to determine appropriate management responses to changes in forest structural, floral and faunal characteristics following selective logging and it provided guidelines for management of protected areas.

Several projects talked about adaptive management (14-025; 15-016) in response to ongoing results and could be considered to have the potential to take on board necessary alterations for climate change, but it would be difficult to pick up any climate change signal in short-term projects.

Coastal and Marine and monitoring

Twenty-nine of the coastal and marine projects incorporated monitoring activities. Almost all of these projects involve surveying the habitats and producing distribution and diversity maps. Many projects aimed to set up routine monitoring operations. As part of establishing this monitoring a significant number of these projects (at least 13) include preparation of inventories, identification guides and educational material and staff training on how to conduct monitoring activities. These monitoring data will be used to assess the situation, analyse changes and examine how interventions affect the area.

Project No.	Title	Monitoring	Comments
3-018	Conservation of Coral Reef Fish Biodiversity	Train Marine Park staff to monitor fish populations and coral reef fish biodiversity	SSA
3-137	Biodiversity in Malaysian Mangrove Forest	Assess the effects of mangrove tree species diversity, root structural complexity and tree productivity on marine biodiversity	
4-151	Marine Biodiversity and Resources Use Surveys in Northern Mozambique	Survey and map marine habitats and resource use patterns of the inshore coastal zone	
4-156	Conservation of Coral Reef Biodiversity in Sri Lanka	Survey and monitoring biodiversity of fish and invertebrate populations and reef conditions in important sites for ornamental fisheries. Establish co-operative data collection and monitoring schemes.	
5-077	Coastal Resources and Environmental Management Training in Eritrea	Train staff to carry out species identification and marine habitat surveys.	SSA
6-173	Protected Areas Management Planning in the Andaman Islands, India	Produce biodiversity inventories for key taxa, species distribution maps and species conservation reports for globally threatened species; to strengthen capacity to plan and conduct biodiversity surveys, monitor key species population, and evaluate survey and monitoring data.	SI Carbon sequestration Also livelihoods
7-045	Marine biodiversity capacity building in the West African sub-region	To provide West African scientists who can identify, catalogue and map marine biodiversity	SSA
7-055	Marine environmental training in Seychelles and Mauritius	Training in biodiversity assessment (manual produced), marine science research techniques, taxonomy, resource management and conservation	SI

Project No.	Title	Monitoring	Comments
7-104	Coral reef biodiversity in the Caribbean - schools project and resources	Dissemination of educational materials on coral reef status & biology	SI
7-115	Ecology and conservation of the endemic St Helena wirebird	Research and monitoring studies to quantify the current status of the population and assess threats to the long term survival of the St Helena wirebird	SI
8-253	Invertebrate Diversity and Endemism at Gough Island and Threats from Introduced Species	Train local scientists to characterise and evaluate the threatened invertebrate biodiversity of the island; to carry out survey work to establish the current status of indigenous and introduced species and factors which threaten their survival. Train research assistants in sampling techniques, identification and preservation of samples.	SI
9-004	Plankton biodiversity: training, sampling, taxonomy and data evaluation in Seychelles & Mauritius	To identify interactions between huemul and forestry exploitation, livestock and other ungulates (guanaco). To assess seasonal and diurnal movement patterns. To obtain estimates for rates of recruitment and adult survival, so as to identify the causes of population changes and individual animal mortality.	SI
9-006	Towards Sustainable Development of southeastern Madagascar's biologically unique littoral forests	Define a biodiversity monitoring and conservation strategy. Train staff in biodiversity measuring and mapping techniques, and integration of aerial remote sensing data and GIS. Map and analyse the structure and community composition of forest fragments; provide a detailed database of plant species	Also forest SSA Also livelihoods
10-005	Conservation of the African penguin (Spheniscus Demersus)	Establish a long-term monitoring programme, carrying out annual censuses on the penguin's breeding grounds. Develop new technology for penguin monitoring; analyse trends from earliest available count data; resighting programme.	SSA
10-020	Phyllosoma larvae of the Cape Verde Islands	Training on morphology and identification of phyllosomas. Produce a key to phyllosomas to facilitate research	
10-021	Madagascar Marine Biodiversity Training Project	team of expertise created with skills to collect marine baseline data, and to manage and monitor resources through implementation of a long-term monitoring plan; identification of permanent monitoring sites	SSA
11-017	The Effect of Macroalgal Overgrowth on the Growth Rate and Survival of Coral Recruits in Honduras	To incorporate data on coral algal competition and the temporal/spatial dynamics of free space on coral reefs into coastal zone management strategies for Roatán	
12-018	Climate change and conservation of Galápagos endemic bird species	Monitoring of bird populations in reference to climate, direct and indirect anthropogenic impacts	SI
12-033	Blue Forests: Sustainable Farming of Coral Reefs, Fiji, Solomon Islands	Baseline surveys of no-take zones	SI Also adaptation & livelihoods
13-010	Living Reefs: Community-Based Coral Reef Management In The Pacific	Baseline monitoring surveys conducted and re-sampled	SI Also livelihoods

Project No.	Title	Monitoring	Comments
13-013	Establishing biodiversity monitoring networks to inform Estonian coastal wetland management	Biodiversity indicators and monitoring stations for coastal wetland ecosystems established. Effective practice and monitoring plans (including key biodiversity indicators) disseminated.	Also livelihoods
13-014	Capacity building in mammal management for Western Cape nature reserves	Increased capacity for mammal surveying and management through staff training. Enhanced and updated CMZ monitoring and records.	Classed as mixed SSA
14-006	Conservation of Small Vertebrates in the Tsingy Bemaraha National Park, Madagascar	Training in fieldwork surveys, implementation of a new monitoring programme	Mixed (also wetland & mountains) SSA
14-007	Community Action for Sustainable use and Conservation of Coral Reefs, Malaysia	Reef biodiversity monitoring programme established and functioning	Also livelihoods
14-020	Network of Locally Managed Marine Protected Areas in Solomon Islands	Biological and socio economic data collection and analysis	SI Also livelihoods
14-048	Galápagos Coral Conservation: Impact Mitigation, Mapping and Monitoring	Improved baseline knowledge of northern GMR coral reefs.	SI Also adaptation
14-057	Conserving Coral Reefs Through Community Ownership and Enterprise in Indonesia	Research on ecological carrying capacity	Also livelihoods
15-005	Conservation of the Mangrove Finch (Cactospiza heliobates)	Field research programme: establish basic ecology of species (Mangrove finch)	Also adaptation
15-025	Quantification and Elimination of Threats to the Caspian Seal	Strengthen ability to identify, monitor and manage present and future threats to the Caspian seal. Estimates of population size, movement & habitat usage, health status, diet, genetic structure, & climate change response model.	

Table 12 Coastal and Marine Projects Incorporating Monitoring Activities

Wetlands and monitoring

Fourteen of the wetlands projects incorporated some monitoring activities (e.g. 3-095; 4-197; 7-135; 14-006). A number of these projects were concerned with inventory and evaluation of sites, for example 14-035 (Strengthening Pro-Poor Wetland Conservation using Integrated Biodiversity and Livelihood Assessment, Cambodia and Tanzania); 6-081 (Bogs of Tomsk Province); 15-002 (Integrating Crane Conservation with Sustainable Habitat Utilisation); 14-017 (Tool-kits for the Sustainable Management of Ghana's Riverine Biodiversity) used monitoring to produce a nested set of indicators of ecosystem health; 7-113 (Darwin Madagascar Wetlands Project) used monitoring to assess the status of and threats to biodiversity in the Lac Sahaka wetland system; and 12-019 (Sustainable Management of the Rupununi, Guyana) ran a field research programme to produce an eco-hydrogeomorphic classification of habitats with identification of landuse types. Project 13-001 (Conservation of wetlands and associated biodiversity in Northern Zambia) set up monitoring for protection of water levels and hydrological flow pathways in key wetland habitats.

Three projects were specifically monitoring projects: 11-002 (Monitoring biodiversity for site management planning in eastern African) which established the Eastern African Wetland and Waterbird Monitoring Scheme (EAWMS). Project 11-003 (Kenyan Important Biodiversity Areas: Improving monitoring, management and conservation action/EIDPO7 Ensuring legacy and conservation impact within Kenya's biodiversity monitoring network) aimed to establish and co-ordinate an effective, sustainable monitoring system at 60 Important Bird (Biodiversity) Areas (IBAs) throughout Kenya. Project 14-029 (Monitoring and Simulating Threats to Aquatic Biodiversity in the Okavango Delta) involved the following monitoring activities: acquisition of extensive baseline aquatic biodiversity and water quality data across hydroperiod gradients in Okavango Delta; development of robust Indices of Biological Integrity (IBIs), sensitive to hydroperiod; development of future scenarios of Okavango Delta flood frequency, extent and duration and biodiversity response; and establishment of on-going systematic biodiversity monitoring programme based on identified IBIs. This information will be crucial to informing policy decisions for biodiversity protection/conservation within the Okavango Delta Management Plan.

Sub-Saharan Africa and monitoring

35 projects are involved with monitoring with a further seven concerned with capacity building.

One of the best examples of monitoring is project 14-009 in the Bale Mountain National Park, but as its primary focus is forest ecosystems it is dealt with under this section. The monitoring is usually undertaken to establish baseline data for biodiversity and conservation. One example is the project 14-029 "Monitoring and simulating threats to aquatic biodiversity in the Okavango Delta" as described in the previous paragraph.

The need to balance conservation with the sustainable use of wildlife resources was a focus of several projects and thus overlap with livelihoods. For example, in project 9-015 the issue was the unsustainable hunting quotas for lion the population of Hwange National Park, Zimbabwe, while 10-003 aimed to assist a community living adjacent to Maasai Mara National Reserve, Kenya to develop sustainable utilisation of wildlife, including through ecotourism.

Arctic and monitoring

The one project based in the Arctic region (3-024) was concerned with the impact of atmospheric pollution on tundra vegetation in the Russian Arctic. This project used satellite remote sensing data to measure biodiversity of vegetation species, and to assess the impact of industrial pollution on the tundra vegetation. This project did not involve any adaptation or mitigation activities but clearly focused on monitoring. The project also aimed to build capacity by developing a close collaboration between Moscow State University, the World Conservation Monitoring Centre and the University of Cambridge.

Case Study - 15-033 Monitoring Bat Biodiversity: Indicators of Sustainable Development in Eastern Europe

This project develops bat monitoring programmes in two countries in Eastern Europe in order to generate long-term data on biodiversity indicator species to assess the impact of national development and global change, including assessing the impacts of the changes in climate. Working with the existing bat and other wildlife conservation organisations in Romania and Bulgaria and using the expertise of The Bat Conservation Trust and The Zoological Society of London in the UK, the project have established novel ultrasonic acoustic monitoring techniques to detect selected bat species using echolocation calls along road networks. By training existing personnel in monitoring protocols and equipment use, they have developed sustainable volunteer monitoring networks able to generate long-term data on changes in bat biodiversity. The baseline data collected initially on bat abundances, distributions and environmental and habitat associations will be used to model currently suitable habitat and climate envelopes. These can be used to generate predictive models of abundance and distribution under different future scenarios of global change.

Bat population data collected over the forthcoming years will serve as indicator measures of biodiversity change allowing national policy makers to make informed decisions on effect of anthropogenic and climate change on their biodiversity.

This project brings together a unique partnership between conservation groups in two transitional countries, the volunteer development and biodiversity monitoring strengths of The Bat Conservation Trust and the scientific expertise of the Zoological Society of London, to leave a sustainable legacy of national monitoring programmes that meet the Convention on Biological Diversity's (CBD) fundamental obligations. This also forms part of a larger global initiative to develop bat monitoring programs (as indicators of global change) all over the world (see Indicator Bats Program http://www.ibats.org.uk) - using citizen networks to deliver science and conservation.

3. Climate Change, Sustainable Livelihoods and Biodiversity

Predicting environmental change and its impacts on human well-being at local to global scales remains a significant challenge for the international scientific community (MEA, 2005). Our understanding of the biophysical and anthropogenic processes transforming the earth's land, oceans and atmosphere and quantifying how such processes impact upon human health and security are limited. This is due largely to the fact that the Earth is made up of complex, interactive and non-linear dynamic systems that are often unpredictable. For instance, although climate and natural resources have significantly shaped the development of civilizations throughout history, human society now impacts and, in many examples, dominates the regulation of our climate, the biogeochemical cycling of materials and biodiversity, which are essential to life itself. Uncertainty on the interactions and feedback between the natural and human drivers of environmental change that may operate at different spatial and temporal scales, make it difficult for societies to resolve an appropriate course of collective action to pursue sustainable livelihoods.

Many recent studies on ecosystem-society interactions recognised that important relationships exist between people, biodiversity and ecosystems. That is changing human conditions drive, both directly and indirectly, changes in biodiversity and ecosystems, and ultimately changes in the services ecosystems provide (MEA, 2005). However to capture the social and ecological dynamics, the human dependence on the capacity of ecosystems to generate essential services, and the considerable importance of ecological feedbacks for societal development suggest that social and ecological systems are not merely linked but rather interconnected (Galaz *et al.*, 2007) or that relationship between social and ecological system is based on mutual partnership and not domination over each other. To emphasize such a concept of humans-in-nature Berkes and Folke (1998) have coined the term social-ecological system (SES).

The Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change has reported that developing countries in the lower latitudes, and especially seasonally dry and tropical regions, are expected to suffer significantly from the negative impacts of climate change and variability (IPCC, 2007b). This situation arises mainly through the weak adaptive capacity of human, institutional and financial systems in developing countries to respond to the direct and indirect impacts of climate change. Projected climate variability is expected to increase the frequency of droughts and floods that will have direct effects on water resources, human health, fisheries, crop production and food security. For example, most Africa countries are highly dependent upon agriculture for jobs, national income and export earnings making them very vulnerable to climate change. It is projected that by 2020, up to 250 million people in Africa will be exposed to increased water stress, adversely affecting crop yields and exacerbating malnutrition in the continent. Many Defra DI projects work in 'Biodiversity Hotspots', regions identified as having exceptional levels of endemic plant biodiversity, but suffering serious levels of habitat loss through anthropogenic transformation of the landscape, such as logging and deforestation (Myers *et al.*, 2000). It is crucial, therefore, that strategies for increasing the resilience of SESs to climate variability and extreme events are devised and implemented.

The DI projects were reviewed for livelihood activities, with 38% found to include some livelihood activities (Table 13).

Livelihoods	Total	%
Yes	92	37.6
No	153	62.4
Total	**245**	**100.0**

Table 13 Projects Involving Livelihood Activities

Mountains and livelihoods

Six projects contain components that address the livelihoods of local people (3-063; 8-116; 12-007; 14-019; 14-021; 15-001). The most explicit one is “Bees, biodiversity and forest livelihoods in the Nilgiri Biosphere Reserve, India” (15-001).

This project, for example, seeks to elucidate the interdependencies between bees, biodiversity and forest livelihoods in the Nilgiri Biosphere Reserve. The indigenous bees of the mountainous Nilgiri Biosphere Reserve are known to play an important role in local livelihoods, yet the bees have not been scientifically identified or classified, their populations and distributions are unknown, and their vital role in pollination and the maintenance of forest biodiversity has not been studied. This project seeks to combine scientific data about the status of these indigenous bees and their ecology, with participatory livelihoods analysis. Again there is no specific climate change component and at the moment knowledge is probably inadequate for its incorporation.

DI Projects: Extended Case Study – Forests and sustainable livelihoods

Madagascar, as much of sub-Saharan Africa, suffers from highly variable and unpredictable climate. Human societies, as well as the natural ecosystems upon which they depend, have evolved and adapted to cope with this to some degree since humans populated the island some 2000 years BP. In Madagascar, human activities are recognised to be an integral component of most landscapes and, thus these landscapes may be considered as social-ecological systems (SESs). In the SES of southeast Madagascar, the littoral forests provide important ecological services for local communities, including food, energy, medicines and construction materials. Indeed, for many of the rural poor, these forests act as a critical safety net during times of shock, for example, crop failure arising from extreme climate events, such as drought or during seasonally ‘lean’ periods. Assessing the sustainability of natural resource use requires resolving appropriate spatial and temporal scales for establishing a baseline assessment.

The DI project number 9-006, working in the littoral forest ecosystems in south eastern Madagascar, near the township of Fort Dauphin (entitled ‘Sustainable development of Madagascar’s biologically unique littoral forests’) had undertaken a synthesis of remote sensing techniques at multiple spatial and temporal scales.

This was combined with climatic data and information collected during ecological field surveys within a SES framework analysis to decouple natural variability from anthropogenic processes.

In the context of rural communities and natural resources management in the littoral forests, global climate change is considered an external (exogenous) and unremitting pressure (chronic) to the social-ecological system. It is helpful to understand this pressure so that management strategies can be devised to stem degradation and deforestation of the forests.

Drought and cyclones would also be exogenous events, but would be classified as transient (although they could potentially be exacerbated by chronic climate change). Internal (endogenous) pressures on the system includes processes such as harvesting for fuel-wood or construction purposes by local people or forest clearance for charcoal-making by itinerant groups of people.

The long-term selective use of forest resources could be chronic in nature whereas a large-scale forest clearance event would be transient.

Both types of events can negatively affect both ecosystem functioning and biodiversity, which may compromise the ability of the natural forest system to provide essential ecological goods (fuel-wood, wild food, medicines) and/or vital ecological services (soil stabilization for erosion prevention, windbreaks or water filtration).

The forests were already fragmented and degraded to varying degrees across the study area. The project had established fixed plots in several of the fragments; to determine plant and tree species composition and to provide Diameter at Breast Height (DBH) measurements for validation of the satellite-derived degradation map (Figure 5) (Ingram *et al*., 2005a).

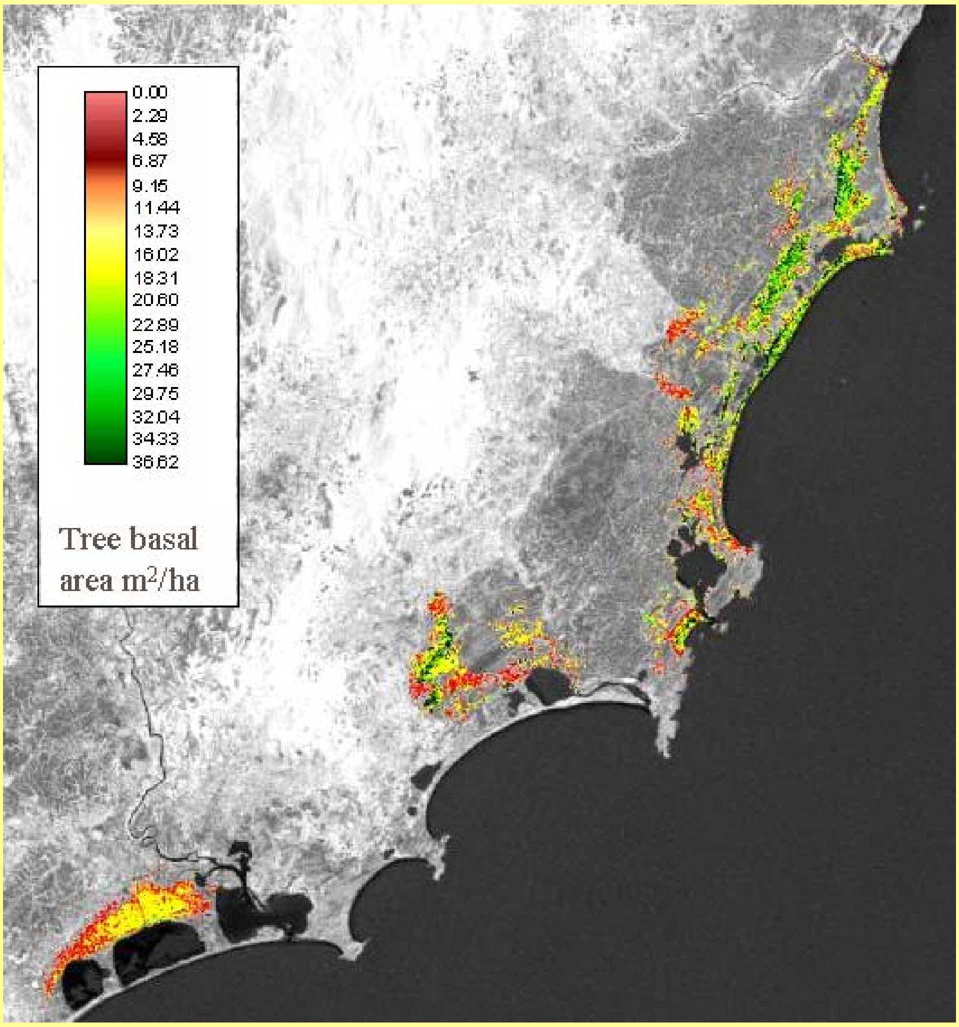

Figure 5 **Satellite-derived map of forest fragmentation and degradation in south eastern Madagascar (from Ingram *et al*., 2005a)**

The inventories confirmed the importance of the majority (>84%) of the tree species as being of utilitarian value to the local communities (Figure 6) (Ingram *et al*., 2005b).

The study had drawn on an extensive satellite data set spanning 23 years (1984-2007) to evaluate vegetation cover for the whole of Madagascar using a vegetation index (the Normalised Difference Vegetation Index, NDVI, see Tucker, 1979), which was monitored for each month over the period.

A number of previous studies have reported strong correlations between times series analysis of NDVI and temperature (Clark *et al.* 2003), precipitation (Schuur 2003) and El Niño/Southern Oscillation (ENSO) events (Anyamba *et al*. 2001).

The project used the Japan Meteorological Agency (JMA) ENSO index, which is based upon sea surface temperature (SST) anomalies in the Pacific Ocean for identifying variability in the ENSO cycle (Meyers *et al*. 1999).

A Pearson's correlation co-efficient of the two year mean of the JMA index values with the mean October forest NDVI values was very strong for the entire time period ($R = -0.80$, $p<0.01$, $n=17$) and negative as have been reported for other ENSO events and East African NDVI anomalies (Ingram and Dawson, 2005).

ENSO events result in variable climatic conditions and extremes, both temporally and spatially, making it difficult to predict categorically the impacts such events will have on ecosystems and the human communities living within them. For example, the El Niño of 1982/1983 produced devastating droughts in southern Africa and Australia while the 1997/1998 El Niño produced flooding in east Africa and droughts in Indonesia (Jury *et al.* 2001).

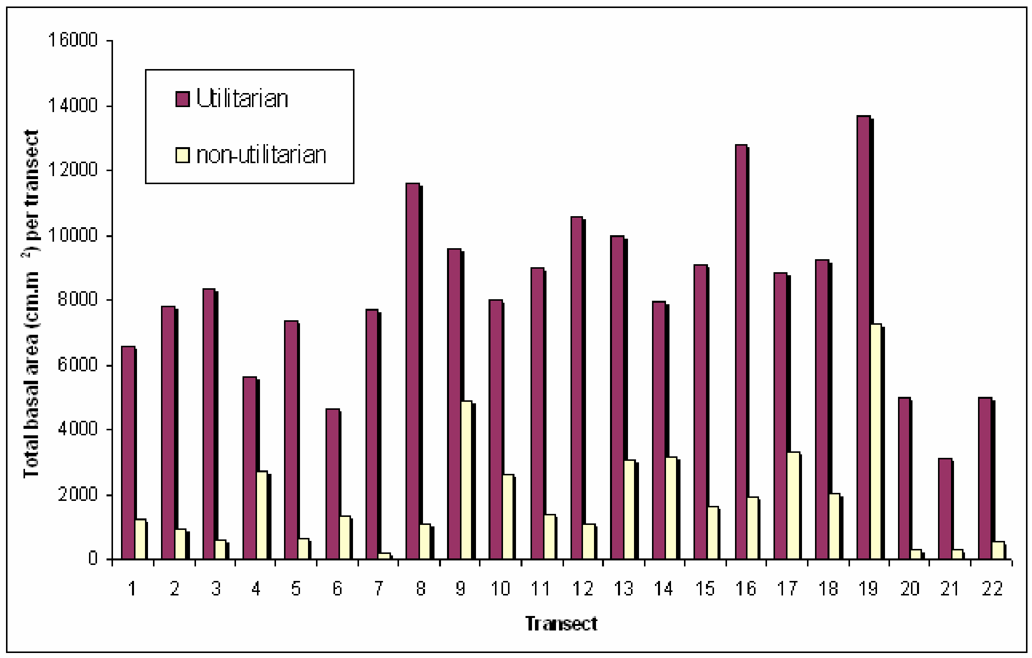

Figure 6 **Utilitarian versus non-use species of trees for 22 transects surveyed in the fragmented forests of southeast Madagascar (from Ingram *et al.*, 2005b)**

Both had a negative impact on vegetation and local livelihoods. Zinke *et al.* (2004) demonstrated that the impact of ENSO cycles in the region of the south-western Indian Ocean had changed significantly since 1970 and related this effect to a warming of south-western Indian Ocean surface waters.

Their findings also support other studies that have shown a significant impact of El Niño on south-western Indian Ocean sea surface temperatures and rainfall variability since 1960.

The results presented here are only a preliminary exploration of the relationship between inter-annual climate change and vegetation response within Madagascar.

Nevertheless, this study demonstrates that climate is a dominant, highly variable exogenous pressure influencing the SESs that are underpinned and supported by forest ecosystem productivity.

Marine and coastal habitats and livelihoods

Twelve of the coastal and marine DI projects reviewed involved livelihood activities. Of these seven were based on small islands, one in sub-Saharan Africa and one in an Asian megadelta. Five projects were concerned with coral conservation, two with coastal wetland and one with littoral forest.

Project No.	Title	Livelihoods	Comments
6-173	Protected Areas Management Planning in the Andaman Islands, India	Participative project planning to develop management plans for three protected areas where there is a need to integrate conservation, rural development and tourism.	SI Carbon sequestration Also monitoring
7-006	Assessing the status of Ascension Island green turtles	To establish a sustainable eco-tourism industry so that the green turtles can be used to generate revenue for the local population	SI
8-176	Coral Reef Conservation in Fiji	Participatory community approaches to conserve coral reefs and their associated biodiversity by managing land based sources of pollution, particularly wastes containing nutrient loadings	SI
9-006	Towards Sustainable Development of southeastern Madagascar's biologically unique littoral forests	Stakeholder involvement and workshops	Also forest SSA Also monitoring
12-010	Empowering the people of Tristan da Cunha to implement the CBD/EIDPO23 Enabling the people of Tristan to implement the CBD in the marine environment	To increase local people's control, ownership and involvement in implementing the CBD. Conservation priorities identified on grounds of livelihoods (utility) as well as science. Train local people to participate in the plan as far as possible.	SI
12-033	Blue Forests: Sustainable Farming of Coral Reefs, Fiji, Solomon Islands	Compile Market information and economic weak points of the coral trade	SI Also adaptation and monitoring
12-034	The Darwin Southeast Asian Wetland Restoration Initiative, Vietnam	Scientific and socio-economic databases of wet-land biodiversity and values	Also wetland. AMD Also adaptation
13-010	Living Reefs: Community-Based Coral Reef Management In The Pacific	Community-based coral reef management established in Kiribati, Tuvalu and Vanuatu	SI Also monitoring
13-013	Establishing biodiversity monitoring networks to inform Estonian coastal wetland management	People network and monitoring sites established and integrated for sustained monitoring programme. Educate and publicise (building stakeholder network, informing wetland management)	Also monitoring
14-007	Community Action for Sustainable use and Conservation of Coral Reefs, Malaysia	Mariculture and Sea Ranching Programme developed and operational. Socio-economic monitoring programme established and functioning	Also monitoring
14-020	Network of Locally Managed Marine Protected Areas in Solomon Islands	Biological and socio economic data collection and analysis. Identification & estab. of pilot sustainable income generating projects appropriate to target communities	SI Also monitoring
14-057	Conserving Coral Reefs Through Community Ownership and Enterprise in Indonesia	New supply chain developed. MAC certified fishermen and exporters	Also monitoring

Table 14 Coastal and Marine Projects with Livelihoods Activities

Ten of the projects involved participatory approaches to conservation and sustainable use of resources (e.g. 6-173 Protected Areas Management Planning in the Andaman Islands, India;; 12-034 The Darwin Southeast Asian Wetland Restoration Initiative, Vietnam; 14-007 Community Action for Sustainable use and Conservation of Coral Reefs, Malaysia), while the tenth trained locals to monitor wetlands (13-013 Establishing biodiversity monitoring networks to inform Estonian coastal wetland management). For more information about project 9-006 Towards Sustainable Development of southeastern Madagascar's biologically unique littoral forests, see the extended case study.

Project 12-010 (Empowering the people of Tristan da Cunha to implement the CBD/EIDPO23 Enabling the people of Tristan to implement the CBD in the marine environment) put livelihoods at the centre of project aim and activities. This project set out to increase local people’s control, ownership and involvement in implementing the Convention on Biological Diversity in Tristan da Cunha. Conservation priorities were identified on the grounds of livelihoods (utility) as well as science. Local people were trained to participate in the plan as far as possible and enabled and encouraged to make informed decisions leading to sustainable use of resources.

Project 8-176 (Coral Reef Conservation in Fiji) aimed to conserve coral reefs and their associated biodiversity by using participatory community approaches to managing land based sources of pollution, particularly wastes containing nutrient loadings. The project raised awareness among communities of the importance of coral reefs and the implications of water and waste management on the marine environment and encouraged the community to initiate simple waste management innovations. To achieve this they trained community members in reef monitoring; ran Participatory Learning and Action workshops and produced a book called 'Locally-managed marine protected areas toolkit: a guidebook for coastal resource managers and conservation practitioners'.

Project 14-020 (Network of Locally Managed Marine Protected Areas in Solomon Islands) aimed to support Solomon Islands’ peoples to maintain marine biodiversity and fisheries productivity within the Solomon-Bismarck Sea Ecoregion through appropriate resource management practices such as development of new community managed MPAs and sustainable income generating projects appropriate to target communities. Participatory Rural Appraisal and awareness raising were conducted initially so that communities have a greater understanding of the status, conservation and management of their marine resources and are empowered to manage near shore marine resources for subsistence and artisanal uses. (MTR) Project 14-057 (Conserving Coral Reefs Through Community Ownership and Enterprise in Indonesia) used a participatory approach to develop an integrated coastal management plan and establishing a sustainable fishery enterprise – based on Marine Aquarium Council standards to certify 150 community members in sustainable fishery management while conserving threatened marine biodiversity of Bali Barat National Park and neighbouring buffer zone.

Wetlands and livelihoods

Eleven wetlands projects were classified as having some livelihood activities, e.g. 3-095; 4-197; 6-151; 7-113 (Darwin Madagascar Wetlands Project); 12-019; 12-034 (see coastal livelihoods section); 15-002 (Integrating Crane Conservation with Sustainable Habitat Utilisation).

Project 15-014 (Managing Wetlands for Sustainable Livelihoods at Koshi Tappu) established the Darwin Centre for Wetland Management for Sustainable Livelihoods in Nepal.

Project 12-016 (Indigenous methods to sustainably manage riverine plantations, Amazon region) studied the mythology and rituals behind the indigenous techniques of forest and plantation management in the periodically flooded regions of the Amazon in Colombia, Brazil and Peru and produced educational material usable by indigenous personnel as well as other members of the local communities/institutions.

Project 13-001 (Conservation of wetlands and associated biodiversity in Northern Zambia) trained local staff and held conservation and natural resource management activity workshops at Kasanka Research Centre.

Project 14-035 (Strengthening Pro-Poor Wetland Conservation using Integrated Biodiversity and Livelihood Assessment) produced electronic databases and maps identifying key sites of overlap between threatened species and high livelihood dependence.

Sub Saharan Africa and livelihoods

There are 40 projects in sub-Saharan Africa which include livelihoods activities (about a third of the projects based in this geographical region). Priority habitat types are well represented in these projects (3 coastal and marine, 6 wetlands, 10 forests, 4 in mountains and 8 in semi-arid regions).

These projects vary in the level of engagement with livelihoods, some simply involve stakeholder workshops and awareness-raising in local communities and schools (e.g. 9-006) while a good number incorporate training to strengthen local capacity (e.g. 6-054; 12-001; 13-001). An example of this type of project is 14-033, Darwin Training Programmes for Integrated Protected Area Management, Ghana, which aims to build the capacity to deliver effective training programmes to improve community liaison and biodiversity protection around Ghana's protected areas. Project 13-019, The Greater Maasai Mara Community Scout Programme, similarly aims to empower Maasai communities to monitor and protect natural resources and manage human-wildlife conflict, and thereby improve local livelihoods.

Sustainable conservation is the main aim of a group of projects; for some livelihoods are addressed mainly to better the prospects for conservation by improving levels of community awareness and involvement. Examples include project 6-151, Biodiversity Survey of the Akagera National Park, Rwanda; 15-012, Protected Key South African Biodiversity Sites Through Community Based Conservation.

Other projects go further and aim to foster participatory conservation. For example, 16-010; 14-049, Participatory Management of Priority Biodiversity Sites in Taraba State, Nigeria; 5-174, Chameleons, Conservation and Local Communities in Madagascar; and 9-001, Renewing management of Sapo National Park and creation of the Liberian protected areas system. Project 12-007, Afi Mountain Wildlife Sanctuary Gorilla Research and Conservation Project (Nigeria), goes even further as it aims to empower the community to protect the fauna, flora and overall ecosystem functions through locally integrated and effective management without external assistance.

Poverty alleviation is a factor is a number of projects, for example, project 10-031, Biodiversity conservation in ancient church and monastery yards in Ethiopia, uses participatory conservation of the biodiversity of the forests preserved on sacred lands and their establishment as a resource of value to alleviate local poverty.

The link between conservation and sustainable rural livelihoods is a focus for a large proportion of the projects. Some involve the sustainable use of natural resources, for example, 3-047; 3-063; crop genetic resources in Zimbabwe in project 4-101; strengthening pro-poor wetland conservation using integrated biodiversity and livelihood assessment in East Africa in project 14-035; and sustainable timber harvesting in community forests in project 14-043. Project 13-008, Establishing community-based forest biodiversity management around Sapo Park, Liberia, aimed to ensure forest biodiversity conservation and sustainable rural livelihoods based on a working model of forest community empowerment and forest resource use. Another example of a project with a well integrated conservation and sustainable rural livelihoods strategy is 11-009, Painted Hunting Dog Conservation Through Education & Development, which aimed to promote the understanding among local people of the relevance of biodiversity to livelihoods; to move to local scale, sustainable income generating activities; to reduce snare related wild mammal, including hunting dog, mortality through an education and development based approach to conservation.

Tourism (and in particular ecotourism) as a contribution to sustainable rural livelihoods and sustainable conservation, is mentioned in five projects. These are: green turtles on Ascension Island in project 7-006; big cats in Southern Africa in project 9-015; 10-003 (see below); black rhino in NW Namibia in project 11-005; and 13-001.

The value of indigenous knowledge is recognised in three projects. These are: project 7-113, Darwin Madagascar Wetlands Project, which documented traditional management methods used by local people at Lac Sahaka; project 5-132, Integrating Traditional Resource Management & Conservation Strategies, Ethiopia, included a participatory rural appraisal programme to establish local community attitudes towards wildlife and to investigate prevailing sustainable communal land management of the area and local agro-pastoral systems. Project 14-050, Africulture Centre, focused on traditional healing and protection of biodiversity in the Eastern Cape, South Africa. They established a nursery to demonstrate sustainable resource management & foster the technical skills of traditional healers, small-scale agro producers, suppliers and informal traders using participatory principles and provided a forum for traditional healers to exchange & update informal health care practices.

Resolution of conflicts between conservation and community priorities was a central feature of four projects. These projects are 7-138; 6-131 and its continuation in 10-003, which dealt with protecting endangered wildlife and alleviating human-wildlife conflict in Maasai Mara Kenya. These two projects studied the scale and impact of two contrasting forms of human-animal conflict and identified ways of resolving these conflicts to the benefit of wildlife, local Maasai and tourists; it also investigated the perceptions of local Maasai towards these human-animal conflicts and integrate local attitudes and perspectives into long term solutions for conservation; and built a management plan for large mammal conservation that will provide a lasting benefit for local Maasai. The fourth conflict resolution project is 11-004, Conserving Kenya's indigenous forests through certification of sustainably sourced woodcarvings, which put in place an incentive to enable carvers to shift from traditionally preferred forest hardwoods to farm-grown or plantation species, thereby providing for sustainable livelihoods for carvers and tree owners.

4. Recommendations

This section makes recommendations for the future and potential contribution of Darwin Initiative projects to climate change issues.

4.1 The Contribution to an Understanding of Climate Change and Biodiversity

Climate change has played a minor role in DI projects and as a result they have made relatively little contribution to our understanding of climate change and biodiversity. Some of the few projects that have focused on climate change have, however, produced very relevant results.

A much wider, although still modest number of projects, have promoted activities that contribute to adaptation (20%) and mitigation (7%). They have shown in support of other research that adaptation and mitigation activities can be complementary, such as in the case of forest restoration and carbon storage and attention should be given to maximising these situations.

4.2 How have Climate Change Issues been Addressed in DI Projects?

The various climate change related activities are summarised at the end of each habitat and region in Section 3. These show how monitoring is fundamental to any project in order to establish a baseline from which to measure changes and, in some cases, to explore their natural or anthropogenic causes. Most of those that have such a climate change component are involved in setting up long-term monitoring for detecting/understanding the role of natural and human factors leading to change (e.g. 12-018 – Climate change and conservation of Galápagos endemic bird species; 14-048 Galápagos Coral Conservation: Impact Mitigation, Mapping and Monitoring; 15-024 Quantification and elimination of threats to the Caspian seal) and thus their value has yet to be realised. The ongoing project 14-022 Predictive Tools for Targeting Conservation Effort in Borneo Forest Reserves, Sabah, Malaysia has the potential to alert national and local conservation organisations of the need to take account of how climate change may interact with land-use changes to affect species distributions and, through the modelling undertaken, to develop tools for identifying existing reserves of high conservation value, and to determine how their value may change in the future. It is too early to say whether the protocols developed and the projections of reserve biodiversity will be adopted.

4.3 Recommendations to make DI Projects more Relevant to Climate Change

- **Provide guidance for projects:** Provide guidelines along with details of grant application on climate change and how it could be incorporated into projects (see below).
- **Contribute to long-term data sets:** Encourage projects to build upon any national or regional long-term ecological datasets where already available, or to establish baseline datasets. Alongside this, develop rapid assessment methodologies, or train para-taxonomists to continue to contribute to long-term databases.
- **Include climate change in planning:** Ensure that any management plans take into account any such projected climate (and other environmental) changes and their potential impacts, so that any plans have long-term viability.
- **Fill knowledge gaps:** Contribute to building up the knowledge base of climate change and biodiversity and assist in filling knowledge gaps identified by the IPCC. This will be particularly useful in situations where there is an insufficient ecological knowledge about the ecosystem, let alone potential climate change impacts at a local level (e.g. “Bees, biodiversity and forest livelihoods in the Nilgiri Biosphere Reserve, India, No. 15-001).

- **Focus on vulnerable habitats and regions:** Encourage the establishment of projects where there are sensitive, vulnerable or under-represented habitats, regions or species. These would in include the boreal and tundra habitats, and the Arctic and Asian megadeltas regions.

4.4 Guidelines for Incorporation of Climate Change issues into DI Projects

The following recommendations are suggested best practice for climate change adaptation that can be applied at the project scale. These have been drawn from the review and from the recent literature where relevant (e.g. Huntley, 2007).

Recommendations for adaptation for climate change

- **Re-evaluated protected area strategies to allow species mobility:** Management strategies for conservation must recognise the dynamic nature of species and their geographical ranges. This may well require a re-evaluation of the current and planned protected areas strategy for a project to ensure that there is a potential for mobility of species under a changing climate, for example through the removal of barriers and the establishment of corridors or 'stepping stones' within a wider landscape. This would involve local community participation in creating a landscape that can facilitate the dispersal of species. It should be noted that promoting connectivity, particularly the use of corridors is controversial as it may also facilitate the spread of invasive species. The principle is good and widely accepted but it is by no means clear what the best measures are for different species and situations. This is an area that requires further research and the adoption of a 'no regrets' approach to adaptation.
- **Strengthen populations of rare and endangered species:** Conservation strategies should look to increasing population numbers of rare and endemic species, for example, through habitat creation, enlargement or restoration. Maximising the numbers and geographical range of species is likely to increase their resilience to extreme events and rapid transient shocks, such as forest fires, that might cause local extinctions. Recognising and preserving meta-population dynamics will require connectivity between fragmented populations, further strengthening the connectivity argument above.
- **Adopt the ecosystem approach to conservation action:** Management strategies should use an ecosystems approach to conservation, which looks at ecosystems in a holistic manner and includes developing a stakeholder forum and applies adaptive management over space and time. This approach is useful because species are likely to individual response to climate change, with species from a community not necessarily moving synchronously and in similar directions. Thus communities are unlikely to move "en masse" and so it will be necessary to consider the connectivity and dynamics between a species, its food and habitat requirements, competition from other species or predator-prey relationships, as well as the role of people affecting the system under a rapidly changing climate. This also offers the opportunity to incorporate a more ecosystem service focused approach, thus further supporting the value of biodiversity to humans and their livelihoods.
- **Maintain maximum genetic diversity especially in leading and trailing edge ranges:** Genetic diversity is an important determinant of the ability of populations to effectively respond to climate change. Because climate change is projected to be a rapid process in evolutionary time-scales, conservation strategies must take into consideration the intra-specific gene pool in species populations and take steps to maintain genetic diversity. This might enhance the ability of species to autonomously adapt to climate change. Management strategies could take the form of creating or maintaining seed-banks or *ex-situ* conservation of species. It is important to preserve the genetic variation and differences between those species on the leading and trailing edge of their geographical range to increase the likelihood of a species' success in coping with climate change.

- **Promote landscape connectivity:** Darwin Initiative projects should take into account the wider landscape to ensure the continued protection of species and identify gaps in the network of existing protected areas. In particular, the creation of buffer zones around existing protected areas can enhance conservation effectiveness. It should be recognised that even degraded habitats are useful to maintain connectivity and mobility in species.
- **Explore climate change synergies in clusters of DI projects:** It is suggested that individual projects that are regionally located together might want to investigate opportunities to collaborate more closely for mutual sharing of the knowledge base and to strengthen advocacy for biodiversity protection within the region.
- **Contribute to National Adaptation Programmes of Action:** Darwin Initiative projects could see if they can contribute to National Adaptation Programmes of Action (NAPA) being produced by host countries under the UNFCCC. NAPAs provide a process for Least Developed Countries (LDCs) to identify priority activities that respond to their urgent and immediate needs with regard to adaptation to climate change. The rationale for NAPAs rests on the limited ability of LDCs to adapt to the adverse effects of climate change. In order to address the urgent adaptation needs of LDCs, a new approach was needed that would focus on enhancing adaptive capacity to climate variability, which itself would help address the adverse effects of climate change.
- **Incorporate climate change into biodiversity threat analyses:** DI projects should seek to identify the pressures on biodiversity, including climate change, and to ensure that consideration is given to them in any management strategy, as if pressures are reduced species should be better able to cope with or adapt their situation (Section 1.3).

Recommendations for mitigation of climate change

- **Promote the conservation and restoration of forests, and wetlands, and especially peatlands**. The potential contribution of forests to mitigating climate change has been recognised by the UNFCCC, which allows for reforestation and afforestation under the Kyoto Protocol Clean Development Mechanism and the avoidance of carbon release from deforestation and forest fragmentation and degradation (REDD) will be included in future, This could enhance the non-use value of these ecosystems, but the calculation of avoided emission will be need careful calculation and DI projects could contribute to the understanding and monitoring of carbon stores in local situations. The conservation and restoration of forests and wetlands would also contribute to adaptation through the potential increase in habitat area, connectivity and species population numbers,
- **Use Clean Development Mechanism:** Projects involving forests and wetlands should seek to ensure that full advantage is taken of the financing opportunities under the Kyoto Protocol Clean Development Mechanism (CDM).
- **Encourage low or neutral carbon energy sources:** Projects involved in sustainable livelihoods should seek to develop and encourage local non-carbon or carbon-neutral energy sources, and techniques for improving energy efficiency.
- **Off-set project emissions:** Projects (or the DI Secretariat) could also consider off-setting the carbon emissions generated by the project.

Recommendations for monitoring for climate change

- **Deposit data sets nationally:** All Darwin Initiative project data should be deposited with national (or if appropriate international) organisations. This should include details of the survey sites and methods such that they can be replicated.
- **Ensure continuity of monitoring effort:** Every effort should be made to secure the continuation of any monitoring, such that long-term data sets, which can contribute to climate change detection, can be gathered.

- **Select climate sensitive taxa for monitoring:** If possible attention should be given to specific animal groups, such as birds, butterflies and moths, which are known to be sensitive to climate in the region and are easy to record, as an effective means of detecting change. Changes in their phenology, distribution (latitudinal or altitudinal), population numbers could be recorded.
- **Make weather recordings:** If there are no local weather stations then simple recording of temperature and precipitation should be undertaken.
- Other drivers of change should also be identified and recorded.
- **Mountains:** Specific monitoring activities for mountains could include the monitoring of species and habitats at their upper altitudinal range and monitoring snow cover and extent (altitude of snow-line, length of cover).

4.5 Recommendations for the Darwin Initiative Secretariat

- **Vulnerable habitats and regions:** Encourage the establishments of projects in vulnerable or sensitive under-represented habitats or regions e.g. the boreal/tundra and Arctic regions, Asian megadeltas.
- **Long-term data sets:** Encourage projects to build upon any national or regional long-term ecological datasets where already available, or to establish baseline datasets. Develop rapid assessment methodologies, or train para-taxonomists to continue to contribute to long-term databases.
- **Provide guidance:** Provide guidelines along with details of grant application on how climate change could be incorporated into projects.
- **Planning:** Few of the projects explicitly mention climate change but it would be important to ensure that management plans took into account any such projected changes and their potential impacts.
- **Knowledge gaps:** In some situations there is an insufficient ecological knowledge base about the ecosystem, let alone potential climate change impacts at a local level (e.g. "Bees, biodiversity and forest livelihoods in the Nilgiri Biosphere Reserve, India, No. 15-001). In these cases DI projects can contribute to building up the knowledge base and to filling knowledge gaps identified by the IPCC.

The following is an example of the potential of DI projects in contributing to climate change issues. It is based on a review of some closed DI projects and interviews with people involved in them undertaken in Costa Rica.

Case Study: Darwin Initiative Projects and Costa Rica's Climate Change Strategy (Karp, 2007)

A small country, with a population of c. 4,600,000 people and a small land footprint of 51,100 km^2, Costa Rica is located in the Neotropics, and is considered to be one of the top 20 richest countries in terms of biodiversity of species and diversity of ecosystems. It has an advanced regulatory and institutional framework for environmental protection and conservation. Government policy has favoured the protection of natural resources as a way to generate revenue through tourism and has developed fiscal incentives to ensure natural resources are conserved, through systems of payment for environmental services.

The Ministry of the Environment and Energy, MINAE is charged with the task of protecting the environment, and the National System of Conservation Areas (SINAC) remit is the conservation of the country's biodiversity alongside the National Commission for Biodiversity Management (CONABIO). Over 25% of Costa Rica's territory is protected.

Policy innovation includes Costa Rica's goal to become the first country to be Carbon Neutral, by 2021. The strategy is led by the interdisciplinary group *'Estrategia Nacional de Cambio Climático de Costa Rica'* (ENCCCC), which is working under the auspice of MINAE. The ENCCC issued a public consultation strategy in November 2007 which outlines how to achieve this. Broadly, the Government will promote the use of cleaner energy, and will further the concept of 'carbon allowances' for energy intensive industries and Government support of service industries, such as tourism, which will have to make a transition without becoming uncompetitive *vis a vis* the global tourism market. The ENCCC initiative strongly suggests the creation of an eco-label, 'C –Neutral' for Costa Rican products and services. It is outlined as a key instrument which will front structural change in the country's policy and regulatory framework. A lot will have to change in order to achieve using a national eco-label for all products and services originated in Costa Rica, across widely different industries.

Costa Rica is a country that values the economic benefits that its biodiversity provides and is placing ecological imperatives at the heart of economics. Indeed, Costa Rica's strategy is making a move towards attaining, and in some cases surpassing recommendations outlined in the recently published UNDP's Human Development Report 2007-2008[2].

The ENCCC brings together experts from diverse disciplines and one of the key sectors it focuses on is biodiversity. In terms of adaptation and mitigation, there is an interest in the reduction of emissions from source (i.e. agricultural sector, energy), in carbon sequestration via afforestation and continued payments for environmental services, and in participating in the international carbon markets.

Where the Darwin Initiative fits in

Darwin has two closed projects focused solely on practical, field level conservation in Costa Rica (3-101, 12-020). Project 3-101 had a taxonomic remit and helped to: i) set up a collection of the *Pimplinae* family of wasps, ii) develop a Spanish guide for the identification of *Pimplia*, iii) developed capacity (namely Jesús Ugalde). Project 3-101 was a building block in that it helped gather information and establish a collection. Project 12-020 operated in the San Juan Biological Corridor in Nicaragua and Costa Rica. A current project, 15-027, is operating in Panama and Costa Rica and a current project is focused solely in Costa Rica (14-001[3]). Projects 12-020 and 15-027 have helped to: i) develop methodologies for biodiversity indicators, ii) provide scientific data for baseline studies iii) establish plots which are suitable for long term monitoring.

How can Darwin Initiative projects help

i) Support institutions with a climate change and biodiversity agenda

Granting finance to institutions with a DI portfolio can increase the likelihood that DI outputs will be used comprehensively. Two closed projects (3-101, 12-020) have been carried out in partnership with the National Biodiversity Institute (INBio), as well as the current project 15-027. INBio was created in 1989 as a private research and biodiversity management Non Governmental Organization and has a strong track record in knowledge generation, as well as collaboration with Government Institutions, such as MINAE and SINAC. INBio is seeking to include climate change considerations in its monitoring work (see below).

ii) Capacity development and networking

Jesús Ugalde, now a Director in Biodiversity Sciences in INBio participated in 3-101, when he was curator for the Institute. He is now a member of the scientific committee participating in the discussion within the Biodiversity remit of the ENCCC*.* A high number of the DI portfolio of projects, have had a capacity development scope.

[2] Recommendation 1: Develop a multilateral framework for avoiding dangerous climate change under the post 2012 Kyoto Protocol and Recommendation 2: Put in place policies for sustainable carbon budgeting – the agenda for mitigation.

[3] There was no time to contact leaders or team members of this project.

The network of 'Darwin Fellows' can be used to stimulate climate change considerations in host countries, through, for example, regional workshops with a climate change theme.

iii) Collection of baseline data

The Darwin baseline data can be used to measure ecosystem change systematically and periodically thereby impacting on Costa Rica's ability to identify possible climate change impacts and to build adaptive capacity and vulnerability safeguards into key Protected Areas.

For example, project 15-020 is producing a 'life-zone map that can be used to predict changes at one point based on observation at another' (Monro, questionnaire). According to Jesus Ugalde, information gathered through projects 12-020, and 15-020 can be plugged into wider INBio monitoring efforts in the Parque Nacional la Amistad and Osa - the former is extremely sensitive to climate change.

What next?

As highlighted above, a practical step forward is for projects to use baseline data effectively. For example, in Costa Rica, INBio could be involved in the development of protocols which can help inform the institution's long term climate change work - information which can be collected by dovetailing on current DI projects.

Events such as regional workshops with a tight thematic scope can be a good first step towards creating synergies for projects which are operating in areas that are highly prone to climate change impacts.

Discussions with the British Embassy highlighted their interest in supporting Costa Rica's Carbon Neutrality objective and in bridging the gaps with UK organizations. As a norm project leaders could find out at the application stage whether initiatives such as ECCC exist and how their projects can help. Contacting the British Embassies to find out more is a simple procedure which could impact positively on DI projects' contribution to dealing with adaptation and mitigation.

5. Conclusions

This review has examined the Darwin Initiative projects and their role, or potential role, for mitigation, adaptation and/or monitoring of climate change and its impacts. Although very few of the projects (< 10 of the 245 projects reviewed) had considered explicitly the impacts of climate change on their strategies and objectives, a significant number of projects are undertaking useful activities which can be described as **contributing to the mitigation, adaptation and monitoring of climate change impacts**. These aspects could be strengthened by explicitly considering their contribution to our understanding, identification and offsetting of climate change impacts on biodiversity. The role of sustainable livelihoods needs to be considered carefully as they have the potential to exacerbate the impacts of climate change and to hinder adaptation activities, but as has been shown they can, with care, also be a part of the adaptation process, whereby biodiversity is valued and conserved, while still providing a means of livelihood for local communities.

On the **mitigation** side, it is clear that forests, and particularly boreal forests, and wetlands are very important stores of CO_2 and the long-term protection and enhancement of these habitats in particular can contribute to a portfolio of mitigation measures. There is a lack of projects concerned with mitigation, which may reflect the general omission of climate change considerations from projects or the long-term nature of such action relative to project duration. There are clearly new opportunities under the Kyoto Protocol for carbon sequestration and REDD to built into projects, and a new avenue for DI projects and mitigation could be an exploration of the relationship between green energy technologies and biodiversity in developing countries.

A larger number of DI projects have been or are actively involved in activities which can contribute to **adaptation strategies**, specifically the protection, expansion and restoration of habitats. These can increase habitat or species resilience to the negative effects of climate change. The efficacy of these could usefully be assessed through combining with monitoring. The commencement of monitoring in many projects is important in establishing baselines for change, but the short-term nature of DI projects means that there is a need to involve local organisations and communities in the recording, so that it can be continued to provide the more valuable long-term datasets. These are vital for truly understanding the effects of any actions undertaken in the project and the possible impacts of climate and other drivers of ecosystem change. Projects that are developing effective conservation management practices and building local capacity through training and knowledge dissemination are also helping to strengthen the adaptation process.

It is the nature of the DI that very few projects were operating in the Arctic region (one only) and this is a reflection of the fact that funding is limited to those projects in countries that are rich in biodiversity but poor in resources, primarily financial resources. Conversely, African projects made up nearly half of those projects reviewed, which appropriately reflects the low capacity of people, institutions and systems on the continent. Climate change is predicted to have very negative consequences on African habitats and species as well as livelihoods and the DI has an important role to play in strengthening their capacity for adaptation.

While climate change does not figure directly in many DI projects a number of activities, in a selection of projects, do contribute to mitigation and adaptation actions. These activities need to be explicitly recognised and their potential for climate change mitigation and adaptation assessed. In addition, the valuable **monitoring** that is undertaken in a greater number of projects could also be strengthened, especially if it could be continued long-term, so that there is a longer lasting legacy from projects.

This review had identified that while few DI projects explicitly consider climate change, many of the activities undertaken in the projects can be re-evaluated for their contribution to climate change mitigation and/or adaptation and thus a greater emphasis on these activities for climate change in future projects is possible through guidance at the planning stages. This would not necessarily require large shifts in the activities undertaken, but rather an explicit realisation of their **climate change potential** through a re-focusing or incorporation of additional objectives.

Their success will lie in the execution of the adaptation and mitigation activities identified and monitoring of their effectiveness. Both of these require longer-term commitment, and thus funding, than currently available in DI projects. Therefore, there is considerable potential for DI projects to address climate change impacts, adaptation and mitigation through making it an integral part of any proposal. There is also an opportunity in the long-term for DI projects, through the implementation of the guidelines, to demonstrate good practice in climate change adaptation, mitigation and monitoring.

6. Towards understanding climate change and biodiversity

This section develops in greater detail the outline information presented in section 1. This section aims to be a summary of current knowledge and information about climate change. Given that knowledge about climate change impacts on biodiversity is a rapidly evolving field and that the Darwin Initiative constituency in general has a low awareness of the subject it was felt that a more in-depth treatment of the subject would help raise knowledge and understanding and assist with the development of more climate change aware DI projects. Each section will be prefaced with summary points (duplicated in section 1) which aims to help the reader summarise the points within the section.

- Climate change defined;
- The expected mean global warming over the 21st century is 'very likely' to be greater than 1.5°C and 'likely' to lie between 2°C and 4.5°C;
- Greatest temperature increase is projected to occur over land at high latitudes in the northern hemisphere. Fewer low temperature spells are expected;
- Precipitation likely to increase in areas of regional tropical monsoon regimes with a general decrease in rainfall in the subtropics;
- Extreme weather events such as heat waves are 'very likely' to be more intense and frequent.

For the purposes of this report, the term climate change is used as defined by the United Nations Framework Convention on Climate Change (UNFCCC):

"A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

Increasing evidence of human-induced changes in climate in recent years has led to the establishment of the Intergovernmental Panel on Climate Change (IPCC), which has published a series of Assessment Reports since 1990 to provide the latest information on projections, impact and mitigation of global climate change. In the Fourth Assessment Report (FAR) published in 2007, the expected mean global warming over the 21st century over a range of different socio-economic storylines developed in a *Special Report on Emissions Scenarios* (SRES, 2001) is 'very likely' to be greater than 1.5°C and 'likely' to lie between 2°C and 4.5°C (Figure 7).

The greatest temperature increase is projected to occur over land and at high latitudes in the northern hemisphere. There is consistency across multiple model projections that fewer low temperature spells are expected. In relation to the temperature changes, precipitation will increase in areas of regional tropical precipitation maxima (e.g. monsoon regimes) with a general decrease in rainfall in the subtropics.

Extreme weather events such heat waves are 'very likely' to be more intense and frequent, based upon model simulations. However, precipitation extremes are less successfully simulated by current models. Other extreme events such as tropical cyclones are projected to increase in strength (in terms of wind and precipitation intensities) however changes in frequency of occurrence are relatively uncertain (Chapter 8 and 11, IPCC, 2007a).

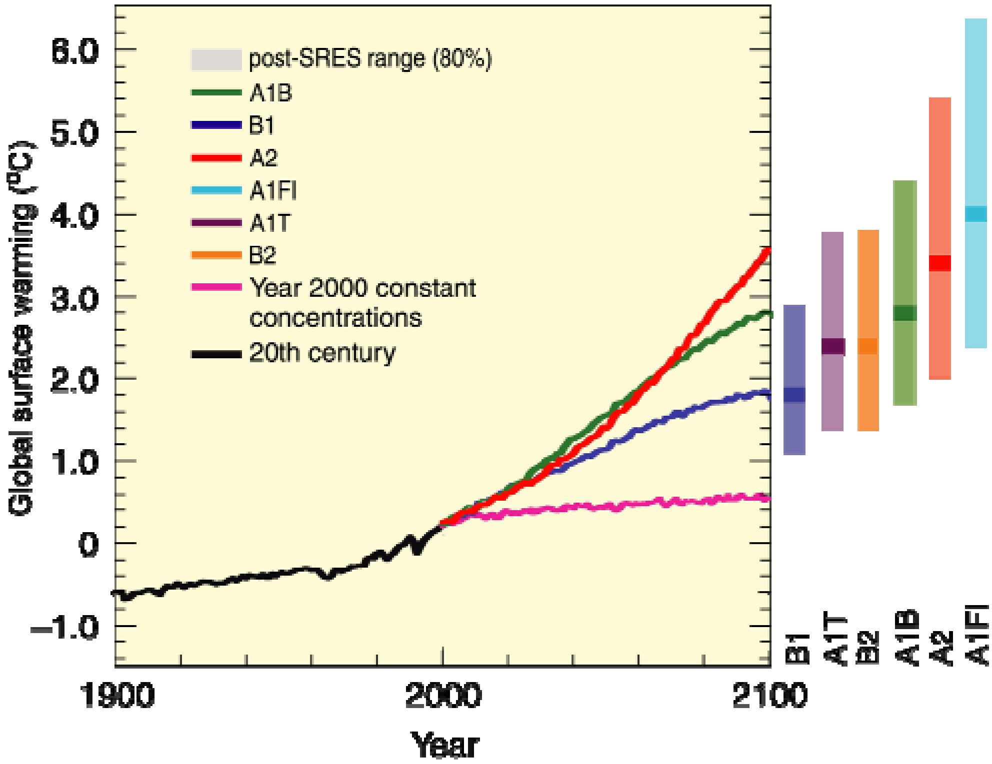

Figure 7 **Global mean surface temperature projections for different SRES scenarios. Temperatures relative to the period 1980-1999 (Source: IPCC, 2007a)**

Direction and magnitude of changes in climate vary from region to region. The difference is driven by the uneven distribution of solar heating, responses and interactions of atmosphere, oceans and land surface. Climate change therefore represents both opportunities and risks – it is likely to favour regions currently limited by low temperatures while posing threats on low-lying coastal zones by sea-level rise. Despite the beneficial effects in some parts of the world, the overall impact is likely to be negative on society and the natural environment whilst "previous IPCC assessments had concluded that net negative climate impacts are more likely in most parts of the world", stated in the Third Assessment Report (TAR) by IPCC in 2001.

6.1.1 Climate change and impacts on biodiversity

- Significant impacts on biodiversity and ecosystems are predicted but their nature is poorly understood;
- Many ecosystems and species could be adversely affected by increases in global mean temperatures of 1°C to 2°C, in relation to both their range or existence, and also their ability to deliver various services to humans;
- A temperature rise beyond 2°C may be beyond the tolerances of many species and ecosystems;
- Actions are needed to avoid such temperature increases through **climate change mitigation**;
- While in the past species and ecosystems have adapted to changes in climate, the current fragmented and reduced levels of biodiversity means greatly reduced ability to adapt to changes in climate;
- Actions are needed to maintain or increase populations and genetic variation through **climate change adaptation**;
- Adaptation strategies to reduce vulnerability to climate change are likely to resemble other activities for improving natural resources management.

Projected climate change is predicted to have significant impacts on biodiversity and ecosystems. Some species and ecological processes are vulnerable to changes in climate, including the magnitude and rate of change, as well as to changes in climatic variability. However, the potential impacts of these changes on biodiversity remain poorly understood. Research indicates that many ecosystems and species could be adversely affected by increases in global mean temperatures of 1°C to 2°C not just in terms of their range or existence, but also their ability to deliver various services to humans (Leemans and Eickhout, 2004). It has also been suggested that a rise beyond 2°C was unacceptable for many ecosystems and species (IPCC, 2002; Reid *et al*., 2005). In order to attempt to avoid such increases, mitigation (taking actions aimed at reducing the extent of global warming through emissions reduction, for example) is needed but, due to time-lags, the effectiveness of such measures will only be seen in the medium to long term. Adaptation (a structural or behavioral change to enable living organisms to cope with climate change), therefore, is required, especially to counter short to medium-term changes.

Global biodiversity, however, has been affected by variable temperature, precipitation and concentrations of atmospheric carbon dioxide since the beginning of the Pleistocene period (1.8 million years BP), and has adapted through evolutionary changes, species plasticity, range shifts, and/or the ability to persist in small patches of favourable habitat (refugia, which may consist of isolated or relict populations of once widespread species). Pleistocene climate was characterized by repeated glacial cycles and the severe climatic changes during the ice age and inter-glacial periods had major impacts on the fauna and flora (Figure 8). These changes, however, occurred in a period where the human population and pressures from human activities were very low so that landscapes and habitats were not as fragmented as the present time, so species' adaptive capacity was greater. Since the 19th Century, human population growth and associated extensive vegetation clearance and land conversion for agriculture and urban expansion has subsequently increased habitat fragmentation on a global scale. This has restricted many species to a limited range relative to their previous extent, resulting in lower populations and reduced genetic variability; factors that can increase a species vulnerability to local, regional or global extinction. Hence there is a need for adaptation actions to maintain or increase populations and genetic variation. Current warming projections, already expected to be beyond the temperatures reached during the Pleistocene epoch, will further stress current species and ecosystems well beyond the levels experienced in the recent evolutionary past.

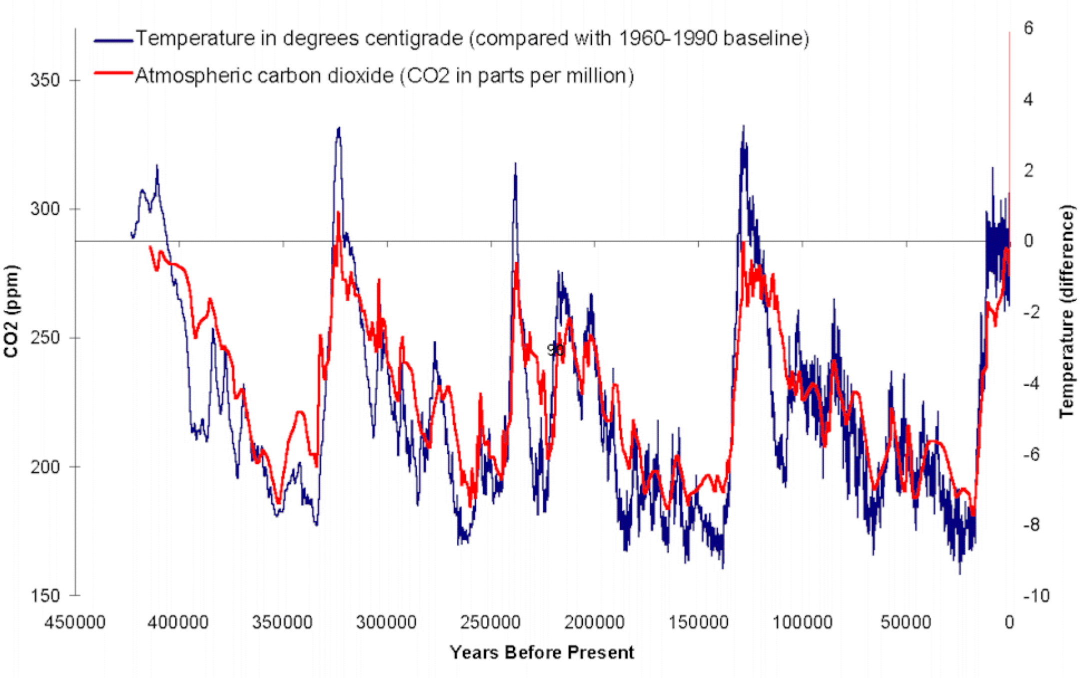

Figure 8 **2 Temperature record from the Vostock (Antarctica) ice core (dark blue), together with CO2 (red) from the Vostock ice core, the Law Dome ice core, and from the Mauna Loa observatory (Hawaii). The near vertical red line on the right represents the change in CO2 associated with the industrial revolution (IPCC, 2007a)**

The rates and magnitude of species extinction at the current time already far exceed normal background rates (Lawton and May, 1995). Human activities have resulted in the loss of biodiversity and thus may have affected the sustainable provision of ecological goods and services that are crucial for human well-being. The rate and magnitude of climate change induced by increased greenhouse gases emissions has affected and will continue to affect biodiversity either directly or in combination with other drivers and pressures of change.

Many natural systems comprise of a number of clearly defined interacting elements, for example climate and ecosystem productivity, species competition for nutrients and predator-prey relationships. In addition, human dependency upon natural resources and land adoption and conversion for agricultural use will also impact upon terrestrial ecosystems. Factors such as increasing human population levels, food scarcities and land suitability for crops and grazing can result in land-use change when human demands cannot be met by existing land-use. In the seas and oceans, improved technologies and increased fishing efforts are depleting fish stocks to the level where many important fisheries have collapsed (Worm *et al.*, 2006). Wetland habitats, river channels, riparian zones and aquatic communities are experiencing significant hydrological changes due to anthropogenic interventions, in particular through expansion of agricultural land in water catchment areas, the development of large irrigation schemes to meet increasing water demands, and unsustainable water and groundwater extraction strategies. Anthropogenic factors affecting natural habitats and ecosystems are pervasive throughout the globe and their influence challenges our evidence base when it comes to trying to establish causality between changing climate and its impacts upon biodiversity. However, an assessment of existing evidence of climate change impacts on habitats, species and ecological processes, where it is observable, coupled with projections for future impacts, will allow judgements to be made about ecological responses to perceived changes. This, in turn, will provide information to justify adaptation strategies, management options and mitigation measures, and to determine robust policy responses - particularly in relation to other key areas of nature conservation policy. Management of biodiversity and habitats is characterized by the need to continuously adapt to changing circumstances through a learning-by-doing approach (IUCN, 1999). In this respect, **adaptation strategies to reduce vulnerability to climate change are likely to resemble other activities for improving natural resources management**.

6.1.2 Habitats, ecosystems and regions most vulnerable to climate change impacts

- Habitats and ecosystems most vulnerable to climate change have been identified;
- Two classes of habitat or region are considered vulnerable and form the basis of the review:

  a) Regions and habitats with low adaptive capacity;

  b) Regions and habitats with high climate change variability.

Certain habitats and ecosystems are likely to be more vulnerable to climate change than others. **The following habitats and regions have been indentified as vulnerable to climate** change (IPCC, 2002, based on the IPCC Third Assessment Report, IPCC, 2001)

- high mountain ecosystems;
- islands and peninsulas;
- restricted ecosystems, such as coral reefs, mangrove forests and other coastal wetlands;
- remnant native grasslands;
- ecosystems overlaying permafrost; and
- marginal sea-ice.

The ecosystems in Mediterranean climates and grassland areas were also identified as potentially vulnerable due to climate change and human influences. The IPCC Fourth Assessment Report (IPCC, 2007a), has essentially confirmed the vulnerability of some of these where the evidence was not so strong and **estimated that climate change was a major driver of biodiversity loss in**

- cool conifer forests,
- savannas,
- Mediterranean-climate systems,
- tropical forests,
- the Arctic tundra, and
- coral reefs.

Regions and habitats with low adaptive capacity: These are all regions and habitats which have been identified as having **low adaptive capacity**, which might be a reflection of:

(i) the **highly specific nature of the environmental conditions** that the habitat or species demands;

(ii) **existing anthropogenic pressure** that may have diminished species populations through habitat fragmentation, isolation or pollution and/or the capacity of the society to effectively manage the resources through a lack of education or finance, or because of other priorities, such as poverty.

Regions with high climate change variability: Other geographical regions have also been identified as high priority (vulnerable) due to the significant **climate change (variability) that is projected to occur in those locations**. These two categories form the basis of this review.

The habitats considered are:

- Terrestrial: tundra, boreal forest, mountain, Mediterranean-type ecosystems and arid and semi-arid zones
- Marine and coastal habitats: coral reefs, mangroves, salt marshes and the sea ice biome
- Wetlands in the dry tropics and subtropics.

The geographical regions are:

- Arctic, because of the impacts of high rates of projected warming on natural systems
- Africa, especially the sub-Saharan region, because of projected climate change impacts and low adaptive capacity
- Small islands, due to high exposure of population and infrastructure to sea level rise and increased storm surges
- Asian megadeltas, due to large populations and high exposure to sea level rise, storm surges and river flooding.

Vulnerability of Terrestrial Ecosystems

- There is very high confidence that recent warming is strongly affecting terrestrial biological systems;
- **Mountains** are highly significant for biodiversity and already some climate change impacts are apparent. Adaptive capacities in montane regions are generally limited with a disproportionately high risk of extinction for many endemic species in various mountain ecosystems;
- Predicted increases in temperature are likely to have greatest effect on **forests** in boreal regions, while some regions are expected to experience significant changes in precipitation and water availability (e.g. Amazon drought). Some scenarios show significant forest dieback in tropical, boreal and mountain areas towards the end of this century and beyond, with a concomitant loss of key services;
- The physical processes of land degradation, biodiversity, and climate change are intimately inter-twined, especially in **drylands.** The CBD sees wetlands in drylands, remnant grasslands, prairies, Mediterranean forests, and desert margins as particularly vulnerable to the impacts of climate change;

There is very high confidence that recent warming is strongly affecting terrestrial biological systems (IPCC, 2007b) and this report focuses on those that have been identified as being particularly vulnerable.

Mountains are highly significant for biodiversity for although they cover 20% of the terrestrial land surface outside polar regions, the Arctic alpine zone covers 3% of the earth's surface, they contain at least 4% of all vascular plants. Also, mountains host over half of the world's 34 biodiversity hotspots (Spehn and Körner, 2005).

A number of organisations and reports have identified mountains as being sensitive to climate change (UNEP-WCMC, 2002; IPCC, 2007b; CBD COP 7 Decision VII/27). Already some impacts are apparent in the regional extirpation of species, movement of species to higher altitudes (including forest pests), loss of snow and ice cover and increased productivity of species towards their upper range margins (IPCC, 2007b). These responses all provide indicators for monitoring climate change impacts and response. In addition to these observed changes, climate change could also lead to changed genetic diversity, changing patterns of disturbance, and warmer and drier conditions in some areas could lead to forest dieback. Secondary pressures, such as land-use changes, over-grazing, trampling, soil and water pollution, and soil losses can further exacerbate ecosystem degradation, particularly in highly diverse regions such as the Caucasus and Himalayas (IPCC, 2001).

The IPCC (2007b) recognised that adaptive capacities in montane regions were generally limited, but many of the highly endemic alpine biota have a high vulnerability to climate change (Pauli *et al.*, 2003). Since the TAR, the literature has confirmed a disproportionately high risk of extinction for many endemic species in various mountain ecosystems, such as tropical montane cloud forests or forests in other tropical regions.

Forests cover about 30% of the land surface (Sabine *et al.*, 2004). Predicted increases in temperature are likely to have greatest effect on forests in boreal regions. Changes in precipitation and water availability are also significant, especially in some regions. Parts of the Amazon, for example have a high drought risk (Mahli *et al.*, 2007). Increases in CO_2 may enhance productivity although this could depend on nutrient dynamics, species composition, dynamic age structure effects, pollution and biotic interactions (Fischlin *et al.*, 2007). Most DGVM models based on A2 emissions scenarios show significant forest dieback towards the end of this century and beyond in tropical, boreal and mountain areas, with a concomitant loss of key services. The vulnerability of forests could be shorter-term if changes in disturbance regimes (drought, insects, fire), partly due to climate change, cross critical thresholds (IPCC, 2002).

Drylands. The physical processes of land degradation, biodiversity, and climate change are intimately inter-twined, especially in drylands (Lean, 1995). Dryland species and ecosystems, have developed unique strategies to cope with low and sporadic rainfall. They are highly resilient and recover quickly from prevailing disturbances such as fires, herbivore pressure and drought. These attributes have great significance for the global system, especially in the context of climate change (Bonkoungou, 2000). Long-term changes in temperature and rainfall patterns can have serious impacts on the biological diversity of dry and sub-humid lands and the CBD sees wetlands in drylands, remnant grasslands, prairies, Mediterranean forests, and desert margins as particularly vulnerable to the impacts of climate change.

The IPCC notes that changes in a variety of ecosystems are already being detected, particularly in southern African ecosystems, at a faster rate than anticipated and changes in grasslands, montane and marine ecosystems are also noticeable (Boko *et al.*, 2007). It reckons that climate change, interacting with human drivers such as deforestation and forest fires, are a threat to Africa's forest ecosystems and it is estimated that, by the 2080s, the proportion of arid and semi-arid lands in Africa is likely to increase by 5-8%. A summary of significant ecosystem responses estimated in relation to climate change in Africa is given in Table 9.1 of the IPCC report (Boko *et al.*, 2007).

Vulnerability of marine and coastal habitats

- Marine and coastal habitats provide globally significant ecological services;
- Global warming is likely to lead to an increase in coral reef bleaching and mortality as well as more frequent algal blooms;
- Sea level rise and an altered hydrological cycle will affect the geographical distribution and extent of many coastal and marine habitats;
- A further likely negative impact of increased atmospheric carbon dioxide will be by changes in ocean chemistry through acidification.

For the purposes of this review, the following habitats are included in this category: coral reefs, sea grass meadows and mangroves, rocky shores, coastal salt marshes, sand dunes and beaches, mudflats and tidal mudflats, coastal lagoons and estuaries. These habitats provide globally significant ecological services which have social, economic and environmental benefits to society including storm protection, fisheries support, erosion control and the biogeochemical cycling of carbon, nutrients and sediments as well as biodiversity resources and tourism opportunities (IUCN, 1999).

Based upon the IPCC projected climate changes for the 21st Century, global warming is likely to result in an increase in the severity and extent of coral reef bleaching and subsequent mortality (IPCC, 2007b). Warming sea temperatures are also likely to produce more frequent algal blooms in some coastal areas, especially where there is an associated increase in nutrient levels through agricultural run-off or inadequate sewerage processing. The effects of eutrophication in coastal wetlands and lagoons results in reduced dissolved oxygen levels and mortality of many species. Sea level rise and an altered hydrological cycle will affect the geographical distribution and extent of many coastal and marine habitats through processes such as coastline erosion and changes in sedimentation transport, changes in tidal ranges and salinity of estuarine regions and increased flooding risk through storm surges. Indirect effects of climate change on marine and coastal resources will arise from changing land-use and water resource management patterns. A further likely negative impact of increased atmospheric carbon dioxide will be by changes in ocean chemistry through acidification (Royal Society, 2005). Although current knowledge is still uncertain, the resultant reduced pH will affect the process of calcification, by which marine species such as corals and molluscs make shells and plates from calcium carbonate. Other calcifying organisms that are likely to be affected are phytoplankton and the zooplankton, which are a major food source for fish and other species.

Vulnerability of wetlands

- Wetlands support significant biodiversity as well as significant social, economic and ecological benefits to societies;
- Climate change will have a significant effect on the hydrological regime and the ecological processes of wetland habitats, and this will essentially be regionally determined;
- Wetland management strategies should incorporate projected precipitation changes in their biodiversity conservation activities;
- Climate change is already having measurable, primarily negative, impacts on wetland biodiversity due to increased invasions from non native species and decreased water availability in many arid- and semi-arid regions;
- Increased concentrations of pollutants, and frequent and more extreme weather events are potentially detrimental to wetland biodiversity.

Freshwater wetlands hold more than 40% of the world's species and 12% of all animal species (Ramsar, 2001). Freshwater wetlands are areas where saturation with water is the dominant factor and comprises of the following general categories:

- Swamps, comprising of seasonal or permanent inundation of large areas of land by shallow water bodies, generally having a substantial number of hammocks, or dry-land protrusions, and covered by aquatic or semi-aquatic vegetation;
- Marshes, which are a type of wetland that is subject to frequent or continuous inundation and has a vegetation cover dominated by grasses, rushes, reeds, sedges, and other herbaceous plants. Unlike swamps, which are either completely or partially wooded with trees and shrubs, a marsh is generally treeless and open;
- Bogs, which are wetland types that accumulate acidic peat, partially decayed vegetation matter. Because they are mainly distributed in the northern hemisphere (Boreal Zone) and in cold, temperate regions, this habitat features rarely in the portfolio of Darwin projects (only one identified: Reference no. 6-081, title 'Bogs of Tomsk Province: Inventory, Assessment and Biodiversity Action Plan' (Russia)).

These types of wetlands may be ephemeral or only seasonally wet, but the important distinction is that they represent a transitional zone between the land and water. This environment is "at the interface between truly terrestrial ecosystems and aquatic systems making them inherently different from each other yet highly dependent on both" (Mitsch & Gosselink, 1986). For the purposes of this review, we shall not be discussing deepwater habitats in this section. Estuarine and tidal wetlands are considered in the Marine and coastal habitats section where they are subjected to sea-level rise and coastal storm surges. Wetlands are critically important ecosystems, providing significant social, economic and ecological benefits such as the regulation of water quantity and quality, providing suitable habitat for biodiversity and are important resources for recreation and tourism (Ramsar, 2007).

Many wetlands and water bodies worldwide are already under some degree of control by humans through water management schemes, whether this is for the specific intention of biodiversity protection or, more likely a consequence of agricultural irrigation or water extraction and drainage practices, which have an overall negative impact on wetland biodiversity.

Climate change will have a significant effect on the hydrological regime and the ecological processes of wetland habitats, and this will essentially be regionally determined. However, precipitation patterns will change both globally and seasonally under the different climate change scenario projections, and wetland management strategies should incorporate those projected changes in their biodiversity conservation activities. Wetlands are biodiversity hotspots and climate change is already having measurable impacts on species, including migratory birds. Although some of these impacts will be beneficial (e.g. increased productivity in mid-latitude regions and possibly lower winter mortality of wetland birds in the high latitudes), there will be more adverse than beneficial impacts on wetland biodiversity due to increased invasions from non native species and decreased water availability in many arid- and semi-arid regions, which will affect the extent of wetlands, available food sources and species population numbers. The lowering of the volume of water would increase the concentrations of the pollutants that accumulate in wetlands (e.g. agricultural chemicals, naturally occurring salts, atmospheric pollutants), which will affect wildlife. Frequent and more extreme weather events, from storms, floods and droughts are anticipated to increase pressure on the utilisation and management of water and watershed processes respectively (Ramsar, 2007), potentially to the detriment of wetland biodiversity.

Vulnerable regions and climate change

The regions encompass many of the vulnerable habitats described above, but have been highlighted because they are extensive, both geographically (e.g. the Arctic region, Africa) and in the number of localities, which share the same issues and exposure to climate impacts (e.g. the Asian Megadeltas, small islands). Impacts and adaptation strategies are likely to be similar to those discussed in the habitats discussions notwithstanding the greater challenges of scale and sheer numbers of people involved.

Arctic vulnerability

- The arctic region is experiencing rapid climate change with melting ice and rising sea levels;
- Climate change is projected to cause a pole-ward shift and reduction of area of the polar desert vegetation zones.

The arctic region, essentially a frozen ocean surrounded by land, is experiencing rapid climate change impacts with recent records showing increasing temperatures; melting glaciers, sea ice and permafrost; and rising sea levels providing clear evidence of a warming trend for the Arctic as a whole. The sea ice covering the Arctic Ocean and neighbouring seas is highly sensitive to both air and ocean temperature changes and over the past 30 years, the mean annual sea-ice extent has decreased by about 8%, which amounts to about one million square kilometers. The ice is also thinning with reduction of up to 40% in some regions (ACIA, 2004). Sea-ice melting has been observed to be more pronounced in the summer with losses up to 15% of coverage.

The major arctic vegetation zones include the polar deserts, tundra, and the northern part of the boreal forest. The polar desert, characterized by open patches of bare ground and an absence of even the smallest woody shrubs, is the northern-most zone that covers most of the high arctic. Although sparse, the polar desert vegetation can support musk ox and other small sub-species of caribou. Climate change is projected to cause a pole-ward shift in the vegetation zones due to rising temperatures, for example boreal forest expansion into the arctic tundra and tundra into the polar deserts. These predicted vegetation changes, along with sea level rise, will result in a contraction of the tundra zone to its lowest extent since the last glacial maximum, greatly reducing the breeding area for many birds and the grazing areas for land animals that depend on the open landscape of tundra and polar desert habitats. Although some arctic species will adapt to climate change, there will be increasing competition from non-native and invasive species, which will be able to migrate into a warmer arctic region.

Sub-Saharan African vulnerability

- Africa, especially the sub-Saharan region, is identified as being particularly vulnerable to climate change;
- Vulnerability to climate change is due to the sensitivity to the projected impacts and the weak socio-economic status of many societies, limiting adaptive capacity;
- Sustained global warming and temperature increases will result in significant changes in forest and rangeland cover; species distribution, composition, and migration patterns; and biome distribution;
- Many organisms in arid and semi-arid zones are already close to their tolerance limits, and some may not be able to adapt further under warmer conditions.

Africa, especially the sub-Saharan region, was identified as being particularly vulnerable to climate change because of the exposure or sensitivity to the projected impacts of climate change and the widespread poverty limiting adaptive capacity. Habitats and ecosystems in Africa today such as tropical forests, savannas and rangelands are under increasing pressure from growing population and inappropriate land use conversion. This results in loss of biodiversity, rapid deterioration in land cover, and depletion of water availability through destruction of catchments and aquifers. It is predicted that climate change will interact with these underlying changes in the environment, adding further stress to an already critical and deteriorating situation. Sustained global warming and temperature increases will result in significant changes in forest and rangeland cover; species distribution, composition, and migration patterns; and biome distribution. Many organisms in arid and semi-arid zones are already close to their tolerance limits, and some may not be able to adapt further under warmer conditions. The grassland areas of eastern and southern Africa, as well as areas currently under threat from land degradation and desertification, are particularly vulnerable. Although rainfall has been expected to increase in the highlands of east Africa and equatorial central Africa, which would make marginal lands more productive than they are now, these effects are likely to be negated by the population pressure on marginal forests and rangelands.

Small island vulnerability

- Small island developing states (SIDS) have been identified as likely to be most vulnerable to climate change;
- SIDS already experience adverse effects of climate change (sea-level rise with tropical cyclones and hurricanes, storm surges, coastal erosion and increasing sea surface temperatures resulting in coral bleaching events).

The IPCC Third Assessment Report identifies small island developing states (SIDS) as the countries likely to be most vulnerable to climate change (IPCC, 2001). 51 SIDS, located in the Atlantic, Indian and Pacific oceans as well as the Caribbean and Mediterranean seas share many similar economic and sustainable development challenges. These include low availability of resources, a small but rapidly growing population, isolation and remoteness, susceptibility to natural disasters and a high dependency on international trade (Sem, 2007). Because climate is predominantly influenced by ocean-atmosphere interactions, SIDS already experience adverse effects of climate change and variability through sea-level rise with tropical cyclones and hurricanes causing storm surges, coastal inundation and erosion and increasing sea surface temperatures resulting in coral bleaching events. Sustainable development strategies for SIDS under a changing climate will need to account for potentially negative effects on water resources, coastal infrastructure and activities, human health, tourism, fisheries and biodiversity where people's capital assets, resilience and adaptive capacity is low.

Asian Megadelta vulnerability

- Eleven megadeltas contribute about 40% to 50% of the world's sediment flux from the land to the ocean;
- The resulting alluvial soils have created some of the most fertile plains in the world supporting the livelihoods of millions of people, mainly located in seven megacities in the region;
- Human activities have resulted in severe coastal erosion of the megadeltas in Asia, with climate change expected to enhance erosion through increased frequency and level of inundation;
- Megadeltas are highlighted as one of most vulnerable regions due to global climate changes.

There are eleven megadeltas in the coastal zone and low-lying regions of Asia having an area greater than 10,000 km^2, which are heavily populated. The Yellow (Huanghe) River, Yangtze (Changjiang) River, Zhujiang (Pearl) River, Song Hong (Red) River, Mekong River, Chaophraya River, Ayeyarwady (Irrawaddy) River, Ganges-Brahmaputra River, Indus River, Narmada River, and the Godavari River contribute about 40 % to 50 % of the world's sediment flux from the land to the ocean (Chen, 2006). The alluvial soils deposited by these rivers have created some of the most fertile plains in the world supporting the livelihoods of millions of people, mainly located in seven megacities in the region (Nicholls, 1995).

Human activities in the drainage basins and coastal plains of the Asian megadeltas have already resulted in the decrease of sediment supply to the coasts due to dam construction, sand mining and irrigation projects. This has been compounded by relative sea-level rise and storm surge events and coastal subsidence due to excessive ground water extraction and coastal habitat destruction and degradation, for example deforestation of mangroves. These combined activities have resulted in severe coastal erosion of the megadeltas in Asia with climate change expected to enhance erosion through increased frequency and level of inundation of megadeltas due to storm surges and floods from river drainage (Nicholls, 2004; Woodroffe *et al.*, 2006). The Fourth Assessment Report of IPCC 2007 has highlighted the megadeltas as one of most vulnerable regions due to global climate changes (IPCC, 2007b).

6.1.3 Climate Change and the Convention on Biological Diversity

- Climate change is one of 17 cross-cutting issues of the Convention on Biological Diversity (CBD);
- **Mountain biodiversity** is a thematic programme with a programme of work which refers to global climate change;
- The relationship between **forest biodiversity** climate change has a clear focus in the forest biodiversity thematic programme. The CBD has also urged the UNFCCC, to ensure that its future activities, including forest and carbon sequestration, are consistent with and supportive of the conservation and sustainable use of biological diversity;
- **Marine and coastal biodiversity** is a CBD thematic programme and global climate change is seen as a major impact. The increasing severity of climate change-induced coral bleaching events is also a cause of concern. One of the goals of the programme is the establishment and maintenance of marine and coastal protected areas;
- Inland water was adopted as a CBD thematic area and the RAMSAR definition of **wetlands** has been included. The CBD recognises that climate change is the driver of wetlands change. Removing the existing pressures on wetlands and improving their resilience is considered the most effective method of coping with the adverse effects;
- Much of **Sub-Sahara Africa** is included in the dry and sub-humid lands biodiversity theme and programme. A joint work programme with the United Nations Convention to Combat Desertification seeks to address multiple and increasing threats, including from climate change.

Climate change is one of 17 cross-cutting issues of the Convention on Biological Diversity (CBD). The Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the CBD has adopted recommendations for the integration of climate change activities within the programmes of work of the CBD, taking into account reports and recommendations of the Third and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change, Technical Series No. 10 and No. 25 of the Convention on Biological Diversity and the Global Assessment on Peatlands, Biodiversity and Climate Change (CBD, 2007).

Mountain Biodiversity in the CBD

Mountain biodiversity is a thematic programme in the CBD. The programme of work focuses on addressing characteristics and problems that are specific to mountain biological diversity, including “the fragility of mountain ecosystems and species and their vulnerability to human and natural disturbances, in particular to land-use change and global climate change”. There are a number of goals and actions related to climate change, including:

1.1.5. Monitor and exchange information on the impacts of global climate change on mountain biological diversity, and identify and implement ways and means to reduce the negative impacts.

1.2.1. Develop and implement programmes to restore degraded mountain ecosystems and protect natural dynamic processes and maintain biological diversity in order to enhance the capacity of mountain ecosystems to resist and adapt to climate change, or recover from its negative impacts including, inter alia, by establishing corridors and taking appropriate measures to maintain ecological functions of natural corridors, where appropriate, to enable vertical migration of species, ensuring minimal viable population sizes to enable genetic adaptation to changing environmental conditions....

3.1.1. Promote the monitoring of susceptible areas subject to climate change.

Several of the adaptation and mitigation actions examined will contribute to or impact on the goals of the programme of work.

(from COP 7 Decision VII/27)

Forest Biodiversity in the CBD

Forest biodiversity is a thematic programme of the CBD arising from concern about their loss, fragmentation and degradation due to a number of causes, including climate change. Increasingly the importance of forest functions and services, such as recreation, health and well-being, maintenance of ecosystem services and the mitigation of climate change are being recognised, as well as the role of forests in the livelihoods of people.

The interaction with climate change is clear, with the CBD COP6 Decision VI/22 requesting the SBSTTA to consider before the sixth meeting of the COP the impact of climate change on forest biological diversity. It also urged the UNFCCC, to ensure that its future activities, including forest and carbon sequestration, are consistent with and supportive of the conservation and sustainable use of biological diversity.

Marine and Coastal Biodiversity in the CBD

Marine and coastal biodiversity is a thematic programme within the CBD and was adopted in 1995. Global climate change is identified as one of five major impacts. Although human degradation is currently more important, the increasing number and severity of climate change-induced coral bleaching events is also a cause of concern. As a result, the seventh meeting of the COP updated the specific work plan on coral bleaching with the aim to make it increasingly action-oriented in undertaking management actions and strategies to support reef resilience, rehabilitation and recovery. The amendments to the plan recognise the need to manage coral reefs for resistance and resilience to, and recovery from, episodes of raised sea temperatures and/or coral bleaching, including taking such factors into account in marine protected areas network design.

One of the goals of the Marine and Coastal Protected Areas programme is the establishment and maintenance of marine and coastal protected areas that are effectively managed, ecologically based and contribute to a global network of marine and coastal protected areas. This could be considered part of adaptation to climate change. Given the transnational nature of the marine environment, the CBD suggest that at the global level, the United Nations Environment Programme (UNEP) (including the Global International Water Assessment), the Food and Agriculture Organization of the United Nations (FAO), the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC/UNESCO), the International Maritime Organization (IMO), the United Nations and other relevant bodies should be encouraged to implement the programme of work.

Wetlands Biodiversity in the CBD

Inland waters was adopted as a CBD thematic area at COP 4 and they include lakes, rivers, ponds, streams, groundwater, springs, cave waters, floodplains, as well as bogs, marshes and swamps. The CBD has adopted the Ramsar Convention's definition of “wetland." as: "Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres." It identifies the actions that Parties need to carry out to halt the trend of biodiversity loss, including monitoring, assessment and evaluation of biological diversity of inland water ecosystems. The programme of work on the biodiversity of inland water ecosystems integrates with other work programmes and cross-cutting issues, particularly as freshwater is the major link between many different ecosystems and issues. It also promotes cooperation with other conventions and organizations through Joint Work Plans, in particular the Ramsar Convention on Wetlands and the Convention on Migratory Species.

The CBD recognises that climate change is the driver of wetlands change with the most rapid increase in impacts and that removing the existing pressures on wetlands and improving their resilience is the most effective method of coping with the adverse effects of climate change (Revenga and Kura, 2003). It is recommended that the implementation of the revised work programme on inland water biological diversity (Decision VII/4) should be guided by the Strategic Plan of the CBD and the Plan of Implementation of the World Summit on Sustainable Development, and their target of 2010 to reduce significantly the rate of biodiversity loss. Also, the programme of work should pay particular attention to the impacts of climate change and the role of inland waters in mitigation of and adaptation to climate change. In this process, the programme of work should consider, support and collaborate with ongoing and/or new initiatives in these areas and in particular those related to the conservation and sustainable use of peatlands.

Sub-Saharan Africa and the CBD

Much of Sub-Sahara Africa would be included in the dry and sub-humid lands biodiversity programme, which includes dryland, Mediterranean, arid, semi-arid, grassland. In this programme, a consideration of options for conservation and sustainable use of biological diversity in dryland, Mediterranean, arid, semi-arid, grassland and savannah ecosystems (COP V/23) resulted in part of Activity 7 recognising the need for "conservation *in situ* as well as *ex-situ*, as a complement to the latter, taking due account of better understanding of climate variability in developing effective *in situ* biological conservation strategies". Decision VIII/2 of COP 8 called for increased attention to climate change and governance and highlighted the need for more detailed assessments to measure progress towards the achievement of the 2010 Biodiversity Target in dry and sub-humid lands.

A joint work programme with the United Nations Convention to Combat Desertification on dry and sub-humid lands was also adopted by the COP to both Conventions in acknowledgement of the fact that biodiversity loss can be both a cause and a consequence of desertification. The joint work programme seeks to address the multiple and increasing threats to dry and sub-humid lands biodiversity, including climate change.

6.2 Climate Change, Mitigation and Biodiversity

- Climate change **mitigation** most relevant to biodiversity conservation is protecting and promoting land-use and habitats that acts as **carbon sinks;**
- Two important habitats that can make a significant contribution to carbon sequestration and storage are **forests** and **wetlands**;
- **Forests** are important in climate change and climate change mitigation because of their role in the carbon cycle;
- The world's forests contain significant carbon, with about 1.5 times as much in soil as in the vegetation;
- The **boreal** forest ecosystem is the world's largest and most important carbon sink largely because in boreal climates the colder temperatures reduce decomposition rates, resulting in deep organic soils that are thousands of years old;
- Increases in temperature, precipitation and water availability could significantly affect the carbon sequestration potential of forests, especially in some regions (e.g. Amazon drought);
- Climate change has raised the value of **wetlands** as stores and sinks of carbon. **Peatlands** are estimated to store over 25% of the soil carbon pool even though they cover only 3% of the world's land area;
- **Coastal wetlands** play an important role in reducing impacts from climate change by acting as buffer zones and sea defences against storm surges and extreme storm events.

Climate change mitigation, through reducing greenhouse gas emissions, is essentially achieved by two principal mechanisms:

- Protecting and promoting land-use and habitats that acts as carbon sinks, and
- Developing and encouraging non-carbon or carbon-neutral energy sources, and improving energy efficiency.

Clearly, the former mitigation activity is most relevant to Darwin Initiative projects through reducing emissions from deforestation and other forms of habitats destruction. Mitigation activities relating to the second category are more likely to involve human development and sustainable livelihoods approaches, for example, the introduction of improved fuel-efficient wood-burning stoves into rural communities for cooking purposes. Although this example will reduce greenhouse gases to the atmosphere, the main purpose of this activity is to avoid overexploitation and reduce pressure on forests, leading to fewer (potentially lengthy) excursions to collect fuelwood (conservation of human effort and time) rather than for climate change mitigation purposes, although some carbon offset organizations and projects are recognizing that these activities can make a contribution to mitigation if uptake of energy-efficient schemes can be scaled up. Two important habitats, which can make a potentially significant contribution to carbon sequestration and storage are forests and wetlands. In addition, coastal zones provide an important role in reducing the impacts of projected sea-level rise on terrestrial habitats.

Forests and climate change mitigation

Forests cover about 30% of the land surface, with about 42% in the tropics, 25% in the temperate, and 33% in the boreal zone (Sabine *et al.*, 2004). They are important in climate change and climate change mitigation because of their role in the carbon cycle through their current stock and sequestration potential. They store large quantities of carbon in vegetation and soil, exchange carbon with the atmosphere through photosynthesis and respiration, are sources of atmospheric carbon when they are disturbed or burnt, become atmospheric carbon sinks during abandonment and regeneration after disturbance, and they can be managed to alter their role in the carbon cycle.

The world's forests contain about 830 Pg C (10^{15} g carbon) in their vegetation and soil, with about 1.5 times as much in soil as in the vegetation (Brown, 1996). The boreal forest ecosystem supports nearly 50% of the world's remaining intact forests and is the world's largest and most important carbon sink storing up to 22 % of the total carbon in the terrestrial environment, and almost twice as much carbon per unit area as tropical forests. This is largely because in boreal climates, the colder temperatures reduce decomposition rates, resulting in deep organic soils that are thousands of years old (Watson *et al.*, 2000).

Increases in temperature, precipitation and water availability could significantly affect the carbon sequestration potential of forests, especially in some regions. For example, there is a high drought risk in the Amazon (Mahli *et al.*, 2007) and DGVM models (based on A2 emission scenarios) show significant forest dieback towards the end of this century and beyond in tropical, boreal and mountain areas, while increases in CO_2 may enhance productivity in other areas (Fischlin *et al.*, 2007).

Wetlands and climate change mitigation

Climate change has raised the value of wetlands through their potentially important role in climate mitigation. In particular, wetlands are an important store of carbon dioxide and act as significant sinks of atmospheric carbon dioxide with estimates of up to 40% of the global terrestrial carbon (Ramsar, 2001). Peatland regions and swamp forests are predominant as carbon sinks. Peatlands are estimated to store over 25% of the soil carbon pool even though they cover only 3% of the world's land area (Ramsar, 2001).

Marine and coastal habitats and climate change mitigation

Beaches, dunes, estuaries, mangroves and other coastal wetlands play an important role in reducing impacts from climate change by acting as buffer zones and sea defences against storm surges and extreme storm events. These 'shape-shifting' habitats have historically been well-equipped to cope with tidal surges, prevailing winds, storms and weather events. However, projected rapid climate change and associated extreme storm events will demand careful management through managed retreat to inland or by 'hard engineering' hold-the-line sea defences. The latter approach may be the only option as a result of built infrastructure associated with human habitation in many coastal areas; about 60% of the world's population already lives in coastal zones and this proportion is increasing (Ramsar, 2001). Although hard construction is the more traditional response to erosion, which involves the construction of structures to stop wave energy reaching the shore, or absorb and reflect the energy, these have often caused problems elsewhere, such as increasing erosion in other areas of the coast. 'Soft' sea defensive techniques, using natural features and systems, are now being recognized as a more appropriate response to coastal protection, which are more cost-effective to construct and maintain than hard engineering solutions, and may prove to be more resilient and sustainable in the long-term.

6.3 Climate Change, Adaptation and Biodiversity

- **Climate change adaptation** is the enabling of biodiversity to cope with and survive through climate change;
- There are limits to adaptation in natural ecosystems, small changes in climate may be disruptive and, beyond certain thresholds, natural systems may be unable to adapt at all;
- For biodiversity conservation adaptation, strategies should enable the maximum biodiversity resource to persist;
- Planned adaptation involves active intervention and management, e.g. the development of habitat "corridors" or the more strategic design of landscapes to facilitate the movement of species;
- Adaptation **principles** developed include actions to reduce direct and indirect impacts, increase resilience and accommodate change;
- **Measures** that support these principles include, direct management; promote dispersal of species; increase available habitat, promote ecosystem functioning, optimise sectoral responses, and continue to reduce pressures not linked to climate change;
- In order to implement these measures it is necessary to, conduct monitoring, develop and evidence base and communicate and transfer knowledge.

"There are clear limits to adaptation in natural ecosystems. Even small changes in climate may be disruptive for ecosystems (e.g. coral reefs, mangrove swamps) and will be exacerbated by existing stresses, such as pollution. Beyond certain thresholds, natural systems may be unable to adapt at all, such as mountainous habitats where the species have nowhere to migrate." (Stern, 2006, Chapter 18 p10). Adaptation is vital to avoiding unwanted impacts of climate change, especially in ecosystems, vulnerable to even moderate levels of warming, (Stern, 2006; IPCC, 2007b). It is also seen as a means maintaining or restoring of ecosystem resilience to single or multiple stresses (Convention on Biological Diversity, 2005).

With respect to biodiversity conservation, adaptation strategies should be designed to enable the maximum biodiversity resource to persist within the context of a changing climate. Some of these adaptations might be autonomous, i.e. systems responding to climate change without any active management intervention. This could include species dispersal and colonisation of new areas or *in situ* evolutionary responses. In contrast planned adaptation involves active intervention and management, for example promotion of dispersal by the development of habitat "corridors" or the more strategic design of landscapes to facilitate the movement of species.

The England Biodiversity Strategy (EBS) has proposed the following key principles for adaptation to a range of possible climate changes (Mitchell *et al.*, 2007):

- **Reduce direct impacts**
- **Reduce indirect impacts**
- **Increase resilience**
- **Accommodate change**

Although the EBS strategy was developed for the UK, the adaptation principles and strategies are applicable around the globe, subject to the capacity of the local governance and society. The direct impacts of climate change include, for example, changes in temperature and precipitation patterns, sea-level rise and an increase in the frequency of extreme events which will occur world-wide. The indirect impacts of climate change are related to the effects of responses in the management of other land and water systems as diverse as agriculture, water resources or town planning. Resilient ecosystems should be able to resist disturbance, maintain biodiversity and re-establish themselves. A system that accommodates changes is one where species can migrate easily and flourish in a new location quickly.

The EBS strategy proposes six practical measures which can be applied to promote adaptation. These are:

- Direct management to reduce impacts of climate change
- Promote dispersal of species
- Increase available habitat
- Promote conditions for ecosystem functioning
- Optimise sectoral responses (e.g. water resources management, forestry sector, etc) to climate change for biodiversity
- Continue to reduce pressures not linked to climate change

In order to implement these measures it is necessary to:

1. Conduct monitoring and surveillance
2. Develop the evidence base
3. Communicate and transfer knowledge

Some examples of application of these measures are as follows:

1. Direct management to reduce impacts of climate change
    a. Manipulate the microclimate to favour a threatened species
    b. Remove or reduce competition
    c. Alter the water inputs and drainage to optimise water regime
2. Promote dispersal of species
    a. Facilitate migration to new regions, altitudes or microclimates
    b. Enhance functional connectivity to allow species to disperse between habitat patches
    c. Increase connectivity and remove barriers to migration using corridors and stepping stones
    d. Improve the quality of the matrix of habitat patches, e.g. enhance and protect hedgerows and field margins
    e. Target habitat creation to fill gaps in an ecological network
    f. Monitor arrival of invasive species and control if undesirable
    g. Consider translocation of slow dispersing species which may not be able to respond quickly enough to climate changes

3. Increase available habitat
   a. Restore degraded habitats or create new areas of habitat to reduce landscape fragmentation
   b. Extend existing areas to support larger more resilient populations and to buffer them from disturbance
   c. Promote colonisation of extension areas from existing patches
   d. Increase the number of patches to assist dispersal and recolonisation following local extinctions
   e. Increase the range of soil types and topographical variations in microclimate within a habitat to provide microclimate refugia
4. Promote conditions for ecosystem functioning
   a. Maintain particular physical conditions where crucial for ecosystem functioning, for example:
      i. remove hard sea defences to allow erosion and deposition processes
      ii. maintain water levels in wetlands
   b. Research the linkages between biodiversity and ecosystem function as protecting species tends to protect some ecosystem processes
5. Optimise sectoral responses to climate change for biodiversity
   a. Consider biodiversity while planning changes in land use and management
   b. Seek solutions acceptable to all stakeholders which maintain or benefit biodiversity
   c. Improve education and knowledge transfer on best practices for maintaining biodiversity
6. Continue to reduce pressures not linked to climate change
   a. Lifting other pressures should reduce vulnerability to pressure from climate change
   b. Focus on local pressures which can be alleviated by changes by just a few stakeholders, e.g. negotiate reduced use of pesticides on a single farm
   c. Coordinate protected area schemes to effect changes at landscape level
   d. Lobby to change policy at a local authority or national government level

The examples above provide a cross section of adaptation strategies that could be incorporated into conservation projects as a long-term strategy for reducing impacts of climate change on species and habitats.

6.4 Climate Change, Monitoring and Biodiversity

- Good scientific monitoring allows biodiversity changes to be detected and quantified and provides an objective basis for assessing the nature and seriousness of threats to biodiversity and improves the understanding of the processes causing change, including that attributed to climate;
- The CBD has a theme on the Identification, Monitoring, Indicators and Assessment. Multiple indicators are required to derive trends and greater understanding of the detailed responses of biodiversity to climate change.

Need for monitoring for climate change

Climate change is just one of the five major threats to biodiversity (Secretariat of the Convention on Biological Diversity, 2006). The detection and attribution of climate change are only the first step in any climate change impact analysis; extending the detection and attribution analysis to observed changes in natural and managed systems is a more complex two-stage process (IPCC, 2003). The detection of climate change is the process of demonstrating that an observed change is statistically significantly different from what can be explained by natural variability (Mitchell *et al.*, 2001). The attribution of climate change to anthropogenic causes involves statistical analysis and the assessment of multiple lines of evidence to demonstrate, within a pre-specified margin of error, that the observed changes are (1) unlikely to be due entirely to natural internal climate variability; (2) consistent with estimated or modelled responses to the given combination of anthropogenic and natural forcing; and (3) not consistent with alternative, physically plausible explanations of recent climate change (based on Mitchell *et al.*, 2001). Both detection and attribution, however, are dependent on evidence that has been collected by (long-term) monitoring. In terms of biodiversity, both climate and non-climate drivers affect ecosystems, making the analysis of the role of climate in observed changes challenging (Rosenzweig *et al.*, 2007). Monitoring is also an important part of the evidence base which is necessary to underpin policy and management responses to adverse impacts. Good scientific monitoring allows changes to be detected and quantified and therefore provides an objective basis for assessing the nature and seriousness of threats to biodiversity. It also improves the understanding of the processes causing change and enables the testing of predictive models (Morecroft *et al.*, 2006).

Monitoring and the CBD

The CBD has an addition to the 2010 target which is a cross-cutting theme “Identification, Monitoring, Indicators and Assessment”. Already countries are obliged to assess the status and trends of biodiversity and this contributes to the assessing progress towards the 2010 target and the Ad Hoc Technical Expert Group on Biodiversity and Climate Change established under the Convention on Biological Diversity considered indicators as a possible tool for evaluating the effectiveness of projects to mitigate climate change and also sought to promote synergy between climate change mitigation and adaptation activities and the conservation and sustainable use of biodiversity (UNEP/CBD/SBSTTA/9/11). SBSTTA has also produced advice on designing national-level monitoring programmes and indicators (UNEP/CBD/SBSTTA/9/10).

The second edition of Global Biodiversity Outlook makes use of the indicators from the above theme and provides a clear presentation of the trends of biodiversity loss (Secretariat of the Convention on Biological Diversity, 2006). They point out that there is no single indicator of the impacts of climate change on biodiversity, but a number of indicators, including those on trends in extent of selected biomes, ecosystems and habitats (particularly applied to coral reefs, polar ice and glaciers, and certain types of forests and drylands), abundance and distribution of selected species, and incidence of human-induced ecosystem failure, can serve to derive trends where specific data are available. The trends in connectivity/fragmentation of ecosystems (for river and forest ecosystems) provide an indicator of the vulnerability of ecosystems to climate change. Thus there is a certain limited potential for DI projects to contribute to this monitoring and indicator work.

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Appendix 1: Terms of Reference

THE DARWIN INITIATIVE

ECTF THEMATIC REVIEW OF CLIMATE CHANGE AND BIODIVERSITY

Introduction

The Darwin Initiative (DI) has funded over 460 projects since 1992 centred on supporting biodiversity conservation in countries rich in biodiversity but poor in resources.

The impacts of climate change on biodiversity and the potential of biodiversity mitigating some impacts of climate change are increasingly being recognised. A small number of DI project have addressed climate change specifically while a larger number of projects have been engaged in activities related to climate change.

Climate change is one of 17 cross-cutting issues of the Convention on Biological Diversity (CBD). The Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) of the CBD has adopted recommendations for the integration of climate change activities within the programmes of work of the CBD, taking into account reports and recommendations of the Third and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change, Technical Series No. 10 and No. 25 of the Convention on Biological Diversity and the global Assessment on Peatlands, Biodiversity and Climate Change (CBD, 2007).

The Edinburgh Centre for Tropical Forests (ECTF) supports the Darwin Initiative through the Monitoring and Evaluation of programme implementation. This includes monitoring ongoing Darwin Initiative projects and supporting dissemination of progress reports, best practice guides, impact assessments and lessons learned from Darwin Projects and from the Programme as a whole. In order to identify impacts and the lasting legacy of the Darwin Initiative, ECTF also carries out thematic reviews of the Darwin Initiative. Climate Change and Biodiversity has been selected as the theme for one of the thematic reviews in the year 2007-08. The intention of this review is to assess the experiences of DI projects in relation to Climate Change and develop a set of best practice guidelines how current and more specifically new projects can incorporate or evaluate practical climate change mitigation, adaptation and other measures. The outcome of the thematic review will inform relevant practitioners addressing issues of climate change impacts on biodiversity in meeting conservation objectives as well as the DI Advisory Committee, DEFRA, and the wider biodiversity and climate change communities.

Objectives

The primary objective of this thematic review is to assess the extent and degree of success of DI projects in addressing CC impacts, adaptation and mitigation. This will lead to the development of more general guidance on how CC issues can be integrated, where appropriate, in future DI proposals and projects to strengthen the longer-term conservation of biodiversity and its sustainable uses, as well as the equitable sharing of its costs and benefits by communities and society at the local to global scales.

Tasks

The thematic review will make use of project annual and half-year reports and other project outputs together with MTRs, ECPs and questionnaires to project personnel and collaborators as well as telephone interviews and other information gathering methods, as appropriate. In support of the above-mentioned objective, the thematic review should:

1) Review the CBD climate change cross-cutting theme and its relevance to DI projects. This will be based upon an examination of all DI projects with respect to mitigation (e.g. carbon sequestration, biofuel production) and adaptation (e.g. translocation, ex-situ conservation, habitat restoration, connectivity and corridors) activities and the following priority habitats and geographical regions identified by the IPCC (IPCC, 2002).

Habitats:

- Terrestrial: tundra, boreal forest, mountain, mediterranean-type ecosystems.

- Marine and coastal zones: coral reefs, mangroves, salt marshes and the sea ice biome.

- Wetlands in the dry tropics and subtropics

Geographical Regions-

- Arctic, because of the impacts of high rates of projected warming on natural systems

- Africa, especially the sub-Saharan region, because of projected climate change impacts and low adaptive capacity

- Small islands, due to high exposure of population and infrastructure to> sea level rise and increased storm surges

- Asian megadeltas, due to large populations and high exposure to sea level> rise, storm surges and river flooding.

2) Analyse the links between climate change and the DI's portfolio of projects.

1. Projects directly addressing climate change issues.
2. Projects that have developed long-term monitoring protocols that could be valuable for identifying climate change impacts on biodiversity.
3. Projects that have incorporated adaptations to climate change.
4. Projects whose activities make a useful contribution to understanding and/or practical implementation of climate change mitigation and adaptation (eg through reducing other pressures, building ecosystem resilience, promoting sustainable livelihoods).
5. Projects that are generating long term data of relevance to climate change impacts assessments.
6. Projects that work with ecosystems and local communities particularly vulnerable to climate change.

3) Review the broader climate change programmes of other biodiversity initiatives to see where DI projects can potentially add value in terms of practical conservation action.

4) Analyse climate change issues related to sustainable livelihoods and biodiversity where DI projects are involving community participation.

5) Collect and present appropriate case study materials from DI projects.

6) Produce an in-depth analysis, as far as possible against the CBD theme, on the future and potential contribution of DI projects and programme to climate change issues – essentially how can DI projects be developed, planned and enhanced to make a positive contribution to climate change mitigation and adaptation in host countries, for example by;

- Identifying elements of biodiversity that are more vulnerable
- Integrating CC impacts, adaptation and mitigation within conservation strategies
- Generating data to provide evidence of impacts and support future predictions about climate change

- Preparing human resource capacities, especially the most vulnerable communities that depend on biodiversity
- Assessing sustainable use and livelihood responses to climate change
- Implementation of sustainable mitigation strategies (e.g. avoided deforestation, agroforestry, securing carbon stocks, land-use change to lower emissions, etc)
- Design and management of protected areas for vulnerable ecosystems
- Ex-situ conservation methods

7) Identify best practices related to climate change relevant to the programme and projects and;

8) Make recommendations for current and future DI projects, sharing case-study examples of best practice with the other biodiversity conservation initiatives and disseminate overall findings with the CBD and other biodiversity stakeholders.

Outputs

- A report documenting the analysis, conclusions and recommendations, and including appropriate illustrative case-studies, and identified best practices.
- A dissemination note (4 to 6 pages) for circulation to COP 8 and other interested parties drawing out main elements of thematic review report, making good use of graphics and photos.
- Poster for use at COP8 and other events (A0 size).

Timetable

The Thematic Review will commence in September 2007 and will be completed by 31 January 2008. A draft report will be presented to DEFRA for review, scheduled for 17 December 2007.

References

CBD, 2007, *Report of the subsidiary body on scientific, technical and technological advice on the work of its twelfth meeting*, Report No. UNEP/CBD/COP/9/2, Available at http://www.cbd.int/meetings/sbstta-12/ (last accessed 6th September 2007).

IPCC, 2002, *Climate Change and Biodiversity* (H Gitay, A Suárez, RT.Watson, DJ Dokken, Eds), IPCC, Geneva, Switzerland. pp 85. Online at: http://www.ipcc.ch/pub/tpbiodiv.pdf (last accessed on 3/10/2007).