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INTEGRATING CLIMATE CHANGE ADAPTATION INTO BIODIVERSITY AND FORESTRY PROGRAMMING

MARCH 2015

ARCC

African and Latin American Resilience to Climate Change Project

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AFRICAN AND LATIN AMERICAN RESILIENCE TO CLIMATE CHANGE (ARCC)

MARCH 2015

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ACRONYMS AND ABBREVIATIONS

AR4	IPCC Fourth Assessment report
AR5	IPCC Fifth Assessment report
ARCC	African and Latin American Resilience to Climate Change program
CBD	Convention on Biological Diversity
CCDS	Climate Change and Development Strategy
EbA	Ecosystem-based Adaptation
FAA	Foreign Assistance Act
GCM	General Circulation Model
IPCC	Intergovernmental Panel on Climate Change
PES	Payment for Ecosystem Services
REDD	Reducing Emissions from Deforestation and Forest Degradation
UNEP	United Nations Environment Program
UNFCCC	United National Framework Convention on Climate Change
USAID	United States Agency for International Development

1.0 INTRODUCTION

Conservation of biodiversity and tropical forests has long been a focus of United States Agency for International Development (USAID) environment and renewable natural resources programming. Indeed, this focus is congressionally mandated under the Foreign Assistance Act (FAA). More recently, addressing global climate change has become a USAID imperative across all development sectors. Although many USAID activities have combined funds for climate change adaptation with its biodiversity earmark, conceptual and programmatic integration of the two remains a work in progress. This brief, developed by USAID's African and Latin American Resilience to Climate Change program (ARCC), is one among several contributions to that conceptual and practical integration.

Key elements of USAID's guidance are placed in the context of scientific information on climate change (Section 2), impacts of climate change on biodiversity and ecosystem services (Section 3), and opportunities for integration of biodiversity conservation and climate change adaptation programming (Section 4).

1.1 USAID GUIDANCE ON BIODIVERSITY CONSERVATION AND CLIMATE CHANGE ADAPTATION

USAID has recent policy and operational documentation related to biodiversity and climate change programming. The ***USAID Biodiversity Policy*** (2014a) goals are to 1) conserve biodiversity in priority places, and 2) integrate biodiversity as an essential component of human development. The Agency has existing tools to guide programming decisions in this respect; these tools are under review to better integrate climate change adaptation aspects.[1]

USAID's approach to biodiversity conservation has long focused on reducing drivers (ultimate factors) and threats (proximate causes) of actual or potential biodiversity loss. Drivers are typically social, economic, political, institutional, or cultural factors, while threats fall into five broad categories in the Biodiversity Policy, which are congruent with those of the Convention on Biological Diversity (CBD):

1. Habitat loss and degradation,
2. Climate change,
3. Pollution and excessive nutrient load,
4. Overexploitation and unsustainable use, and
5. Invasive alien species.

The Biodiversity Policy updates the long-standing "biodiversity code" by elaborating on four criteria used for judging whether a program, project, or activity is eligible for earmarked biodiversity funding:

[1] For example, ARCC drafted a complementary brief, for internal use: "USAID Biodiversity Analyses and Climate Change Adaptation."

1. The program must have an explicit biodiversity objective; it is not enough to have biodiversity conservation result as a positive externality from another program.
2. Activities must be identified based on an analysis of drivers and threats to biodiversity and a corresponding theory of change.
3. Site-based programs must have the intent to affect biodiversity positively and in biologically significant areas.
4. The program must monitor indicators associated with a theory of change for biodiversity conservation.

The policy reviews opportunities for integrating biodiversity conservation and development through Country Development and Cooperation Strategies, activity design and implementation, and through monitoring and evaluation—in the last noting the need to track co-benefits from conservation in food security and other social and economic spheres.

USAID's Biodiversity Policy also references adaptation (Box 1) and its ***Climate Change and Development Strategy*** (CCDS) states that "Consideration of climate change… across a wide range of development sectors is essential to the success of USAID's mission" (USAID, 2012).

USAID thinking on linking conservation and climate change adaptation continues to evolve. A recent draft analysis on programming highlights opportunities for co-benefits whether funding is for biodiversity, adaptation, or a combination of the two, while still meeting specific requirements of each funding type.[2] A series of supporting case studies covering the Limpopo River Basin in southern Africa, central and southern Nepal, coastal Ecuador, and the Mekong Basin in Southeast Asia is drafted to inform the Agency's thinking on conservation and adaptation.

BOX 1: BIODIVERSITY AND CLIMATE CHANGE ADAPTATION (USAID, 2014A)

Climate change affects the distribution and abundance of vulnerable species, with changes in temperature, precipitation, seasonal patterns, and ocean conditions shifting suitable habitat. Changes in climate play an important role in ecosystem transitions and potential shifts as tipping points are reached. Aside from the ecological impacts of climate change on biodiversity, human communities without sustainable climate change adaptation options can put pressure on ecosystems, resulting in further degradation.

Ecosystem-based adaptation is an approach that incorporates biodiversity and ecosystem services; it can be a cost-effective way to help people adapt to climate change and buffer from climate-related shocks, while providing livelihood benefits that increase social resilience to such shocks. For vulnerable people dependent on ecosystem goods and services, ensuring that the protective and productive functions of ecosystems are maintained is crucial to successfully adapting to climate change. As a result, factoring in climate change and taking more adaptive approaches to conservation is becoming increasingly important to achieving conservation results and reducing people's vulnerability.

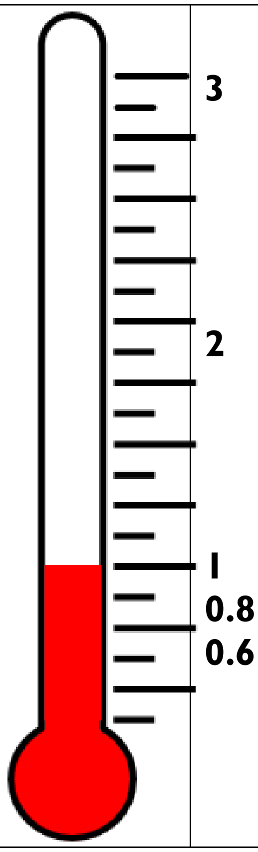
2 *Integrating Biodiversity and Climate Change Adaptation in Activity Design* (USAID, in draft, as this document was finalized).

1.2 EFFECTS OF CLIMATE CHANGE ON BIODIVERSITY AND FORESTS

USAID's Biodiversity Policy adopts the CBD definition of biodiversity as "The variability among living organisms from all sources including, inter alia, terrestrial, marine and other ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems." As discussed in Section 1.1, climate change is only one of five main categories of direct, biophysical threats to biodiversity. It is a threat of uncertain magnitude, and it is likely to accentuate other kinds of threats—especially the conversion of natural ecosystems to agriculture and other uses, currently the main threat to biodiversity worldwide.

The Intergovernmental Panel on Climate Change Fourth Assessment Report[3] provides evidence on effects of temperature rise on some taxa and ecosystem types (Figure 1). Other less predictable climate effects (precipitation, cloud cover, seasonal shifts) and other factors affecting biodiversity come into play in determining biodiversity outcomes.

FIGURE 1. OBSERVED AND PREDICTED IMPACTS OF GLOBAL TEMPERATURE INCREASE ON BIODIVERSITY ATTRIBUTES

°C above pre-industrial level	Selected impacts on biodiversity (compiled by IPCC AR4, 2007)
 	**Predicted impacts** ← All coral reefs extinct 3.1 ← Cloud forests much reduced or extinct 2.8 ← Major loss of Amazon rain forest 2.5 ← Biosphere carbon sink changes to net source 2.5 ← Climatic range of > 5000 African plant species exceeded 2.4 ← 30% rivers lose 10% fish species 2.4 ← 8-12% African larger mammal species extinct (or near) in National Parks 2.2 ← 41-51% of S Africa/Namibia endemic species lost 2.1 ← 2-18% Mexican mammal species committed to extinction 1.7 ← 38-45% Brazilian cerrado plant species committed to extinction 1.7 ← SE Asia and Caribbean coral reefs bleached 1.7 ← 9-31% global species committed to extinction 1.6 **Observed impacts** ← **Estimated average global surface temperature increase since 1850** ← Amphibian extinctions caused by disease linked to climate change 0.6 ← Increased coral bleaching in Caribbean and Indian Ocean 0.6

[3] IPCC Fourth and Fifth Assessment Reports are located at: https://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

While not directly updating information equivalent to that in Figure 1, the more recent IPCC Fifth Assessment Report (AR5, 2013/2014) provides additional perspectives on biodiversity vulnerabilities. For example, using studies on the speed at which the populations of different taxonomic groups may move across a relatively flat landscape, and with unabated emissions, plants (whether trees or herbaceous species) are the most vulnerable; along with rodents and primates they cannot "move" quickly enough, whereas ungulates, mammalian carnivores, herbivorous insects, and fresh water mollusks typically may outstrip climate change for the remainder of this century. Nevertheless, huge variation between studies and species along with more varied terrain and other biodiversity threats such as habitat destruction mean that conclusions need to be site- and circumstance-specific to enable reasonable prediction. The diversity within ecosystems also means that impacts are multifaceted and not uniform. For example, the broad impact on coral reefs is not as simple as depicted in Figure 1. These conclusions tend to assume that all corals respond exactly the same and that their symbiotic algae all respond exactly the same (bleaching) to the same temperature rise. In reality, there is variation between species and locations and in the potential for genetic adaptation to higher temperatures (Hughes et al., 2003). Reefs do not lose their symbionts, or die themselves, at one specific temperature, but they are especially sensitive to temperature and are changing and becoming impoverished at varying rates as a result of diverse threats. Similar variations in response exist in other taxa and ecosystems, including forests.

2.0 CLIMATE CHANGE INFORMATION

2.1 CLIMATE DATA AND MODELS

Weather stations record climate variables over time. Temperature and rainfall are the most common variables, though many additional parameters such as solar radiation, winds, cloud cover, humidity, and evaporation are estimated at more sophisticated stations. International organizations such as the International Maritime Organization, World Meteorological Organization, and the Global Climate Observing System encourage collection and facilitate sharing of meteorological observations; they also invest in digitizing, error checking, and adjusting data to account for known problems and biases. Because weather stations are often widely scattered, characterizing climate at a specific site usually requires spatial interpolation using records from stations located closest to the site. Weather stations are relatively sparsely distributed in many developing countries, resulting in reduced quality of interpolated information in these regions.

Climate models try to model how these different components of the climate system interact, and how the feedback processes between them work to provide predictions about future climate patterns. These models depend on an understanding of physical processes and statistically determined relationships between multiple variables that influence the Earth's climate system. General Circulation Models (GCMs) simulate interactions between gases in the atmosphere and incoming and outgoing radiation, the way the atmosphere circulates, cloud formation and precipitation, interactions between the atmosphere and the oceans, and land cover change (snow and ice cover, vegetation change).

Greenhouse gas emissions depend in part on human economic activities, so predicting their future levels is the realm of socioeconomic modelers. The IPCC has developed sets of socioeconomic assumptions relating to demographic, social, economic, technological, and environmental factors, which model potential future global greenhouse gas emission scenarios. IPCC tracks the trajectory of real emissions through time, comparing them against their models, and periodically revises the socioeconomic assumptions upon which their global greenhouse gas emission scenarios are based. Worldclim (www.worldclim.org) provides a range of download options for different climate models and IPCC greenhouse gas emission scenarios.

2.2 CLIMATE PROJECTIONS

Two approaches are used to predict "climate futures" for specific areas—projection of observed trends from weather stations and "downscaled" predictions from global climate models (which themselves combine weather station observations with many other parameters—see an ARCC review of downscaling, USAID, 2014c). While both approaches consistently show increasing temperatures, predictions for precipitation are not as consistent. For example, in highland prime agricultural areas of Kenya, trends over the past 30 years indicate reduced growing season rainfall, whereas GCMs predict that rainfall will increase during the same months (USGS, 2010 and CIAT, 2011, respectively). Where available, region-specific models, though in early stages of development, may provide better agreement with observed trends than downscaled global models (for example for the African continent, Buontempo et al., 2014). These differences serve to emphasize the need for continued refinement of models as well as improved monitoring of observable weather and climate trends. Uncertainty in prediction of climate change and its impacts is well recognized,[4] and in turn affects feasible adaptation options and responses, whether for biodiversity conservation, forestry, or other sectors.

IPCC AR5 uses four scenarios generated from global climate models ranging from unchanged trends in carbon emissions to significant reductions over the remainder of the twenty-first century. AR5 then assesses probability of outcomes for specific factors (such as temperature or sea level) related to these carbon emission scenarios. Annex II to the Working Group 1 report provides regional projections for climate-related parameters; it is a useful but coarse starting point for assessing future climate in particular places.

The IPCC's probability approach and widely differing scenarios emphasize the uncertainty of predicting specific outcomes and the need for vulnerability assessments and adaptation strategies to consider uncertainty. For example in its AR5 "Summary for Policymakers," IPCC indicates that:

- Global surface temperatures will increase by 0.3–1.7 °C (2016–2035 relative to 1986–2005) with the most optimistic scenario for reduced carbon emissions and by 2.6–4.8 °C if current trends continue.
- Sea-level rise for the same period ranges from 0.26 to 0.55 meters (likely) to 0.45 to 0.82 meters (medium confidence[5]) with the same scenarios. Likely in this context means 66–100 percent assessed likelihood, or statistical probability; medium confidence reflects a broader and more qualitative scale reflecting data quality and consistency.
- It is virtually certain (99–100 percent probable) that "there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales."
- Extreme precipitation events over mid-latitude lands and wet tropical regions will "very likely" become more intense and more frequent by the end of the century.
- There is high confidence that "near term increases in seasonal mean and annual mean temperatures are expected to be larger in the tropics and sub-tropics than in mid-latitudes."

Annex A1 of IPCC AR5 provides an atlas of global and regional climate projections for the near term (2016–2035), mid-term (2046–2065) and long term (2081–2100). The near-term projections overlap the scope of USAID's programming cycle, while the longer-term (and consequently more uncertain) projections also provide useful advisory context even for near-term programming.

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4 https://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf

5 See AR5 for the complete confidence and probability scales used, available at http://www.ipcc.ch/

3.0 VULNERABILITY OF BIODIVERSITY TO CLIMATE CHANGE

Vulnerability of biodiversity and forests to climate change is not a unitary concept as threats, impacts, processes, and inherent resilience or adaptive capacity vary across the hierarchy from genes to biomes. Nor is climate vulnerability independent of other anthropogenic threats to biodiversity (Section 1.1). At ecosystem, landscape, and seascape levels, biotic vulnerability and the supply of ecological goods and services become inseparable from human impacts and socioeconomic systems. This section reviews vulnerability and adaptive capacity of biota at various levels (3.1) and the adaptive interaction of human systems with ecological vulnerability (3.2), as well as integrative policy and economic mechanisms for maintaining ecological connectivity in a changing climate (3.3).

3.1 VULNERABILITY OF BIOTA

Kittel (2012) reviews, with extensive supporting literature, "the vulnerability of biodiversity to rapid climate change across [the biodiversity hierarchy]" and proposes strategic approaches to conservation taking account of vulnerability and uncertainty (see Section 4). He notes the following general ways in which biodiversity is impacted:

- Shifting geographic ranges of marine, continental-water, and terrestrial species;
- Altered species phenologies;
- Species interactions spatially and temporally out of phase—altering food webs, competitive interactions, and mutual associations (e.g., pollination);
- Changing community structure—potentially giving rise to novel ecosystem types;
- Changes in ecosystem function—altering biophysical and biogeochemical processes, including primary production; and
- Disruption of ecosystem services—affecting societal use of resources such as water and food.

3.1.1 Genes and Species

Genetic diversity within populations allows adaptation through evolution to changing biophysical conditions. Genetic diversity is important in determining the resilience of species because a diverse array of genes is more likely to include those enabling adaptation to new climatic conditions.

Individual organisms have micro-climate tolerance limits that are directly affected by climate change—organisms can either die, move to new areas within their tolerance limits, or if suitable mutations arise, adapt to the new conditions through natural selection. Depending on various physiological, genetic, and ecological conditions, some species may adapt quickly enough to projected climate change while others cannot, leading to a "winners and losers" situation detrimental to overall biodiversity and ecological integrity of forests and other ecosystems (e.g., Somero, 2010; van Heerwarden and Sgro, 2014). In general, species with long-lived individuals that produce few offspring are less likely to adapt quickly (i.e., more vulnerable), but such species often have keystone functions in ecosystem structure and processes.

Movements and range shifts, including changes in latitudinal and altitudinal range limits, are the most common response observed so far (Hickling et al., 2006; Raxworthy, et al., 2008; Chen et al., 2011). The ranges of many species already have shifted toward higher latitudes and altitudes, as predicted under a warming global climate.

A scenario analysis of extinction risk for selected endemic species from a range of biomes, based on climate change, predicted 11-58 percent of studied species "committed to extinction" by 2050 (Thomas et al., 2004). Lower projections in this range assume modest climate change (0.8–1.7 ˚C) and ease of species dispersal while higher projections assume greater climate change (> 2 ˚C) and no ability to disperse. Although this model assumed no genetic adaptation and looked only at endemics in selected areas,[6] the predictions emphasize the significance of the climate change threat, and the adaptation and mitigation imperatives. Another study assessed the threat of climate change to all known species of corals, birds, and amphibians (Foden et al., 2008). An estimated 68-83 percent of species classified as threatened by other factors are further threatened by climate change, and 28-72 percent of species currently not classified as threatened are likely to become threatened due to climate change.

In addition to direct effects of climate change, indirect effects (often synergistic with other effects) will impact many species. For example, ocean acidification resulting from increased carbon dioxide is a threat to some marine organisms, and changes in fire regimes threaten some terrestrial species.

3.1.2 Ecosystems and Biomes

Climate change is predicted to have different kinds of effects on ecosystems, with differing probabilities including changes in their distribution, composition, structure, dynamics, and ecological processes and functions. One of the more certain predictions is that the ranges of some species will expand into new regions under future climate conditions, and in many cases those species will compete with established species and thereby affect the composition, structure, and functioning of ecosystems (CBD, 2009b). Some ecosystems seem highly threatened in their entirety by climate change—notably coral reefs through the bleaching effect of temperature (but also see Section 1.2), as well as tropical highland cloud forests. The latter occur in relatively small areas as a result of specific climate regimes, have many endemic species, and are already diminishing as a result of multiple pressures including climate change (Foster, 2001).

Classification of ecosystem types as biomes is largely based on temperature and rainfall patterns. As climate changes, therefore, so will the distribution of biomes. An assessment of global patterns of these major vegetation types predicts that one-tenth to one-half of biome cover is vulnerable to predicted climate change through the end of this century (Figure 2, Gonzalez et al., 2010). The model includes nine climate change scenarios along with soil types, wildfire increase or decrease predictions, and human population growth among other variables. Highly to very highly vulnerable regions include the Andes, the Baltic coast, boreal Canada and Russia, the Himalayas, the Iberian Peninsula, the Laurentian Great

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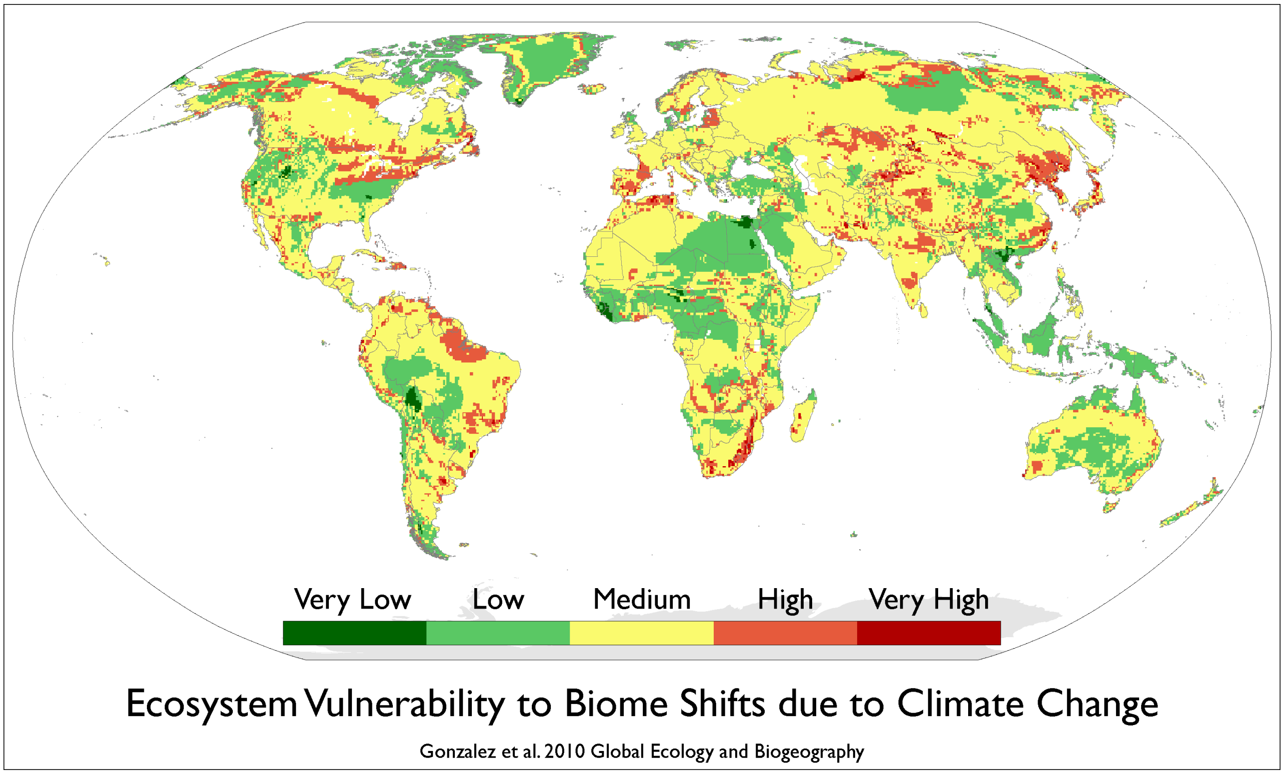
6 Queensland Australia, Mexico and South Africa for mammals, birds, frogs, reptiles, butterflies and other insects for fauna; Amazonia, Europe, Cerrado of South America and South African Proteaceae for flora.

Lakes, northern Brazil, and southern Africa. The authors also note that up to one-quarter of the human population lives in areas of potential biome change and are likely to be affected by concomitant changes to ecosystem services (see Section 3.2).

FIGURE 2. PREDICTIONS OF THE VULNERABILITY OF ECOSYSTEMS AS A RESULT BIOME SHIFTS DUE TO PROJECTED CLIMATE CHANGE THROUGH 2100

Vulnerability categories correspond to the IPCC-AR5 confidence levels. See Gonzalez et al. (2010) for details and methods. Reproduction of this map for this specific use is with the kind permission of Patrick Gonzalez.



3.2 THE ROLE OF BIODIVERSITY IN REDUCING SOCIETAL VULNERABILITY

Biodiversity conservation for societal adaptation to climate change is best promoted by emphasizing two related concepts stressed in USAID's CCDS and Biodiversity Policy: ecological goods and services, and ecosystem-based adaptation (EbA).

The role of biodiversity in maintaining ecological processes and functions is not completely understood, but "there is now unequivocal evidence that biodiversity loss reduces the efficiency by which ecological communities capture biologically essential resources, produce biomass, decompose and recycle biologically essential nutrients" (Cardinale et al., 2012). Because biodiversity underpins ecosystem services, this principle provides a strong link between climate change and conservation. The CCDS states that: "Although these [ecosystem] services are critical to development, they are often not valued appropriately in the marketplace."

Although an ecosystem can be minute conceptually (for example a leaf, or strand of kelp) from a planning and programmatic perspective large interlinked and interdependent systems at landscape or seascape levels are those relevant for both conservation and development in an era of rapid climate change. Climate change may alter or disrupt landscape- or seascape-level ecological processes, from which humans derive ecosystem products and services.

The need to be aware of potential effects on biodiversity and forests from climate change adaptation measures taken in other sectors has long been recognized. A comprehensive review concludes that "Climate change impacts can be exacerbated by management practices, such as the development of seawalls, flood management and fire management, that do not consider other sectors such as biodiversity conservation and water resource management; this results in maladaptation in the longer term" (CBD, 2009b).

The poor and food insecure are the most vulnerable to climate change-induced biodiversity loss. Low technological input levels and lack of financial resources to invest make them more climate-vulnerable and forces them to seek alternative food sources such as wild foods and other supplies from nearby biodiverse ecosystems such as forests and coral reefs. This situation creates a positive feedback loop of more reliance but less availability of wild food and decline in biodiversity and other ecological services from ever more degraded ecosystems. The juxtaposition of poverty and biodiversity hotspots in many parts of the tropics makes both highly vulnerable to climate change. Analysis of this nexus identified the following regions for priority adaptation interventions, ten global and seven regional (Hannah et al., 2013):

- Global: Central America, Caribbean, Andes, Guiana Highlands, Atlantic Coast of Brazil, Albertine Rift (Uganda, Democratic Republic of Congo), Madagascar, Western Ghats (India), Philippines, and Java.
- Regional: northwest Mexico, southern Ivory Coast, Cross River (Nigeria, Cameroon), western Himalaya (Pakistan), eastern Himalaya (India, Bhutan, Myanmar), Sulawesi, and New Guinea.

Similar relationships are evident between concurrent degradation of water resources and aquatic biodiversity. Although causal relationships between good-quality human water supply, climate change, and aquatic ecosystems and biodiversity are less well established than in land-based systems, correlation seems clear in wetlands, rivers, and coastal ecosystems (e.g., Wetlands International, 2010; Vorosmarty et al., 2010; and USAID, 2009, respectively).

3.2.1 Ecosystem Services

Ecosystem services are defined by CBD (and adopted in USAID's Biodiversity Policy) as: "The short- and long-term benefits people obtain from ecosystems. They include 1) provisioning goods and services, or the production of basic goods such as food, water, fish, fuels, timber, and fiber; 2) regulating services, such as flood protection, purification of air and water, waste absorption, disease control, and climate regulation; 3) cultural services that provide spiritual, aesthetic, and recreational benefits; and 4) supporting services necessary for the production of all other ecosystem services, such as soil formation, production of oxygen, crop pollination, carbon sequestration, photosynthesis, and nutrient cycling."

Among ecosystem services likely to be negatively impacted by climate change are:

- Damage to coral reefs and mangroves from temperature and sea-level rise and their coastal protection and fisheries services;
- Altered timber and non-wood product supply and hydrological services (water quantity, quality, and flow regimes) provided by forests from range shifts and increased pest or pathogen outbreaks or wildfires;
- Reduced levels of pollination of economically important crops;

- Reduced populations of predator species (e.g., bats, birds, predatory wasps), affecting regulation of the pest species they consume; and
- Changes in rates of photosynthesis (and plant production), which may increase at high latitudes but may decrease in hotter tropical environments where plants are already operating close to temperature thresholds above which carbon dioxide uptake through photosynthesis declines.

For example, a global assessment of recent tree mortality attributed to drought and heat stress suggests that at least some of the world's forest ecosystems are already responding to climate change in ways that threaten hydrological services (Allen et al., 2010). Pollination is a vital ecosystem service in natural and human systems. Evidence suggests that as climate changes, phenological divergence between plants and pollinators may significantly affect their interactions (Bertin, 2008). Models suggest that climate change effects on flowering will reduce the food available to up to half of all species of pollinators (CBD, 2009b).

3.2.2 Ecosystem-based Adaptation

EbA is the "use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change" (IUCN, 2009b). The concept and systems promoting its use are diverse.[7] Nevertheless, application of EbA is in its early stages and may not be widely understood in other sectors. There may be country-specific circumstances, therefore, where other frameworks focusing on human needs for ecosystem goods and services are more rewarding than EbA until is more widely adopted and integrated into a range of development sectors. Ecological concepts that could be classified as EbA are sometimes applied without using the term in managing adaptation across sectors (IIED, 2011),

According to CBD (2009c): "ecosystem-based adaptation can help to achieve a number of multiple benefits, including for adaptation, biodiversity, mitigation and livelihoods; … Examples of ecosystem-based adaptation [taking account of climate stresses risks and impacts in these sectors and ecological zones] include:

- Sustainable water management where river basins, aquifers, flood plains and their associated vegetation provide water storage and flood regulation.
- Disaster risk reduction where restoration of coastal habitats such as mangroves, or the flood mitigation services provided by wetlands, can be a particularly effective measure against storm surges, coastal erosion and flood risk.
- Sustainable management of grasslands and rangelands, to enhance pastoral livelihoods.
- Establishment of diverse agricultural systems, where using indigenous knowledge of specific crop and livestock varieties, maintaining genetic diversity of crops and livestock, and conserving diverse agricultural landscapes secure food provision in changing local climatic conditions.
- Establishing and effectively managing protected-area systems to ensure the continued delivery of ecosystem services that increase resilience to climate change."

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[7] Several organizations have developed ecosystem-based adaptation concepts (Africa Biodiversity Collaborative Group, 2011; CBD, 2009a; IUCN, 2010; TNC, 2009; 2010; WRI, 2011).

The United Nations Environment Program (UNEP) (2012) notes that EbA expects to deliver co-benefits, but evidence remains incomplete – programs need to incorporate monitoring and evaluation, and cost-benefit approaches incorporating valuation of ecosystem services. Nevertheless, evidence is accumulating as shown in a review of more than a hundred published articles by IIED (2011). Findings indicate that, although evidence is evenly spread among developing and developed countries, it is uneven between biomes, and information on human-dominated ecosystems predominate; and most fully analysed studies conclude that EbA is effective, at least in the short-term. However, the evidence gaps needing more definitive study include:

- Comparisons between EbA and other adaptation strategies that combine and effectively monitor social, environmental, and economic aspects;
- Understanding what EbA approaches are applicable in differing climate and environmental circumstances taking account of potential resilience thresholds and tipping points;
- Better information on the cost aspect of cost/benefit analysis; and
- Intersection of EbA with national policies plans and institutions as an influence on effectiveness.

3.2.3 Incentives for Ecological Connectivity

Landscapes resilient to climate change require resilient ecosystems, which in turn require connectivity between populations of flora and fauna and ecosystem services to local and more distant human populations. The environmental shifts caused by climate change require management of land and aquatic systems that enable migration of flora, fauna, and ecological associations and processes within and between landscapes and seascapes.

Conservation areas on public land, typically for biodiversity or water catchment, strictly limit human activities, but are often "natural" islands surrounded by more intense human activities—predominantly agriculture, but also industrial and urban development often occurring on private land (though tenure arrangements are diverse and not always conducive to conservation opportunities). Biodiversity conservation in response to climate change necessitates that these islands are connected by corridors as buffer zones, habitat patches, and other land use management tools on these intervening areas. Various economic, regulatory, and incentive mechanisms exist to encourage conservation on private or quasi-private land:

- Private conservation areas, for example the conservancy movement in eastern and southern Africa where private and community land owners typically combine wildlife management with tourism income and livestock production (e.g., Lindsey et al., 2009; Glew et al., 2010; IISD, 2009).
- Conservation easements where often a government financial incentive (such as tax relief) and policy framework encourages land owners to maintain biodiverse areas such as indigenous forests, often in perpetuity. The Nature Conservancy has long advocated and practiced this approach in the USA and elsewhere (TNC, n.d.). Legal instruments and opportunities exist in some developing countries, but uptake is not yet widespread (ELI, 2003; Watson et al., 2010).

- Climate-smart agriculture is advocated by many development organizations[8] and many of the practices can have positive biodiversity/connectivity benefits through use of indigenous trees and the biota/habitat impacts of improved soil and water management. At a landscape level, climate-smart agriculture promotes diversity of land use as a resilience mechanism that promotes conservation and ecosystem services (Scherr et al., 2012).

Although these types of land use have their own economic benefits, payment for environmental services (PES) schemes potentially provide additional financial incentives. Payments by downstream water users to upstream land users who maintain good quality and quality of supply, for example by maintaining forests, is one possibility. Carbon credit schemes are another, whether for soil, or perennial vegetation on farm, or in conserved natural vegetation, which also have climate change mitigation benefits. PES schemes are challenging to establish, especially when incorporating numerous smallholders or other community beneficiaries, but these types of stakeholders are often essential to viable schemes in countries with a large rural population. An adjunct to PES is valuation of the resource in question, either through its economic contribution to beneficiaries, or through a real or notional market mechanism (supply/demand or willingness to pay). Economic valuation of biodiversity and other natural resources is advocated by the USAID Biodiversity Policy, and especially if referenced to climate change adaptation scenarios, is an important contribution to policy debates as well as practical interventions across a range of sectors that interact with biodiversity conservation and forestry.

[8] http://ccafs.cgiar.org/climate-smart-agriculture#.VP2aM_nF8ms ; http://www.worldbank.org/en/topic/agriculture/brief/foster-climate-smart-agriculture ; http://www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/09/AGRICULTURE-Action-Plan.pdf

4.0 CONCLUSIONS: OPPORTUNITIES FOR INTEGRATED PROGRAMMING

Much of USAID's biodiversity earmark programming seeks opportunities for combined biodiversity and societal benefits. The label "Integrated Conservation and Development Projects" was a cornerstone of field-based biodiversity activities for many years, and although the approaches and terminology has evolved, activities still seek to combine conservation and community benefits—increasingly with other co-benefits including decentralized governance, land and resource rights, gender integration, property rights, and conflict mitigation—as well as climate change adaptation and mitigation.

USAID's Biodiversity Policy stresses reduction of drivers of biodiversity loss and threats to biodiversity and often, at field level, seeks to mitigate negative impacts. Different types of intervention address different aspects of the driver to impact continuum. For example, policy support is important for reducing drivers, not only in the biodiversity arena, but across all sectors. Identification and reduction of threats is best tackled in the formulation of national or subnational strategies and plans in all relevant sectors while specific threats and impacts should be addressed in site-based plans and activities. Applying a climate change adaptation lens is important at all these levels.

Monitoring and evaluation protocols need to stress developing indicators of climate change adaptation that estimate co-benefits of biodiversity conservation and forestry across appropriate sectors. However, both conservation and adaptation outcomes may take a decade or more to adequately attribute results to programmatic interventions because of long natural cycles (e.g., of forest succession), climatic fluctuations around long-term trends, and the possibility of changing socioeconomic and land use pressures confounding short-term progress. Such long time horizons for impact monitoring stretch beyond typical strategy and project cycles, and call for continuity in programming or periodic evaluations beyond project interventions.

4.1 BIODIVERSITY-LED PROGRAMS

Biodiversity managers propose many ways of addressing climate change. Vulnerability assessments and adaptation options should be integrated into national policies, institutions, and plans (such as those for biodiversity and climate change under the respective CBD and United Nations Framework Convention on Climate Change [UNFCCC] treaties, and site-based strategic and action plans, preferably at landscape level). There is extensive recent literature discussing how to assess the vulnerability of biodiversity to climate change and incorporate those considerations into conservation planning

(Spittlehouse and Steward, 2003; Millar et al., 2007; Guariguata et al., 2008; Heller and Zavaleta, 2009; Cross et al., 2012). Several prominent international nongovernment organizations have developed methods to assess climate change adaptation for biodiversity conservation,[9] some of which primarily address ecological aspects (National Wildlife Federation, 2011; Wildlife Conservation Society, 2011 WWF, 2003), but others combine both ecological and social methods (TNC, 2010; WRI, 2011).

At landscape or seascape level, the most effective strategy for preserving genetic diversity within species will likely include conserving populations of each species over as large a part of their range as possible, maximizing population and habitat patch sizes and maintaining dispersal corridors to allow movement (of either plants or animals) that will reduce inbreeding and loss of genetic diversity. CBD suggests meeting these goals through changes in the extent and design of protected area systems, changes in protected area management systems, and management of the wider landscape to ensure ecological connectivity (CBD, 2009b). These are primarily social challenges that highlight the need for fully embedding social considerations into and taking a social-ecological approach to conservation planning.

A review of more than 500 citations over the last three decades found 113 categories of recommendation, which were ranked by frequency of occurrence, related to climate change adaptation (Heller and Zavaleta, 2008). Recommendations were categorized as conservation, 57 percent (reserve extension, management, restoration and regional coordination); science and technology, 28 percent (research and modeling); policy, 12 percent (land use, governance, capacity); and 4 percent individual landowner or community action. The 10 most-cited approaches were:

1. Increase connectivity (including corridors, reduction in dispersal barriers, reforestation).
2. Integrate climate change into planning.
3. Mitigate other threats (see Section 1.1).
4. Conduct research on species responses to climate change.
5. Intensively manage to secure viable populations.
6. Translocate species to suitable areas.
7. Increase reserve number.
8. Address scale issues through modeling, management, and experiments.
9. Improve inter-agency and regional coordination.
10. Improve basic monitoring.

These, and the additional 100+ types of recommendations provide a menu, or perhaps a smorgasbord, of programming options—most of which are compatible with the USAID Biodiversity Policy. However, the authors were alarmed to note that the recommendations cited focus on ecological rather than social aspects. USAID's mandate and experience would certainly agree with the conclusion that "a holistic landscape approach … driven by a vision of humans and other species co-mingling across reserves and developed lands …" is critical to programming.

[9] These and other methods are reviewed in an unpublished ARCC document by Bruce Byers and Alison Cameron from the perspective of EbA and use of the resilience concept.

In essence, adaptation programming needs a vulnerability approach to biodiversity conservation and forestry planning that (Kittel, 2012):

- Synthesizes established knowledge to assess resilience of species and systems and develop adaptive strategies;
- Uses scenario planning to review options, given the uncertainties of climate projections and ecological models;
- Implements "no regrets" climate adaptive strategies, which benefit current conservation and forestry needs and reduce species and system vulnerabilities to other (non-climate) threats; and
- Ensures adaptive monitoring and management protocols are employed to respond to new information or circumstances.

Where specific climate change-biodiversity threats are identified, it may be possible to design and implement targeted adaptation responses that take account of the approaches listed.

USAID would wish to underpin these planning and decision-making approaches with appropriate governance principles and actions that ensure participatory, rights-based, gender-integrated planning and implementation encompassing all legitimate stakeholders. A landscape or seascape approach is also critical, which includes all natural resource users to optimize co-benefits, but also trade-offs between conservation and development objectives.

4.2 ADAPTATION-LED PROGRAMS

USAID's climate change programming spreads across all relevant sectors as noted in Section 1.1. Typically those programs outside the environment and natural resources portfolio pay less attention to biodiversity conservation and forestry.

Nevertheless, the Agency has tools, such as the FAA, which require periodic Biodiversity and Tropical Forestry Assessments in cooperating countries. These assessments typically look at programming across sectors and identify where biodiversity issues can be addressed, and are beginning to include climate change threats. Each program or project is also subject to an environmental assessment (typically an Initial Environmental Examination unless significant probable impacts are identified). Biodiversity, forestry, and climate change aspects are applicable at this stage too. Most assisted countries have their own environmental assessment requirements. Where agreed, support to make these processes more effective and inclusive of biodiversity, forestry, and climate change adaptation considerations are helpful integrative programmatic interventions.

USAID could usefully incorporate ecological, social, and economic analyses of ecosystem services into program or activity design or implementation in appropriate sectors (such as food security and water resources), with a view toward assessing feasibility of payment for PES (Section 3.2.3). Such schemes tend to have high set-up costs to which a donor contribution can facilitate until they provide a long-lasting financial incentive for communities, biodiversity, and maintenance of ecosystem services.

The key to biodiversity and forestry integration in climate adaptation programs is through recognition of ecological services that depend upon biodiversity, and that will likely change as a result of climate change and concomitant impacts on economic development. CDB has identified geographic or sectoral areas for biodiversity to contribute to societal adaptation through ecosystem-based adaptation, (CBD, 2009b):

- Coastal adaptation,
- Adaptation in the water sector,

- Adaptation in agriculture,
- Forest adaptation,
- Adaptation in the urban environment, and
- Adaptation to health impacts of climate change.

EbA is currently a "best practice" for integrating biodiversity conservation into development across sectors, but it is not a panacea for feasible actions in all circumstances, nor is it yet sufficiently "mature" to have clear operational options for all situations. Not all collaborating countries, or sectors, are necessarily ready to embrace EbA.

In general, EbA is likely attractive to institutions with biodiversity conservation, forestry, and climate change responsibilities, but have less traction with more powerful actors inside and outside government with commercial or livelihood interests in land tenure, agriculture, forestry, fisheries, infrastructure, and mineral resources. Nevertheless other sectors, especially those that depend on renewable natural resources, often recognize the value of ecological services. In promoting biodiversity and forestry interests in the broader landscape in the context of climate change, it is important to identify those ecosystem services that climate change affects, and which services promote resilience or reduce disaster risk. If available, quantitative information on ecosystem services and their economic valuation may provide compelling support for conservation actions to all stakeholders (Section 3.2.1). For example, cloud forests, though highly threatened by climate and land use changes, make an exceptional contribution to downstream social and economic interests as well as biodiversity. A recent study estimates that these ecosystems filter 50 percent of water to tropical dams, yet they cover only 4.4 percent of land area (Saenz and Mulligan, in press). Similarly, mangrove forests and coral reefs provide some protection from sea-level rise, and at the same time are important spawning grounds for commercial fisheries, and intact or restored forests upstream regulate flows and reduce flooding downstream.

Section 3.2.3 provide a range of programming opportunities that combine economic incentives with biodiversity conservation and climate change adaptation. Development of enabling environments and initial practical experience in mechanisms such as easements and PES is complex and challenging, requiring significant investment in policy, public education, and pilot field activities. Such early investment may often need technical and financial support from donors.

In conclusion, USAID has many opportunities to integrate biodiversity conservation with programs addressing climate change adaptation across a range of sectors and geographical contexts. To do so necessitates the use of USAID's collaborating, learning, and adapting approach to program design and implementation. The level of uncertainty in predicting site-specific changes in climate and their impact on ecosystems and people requires flexibility in thought and action, sensitivity to and inclusivity of affected stakeholders, and effective monitoring and evaluation.

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