CLIMATE CHANGE AND BIODIVERSITY CONSERVATION

COURSE CURRICULUM

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DRAFT

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Institute of Resource Assessment,
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Global Change System Analysis Research
and Training

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1. INTRODUCTION

1.1 Background to the Training Program

The global community faces enormous challenges as it strives to ensure that the earth's natural heritage is conserved and sustained over time. Multiple pressures including fragmentation of habitat, land degradation, deforestation, intrusion by invasive species, and pollution threaten the rich biodiversity of Africa. Climate change is adding to and interacting with these and other pressures, which threaten biodiversity. But the institutional capacity in most African countries to deal with biodiversity conservation in a changing climate is low. This is mainly attributed to inadequate knowledge about climate change, its impacts on biodiversity and the effectiveness of different conservation strategies in a changing climate. It is on this basis that the Institute of Resource Assessment (IRA) of the University of Dar es Salaam in collaboration with International START Secretariat, with funding from the John D. and Katherine T. MacArthur Foundation, are developing and implementing this training program to build African capacity for conserving biodiversity in a changing climate thereby filling in identified training needs. The major focus for this training program is the Albertine rift region.

The Albertine Rift region stretches from the northern end of Lake Albert to the southern end of Lake Tanganyika. It covers countries that border the western arm of the Great Rift Valley, namely, Burundi, Democratic Republic of Congo, Rwanda, Tanzania and Uganda. It has a diversity of ecosystems, including volcanic hot springs, alpine vegetation, montane forest, savannah and lowland forests. The rift system is known for its richness in biodiversity, including many species of fauna and flora. It is very rich in vertebrate species and is home to more than half of continental Africa's birds and nearly 40% of its mammals, including gorilla and elephants. It has more endemic species of mammals, birds and amphibians than other regions of Africa. The Albertine Rift region is not only important for its biological diversity but also for the ecological processes and services that it sustains. However, like many parts of the world, the biodiversity of the Albertine Rift region has been adversely impacted and threatened by various factors, including climate change. The implications of the climatic change on the region's biodiversity, and how best to adapt conservation strategies and practices to the changes, are not adequately understood, hence there is need for capacity building to address these issues.

Experiences from various institutions in the Albertine rift countries consulted as part of this process (IRA, 2007) indicate that so far there has been more research on the subject of biodiversity conservation, but very little on climate change. Furthermore, while this biodiversity research has addressed the influence of human activities, the impacts of climate change have not been considered i.e. existing research programs do not integrate the two aspects of biodiversity and climate. This is a reflection on the fact that there is little knowledge on the impacts of climate change on biodiversity that is relevant to the Albertine rift region and much of the available literature on this subject stems from studies done in other parts of the world. These consultations also highlighted the fact that there are inadequate training programs in the Albertine Rift region that address the

changing risks to biodiversity conservation in a changing climate and any relevant university programs only remotely touch upon this topic.

1.2 Purpose and Rationale of the Training Program

The purpose of the proposed training program is to build capacity in Africa, focusing on the Albertine Rift countries, which would support goals for adapting biodiversity conservation in a changing climate. This would be done by developing and implementing an education and training program on climate change and biodiversity at the University of Dar es Salaam for African graduate students and early to mid-career conservation researchers and professionals. The courses developed and implemented under this training program will complement the existing Master of Science degree program in Natural Resource Assessment and Management (NARAM) at the University of Dar es Salaam.

Such a program would target the growing need for expertise in biodiversity conservation in a changing climate arising from a number of factors including the growing concerns regarding climate variability and change; diminishing natural resources and loss of biodiversity; and the need for mainstreaming environmental issues and natural resources in development planning and poverty reduction. Other aspects include changing policies, emerging trans-boundary issues, and growing global and local linkages in natural resources management. Specialized training programs like this can thus empower resource managers at various levels in addressing this issue; help to increase capacity to manage risks to natural resources under a changing climate; and assist policy and decision makers in making informed decisions. At the same time, this program in climate change and biodiversity conservation will also help fulfill the primary mission of the University of Dar es Salaam (UDSM), which is to enhance academic training to cater to the global demand for professional skills in different areas of specialization.

Issues of climate change and biodiversity also rank high in the IRA research agenda and the presence of the MSc. NARAM program is a significant advantage. In addition, NARAM currently offers courses related to climate change and biodiversity. Though the curriculum on climate change and biodiversity conservation will be implemented separately, it will complement the MSc. NARAM.

1.3 Goals and Objectives of the Training Program

1.3.1 Goal of the Training Program

The overall goal of the project is to establish a sustainable program to educate and train early to mid-career conservation researchers and practitioners in Africa for conserving biodiversity in a changing climate. Achieving this goal will contribute to the critical need for greater human capacity to understand and respond to climate change threats.

1.3.2 Objectives of the Training Program

The specific objectives to be accomplished are:

- To educate and train early to mid-career conservation researchers and practitioners to enable them to make substantive contributions in addressing biodiversity conservation issues in a changing climate.
- To equip professionals with innovative knowledge, skills and values in biodiversity conservation in a changing climate integrated in order to enhance understanding of current natural resource management and environmental issues.

2. GENERAL DESCRIPTION OF COURSES

This program recognizes the need to adapt place-based conservation work in order to address the risks of a changing climate. A necessary condition for success will be local scientific and technical capacity in the respective Albertine countries to anticipate and evaluate the changing risks, to communicate risk information to conservation practitioners and stakeholders, and to engage research, practitioner and stakeholder communities in collaborative efforts to design, test and implement appropriate conservation strategies. Local capacity is required because (i) local ownership of conservation strategies is critical for success and can only be achieved with substantive local participation in evaluating and prioritizing risks and response options, (ii) while important drivers of change are global and regional, the risks to biodiversity and the feasibility and effectiveness of different adaptive responses are highly context specific, making local knowledge critical for successful conservation, and (iii) the climate will change continuously, possibly in unanticipated ways and likely with unanticipated impacts, requiring an iterative learning process of reassessment of risks and performance of conservation strategies that is best done by local partners.

This training program will encompass two courses, namely, climate change risks to ecosystems and biodiversity, and conservation strategies in a changing climate administered as 3-week intensive sessions at the University of Dar es Salaam. The 3-week intensive training format will facilitate the participation of students and conservation professionals from across Africa.

The longer-term intention is to establish this curriculum as a recognized focal area within the MSc. NARAM program to be offered on a continuing basis after the completion of the project. It is also planned to explore the possibility of offering these courses as online learning modules in the future to enable wider accessibility.

2.1 Course 1 - Climate Change Risks to Ecosystems and Biodiversity

Course description: Participants in the course will investigate climate change risks to ecosystems and biodiversity, with an emphasis on Africa and the Albertine Rift, and explore methods and tools for assessing climate impacts to ecosystems, species and human livelihoods. Course topics include the climate system and greenhouse effect; changes in palaeoclimate and their impacts on ecosystems and species distributions; more

recent climate changes and their observed impacts; mechanisms by which climate affects ecosystems; projections of future climate change and potential impacts on ecosystems, ecosystem goods and services, and human livelihoods; ecological niche modeling; biogeography models; dynamic vegetation models; and social science methods for assessing human consequences of ecosystem changes and biodiversity losses. Working in teams, the course participants will develop and present case studies of climate change threats to the biodiversity of selected sub-regions of the Albertine Rift (see Module 6).

Course objectives: The overall aim of the course is to enable biodiversity conservation in a changing climate by generating deep understanding of the implications of climate change on ecosystems (including their goods and services), biodiversity and human well-being. Specific objectives for each of the course modules are detailed below.

Objectives of the course are to develop understanding of:

- The processes of climate variability, climate change and the greenhouse effect;
- Mechanisms by which ecosystems have been and are expected to be affected by climate change;
- Risks from climate change and other interacting pressures that act on ecosystems and biodiversity, ecosystem goods and services, and human well-being;
- Methods for assessing climate change risks; and
- Important knowledge gaps and uncertainties.

Course structure and sequence: The course is organized around 6 modules, several of which are composed of a number of sub-units. The modules and sub-units are:

1. Biodiversity in a Changing Climate: Framing the Issues
2. The Climate System: Processes, Variability and Change
   2.1. The Climate System and Greenhouse Effect
   2.2. Climate Change in the Past
   2.3. Climate Change Projections for the Future
3. Vulnerability and Adaptation to Climate Change
4. Ecosystems, Biodiversity and Climate Change
   4.1. Ecosystem Concepts and Processes
   4.2. Ecosystem Goods and Services
   4.3. Mechanisms by Which Climate Change Affects Ecosystems
   4.4. Climate Change Impacts on Ecosystems in the Distant and Recent Past
   4.5. Biomes and Biodiversity of Africa and the Albertine Rift
5. Future Impacts of Climate Change on Ecosystems and Biodiversity
   5.1. Methods for Modeling Climate Change Impacts
   5.2. Methods for Social Assessment of Ecosystem Changes
   5.3. Assessments of Future Impacts
6. Case Studies of Climate Change Threats to the Biodiversity of the Albertine Rift

Readings: Required readings are listed below for each of the modules and subunits and will be provided in paper copy to course participants at the start of the course. Many of

these will also be available in electronic format before the course. Additional readings to explore course topics in greater detail are also listed, and many of these will be made available during the course.

As preparation for the course, participants should read the following before the start of the course, which will be available on the course website:

- Millennium Ecosystem Assessment (2003). Summary. *Ecosystems and Human Well-being: A Framework for Assessment*. Island Press, Washingtion, DC, pp. 1-25.

- Millennium Ecosystem Assessment (2005). Summary for decision-makers, Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC, pp. 1-24.

- IPCC (2007a). Summary for Policymakers. In S. Solomon, D. Quin, M. Manning, Z. Chen, M. Marquis, K. Averyt, M. Tignor and H. Miller, eds., *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.

- IPCC (2007b). Summary for Policymakers. In M. Parry, O. Canziani, J. Palutikof, P. van der Linden, and C. Hanson, eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.

Module 1: Biodiversity in a Changing Climate: Framing the Issues

The conceptual framework of the Millennium Ecosystem Assessment (MEA) will be presented and applied to place in context the multiple pressures acting on ecosystems, including climate change. Major pressures on ecosystems and biodiversity deriving from human activities will be examined, as will their observed impacts over the past 50 years and potential impacts in coming decades. Implications of the impacts for the goods and services that humans derive from ecosystems and for human well-being will be discussed. Course objectives and structure will be presented; students will briefly introduce themselves, their work and purposes for taking the course, and their expectations for the course.

Module 1 Objectives

Course participants will:

- Be able to identify the main components and interactions among components of the MEA framework;
- Understand the concepts of ecosystem goods and services;

- See climate change as one of multiple, interacting pressures on ecosystems and biodiversity but one that exerts unique pressures that are expected to grow in coming decades;
- Become familiar with the course objectives, structure and requirements;
- Become acquainted with the other course participants.

Module 1 Readings:

Hannah, L., T. Lovejoy and S. Schneider (2005). Biodiversity and climate change in context. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 3-14.

Millennium Ecosystem Assessment (2003). Summary. In *Ecosystems and Human Well-being: A Framework for Assessment*. Island Press, Washingtion, DC, pp. 1-25.

Millennium Ecosystem Assessment (2003). Chapter 1: Introduction and conceptual framework. In *Ecosystems and Human Well-being: A Framework for Assessment*. Island Press, Washingtion, DC, pp. 26-48.

Millennium Ecosystem Assessment (2005). Summary for decision-makers. In *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC, pp. 1-24.

Module 2: The Climate System: Processes, Variability and Change

Students will be presented an overview of the climate system and greenhouse effect and examine evidence of climate changes of the distant and recent past and their causes. Students will be introduced to methods for projecting future climate change, projections of climate change at global and regional scales, and uncertainties in climate change projections. Observed and projected climate changes in Africa will be emphasized.

Module 2.1 The Climate System and Greenhouse Effect

The major components of the climate system (atmosphere, ocean, land and cryosphere) and interactions among the components (e.g. Earth's energy balance, surface energy balance, hydrologic cycle, atmospheric circulation, ocean circulation) that determine the state of the climate will be examined. Processes of natural climate variability and climate change will be explored, with emphasis on Africa. Human-caused climate change, or the greenhouse effect, will be investigated.

Module 2.1 Objectives:

Course participants will:

- Understand at a basic level the climate system and processes of natural climate variability and natural climate change;
- Understand at a basic level the main processes that influence climate and climate variability in Africa;
- Understand the workings of the greenhouse effect; and
- Know the main greenhouse gases, their sources and past trends.

Module 2.1 readings:

Karl, T., and K. Trenberth (2005). What is climate change? . In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 15 – 28.

FAQ 1.1: What factors determine Earth's climate? IPCC WGI AR4 Technical Summary, pp. 94-95.

FAQ 1.2: What is the relationship between climate change and weather? IPCC WGI AR4 Technical Summary, pp. 96-97.

FAQ 1.3: What is the greenhouse effect? IPCC WGI AR4 Technical Summary, pp. 98-99.

FAQ 2.1: How do human activities contribute to climate change and how do they compare with natural influences? IPCC WGI AR4 Technical Summary, pp. 100-102.

Hulme, M., R. Doherty., T. Ngara., and M. New (2005). Global Warming and African climate change: a reassessment. In. Low, P.S (ed), Climate Change and Africa. Cambridge University Press, pp 29-40

Additional Source Material for Instructors and Further Reading for Students:

IPCC (2007a). Technical Summary, Changes in human and natural drivers of climate, pp. 21-35. In S. Solomon, D. Quin, M. Manning, Z. Chen, M. Marquis, K. Averyt, M. Tignor and H. Miller, eds., *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.

Houghton, J. (1994). The greenhouse effect. In J. Houghton, *Global Warming, the Complete Briefing*, Lion Publishing, Oxford, pp. 19-28

Houghton, J. (1994). The greenhouse gases. In J. Houghton, *Global Warming, the Complete Briefing*, Lion Publishing, Oxford, pp. 29-45.

Unganai, L. (2007). Climate and extreme events. In L. Otter, D. Olago, and I. Niang, eds., *Global Change Processes and Impacts in Africa: A Synthesis*. East African Educational Publishers, Nairobi, pp. 33-55.

Module 2.2 Climate Change in the Past

Reconstructions of the Earth's climate in the distant past from palaeoclimate proxies and causes of climate changes in the palaeo-record will be examined, with emphasis on Africa. Also to be examined are more recent climate observations, climate trends, and evidence for human-caused climate change.

Module 2.2 Objectives:

Course participants will:

- Know what proxies are used to reconstruct palaeoclimate;
- Understand how the climate has changed in the distant past and what are the main drivers of the changes in the distant past;
- Learn what climate trends have been observed globally and in Africa over the past 100 years; and
- Understand the evidence for human-caused climate change.

Module 2.2 Readings:

Overpeck, J., J. Cole, and P. Bartlein (2005). A 'paleoperspective' on climate variability and change. . In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 91-108.

Hulme, M. (2005). Recent climate trends. . In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 31-40.

FAQ 3.1 through 5.1. IPCC WGI AR4 Technical Summary, pp. 103-111.

FAQ 6.1: What caused the ice ages and other important climate changes before the industrial era? IPCC WGI AR4 Technical Summary, pp. 112-113.

FAQ 6.2: Is the current climate change unusual compared to earlier changes in Earth's history? IPCC WGI AR4 Technical Summary, pg. 114.

FAQ 9.2: Can the warming of the 20th century be explained by natural variability? IPCC WGI AR4 Technical Summary, pp. 120-121.

Additional Source Material for Instructors and Further Reading for Students:

Nicholson, S. (2001). Climatic and environmental change in Africa during the last two centuries. *Climate Research* 17, no. 2: 123-144.

Olago, D., M. Umer, S. Ringrose, P. Huntsman-Mapila, E. Sow, and B. Damnati (2007). Palaeoclimate of Africa: an overview since the last glacial maximum. In L. Otter, D. Olago, and I. Niang, eds., *Global Change Processes and Impacts in Africa: A Synthesis*. East African Educational Publishers, Nairobi, pp. 1-32.

IPCC (2007a). Technical Summary, Observations of changes in climate, pp. 35-58. In S. Solomon, D. Quin, M. Manning, Z. Chen, M. Marquis, K. Averyt, M. Tignor and H. Miller, eds., *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA..

IPCC (2007a). Technical Summary, Understanding and attributing climate change, pp. 58-66. In S. Solomon, D. Quin, M. Manning, Z. Chen, M. Marquis, K. Averyt, M. Tignor and H. Miller, eds., *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.

Manyanga, M (2007). Resilient Landscapes: Socio-Environmental Dynamics in Shashi-Limpompo Basin, Southern Zimbabwe C.AD 800 to the present, Uppsala Universitet, Studies in Global Archaeology 11

Module 2.3: Climate Change Projections for the Future

Climate modeling and uncertainties in climate model projections will be introduced and results of climate change projections from global models will be presented and interpreted. Approaches and challenges of downscaling global model projections to regional and finer spatial scales will be discussed and regional projections for Africa examined.

Module 2.3 Objectives:

Course participants will:

- Understand what climate models do and the main sources of uncertainties in climate change projections;
- Know the changes in climate and sea level that are expected based on projections from global climate models;
- Know the main approaches for downscaling global projections to regional scales and their uncertainties; and
- Know the ranges of projected climate changes for Sub-Saharan Africa.

Module 2.3 Readings:

Raper, S., and F. Giorgi (2005). Climate change projections and models. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 199-210.

Hewitson, B., R. Crane, and M. Tadross (2007). Regional climate scenarios for impact assessment. In L. Otter, D. Olago, and I. Niang, eds., *Global Change Processes and Impacts in Africa: A Synthesis*. East African Educational Publishers, Nairobi, pp. 56-71.

Hulme, M., R. Doherty, T. Ngara, and M. New (2005). Global warming and African climate change: a reassessment. In P. Low, ed., *Climate Change and Africa*, Cambridge University Press, Cambridge, UK and New York, USA, pp. 29-40.

Additional Source Material for Instructors and Further Reading for Students:

Christensen, J., B. Hewitson and others (2007). Regional climate projections. In S. Solomon, D. Quin, M. Manning, Z. Chen, M. Marquis, K. Averyt, M. Tignor and H. Miller, eds., *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA, pp. 847-940. [See in particular pp. 852-864 (Introduction); pp. 866-871 (Africa); and pp. 918-925 (Assessment of regional climate model projection methods)]

Hulme, M., R. Doherty, T. Ngara, M. New and D. Lister (2001). African climate change: 1900 – 2100. *Climate Research* 17, no. 2: 145-168.

Module 3: Climate Change Vulnerability, Adaptation and Mitigation

The coupled human-environment systems framework of vulnerability will be presented to students and the framework will be used to provide a general overview of the nature and causes of vulnerability of human systems to climate change and adaptation and mitigation options for reducing and managing climate change risks. The module will cover climate change risks to agriculture, water resources, livelihoods, human settlements, coastal zones, food security, and human health. Looking on how climate change impacts on these areas in turn can affect the biodiversity conservation efforts in Africa. Emphasis will be on vulnerabilities and adaptation in Africa.

Module 3 Objectives:

Course participants will:

- Understand the concepts vulnerability, exposure, sensitivity, adaptive capacity, resilience and thresholds;
- Understand at a basic level the causes of vulnerability;
- Learn the key vulnerabilities for Africa; and

- Understand the response strategies of adaptation and mitigation and the factors that enable and impede these responses;

Module 3 Readings:

IPCC (2007b). Summary for Policymakers. In M. Parry, O. Canziani, J. Palutikof, P. van der Linden, and C. Hanson, eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.

IPCC (2007c). Summary for Policymakers. In B. Metz, O. Davidson, P. Bosch, R. Dave, and L. Meyer, eds., *Climate Change 2007: Mitigation*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.

Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., Osman-Elasha, B., Tabo, R., and Yanda, P. Africa (2007). In, M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Chang. Cambridge University Press, Cambridge, UK and New York, USA, 433-467.

Additional Source Material for Instructors and Further Reading for Students:

IPCC (2007b). Technical Summary. In M. Parry, O. Canziani, J. Palutikof, P. van der Linden, and C. Hanson, eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.

Leary, N., and others (2008a). "A stitch in time, general lessons from specific cases," in N. Leary, J. Adejwon, V. Barros, I. Burton, J. Kulkarni and R. Lasco, eds., *Climate Change and Adaptation*. Earthscan, London, pp. 1-27.

Leary, N., and others (2008b). "For whom the bell tolls, vulnerabilities in a changing climate" in N. Leary, C. Conde, A. Nyong and J. Pulhin, eds., *Climate Change and Vulnerability*. Earthscan, London, pp. 3-30.

Leary, N., and S. Beresford (2008), "Vulnerability of People, Places and Systems to Environmental Change," in G. Knight and J. Jaeger, editors, *Integrated Regional Assessment*, Cambridge University Press (in press; pre-publication manuscript available).

Van der Post, C. (2007). Human dimensions of African climate and environmental change. In L. Otter, D. Olago, and I. Niang, eds., *Global Change Processes and Impacts in Africa: A Synthesis*. East African Educational Publishers, Nairobi, pp. 72-93.

Hansen, L.J., J.L, Biringer, J.R, Holfman (2003). Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems, WWF, 2003. Hansen, L.J., J.L, Biringer, J.R, Holfman (eds)

Module 4: Ecosystems, Biodiversity and Climate Change

The concepts of ecosystems and biodiversity will be presented. Students will learn about different types of biomes and ecosystems, ecosystem processes, ecosystem goods and services as well as biodiversity in Africa and the Albertine Rift. Students will also learn how climate change affects ecosystems and biodiversity and vice versa. The focus will be on understanding the mechanisms by which the ecosystems absorb carbon dioxide from the atmosphere and how climate change affects ecosystems and its impacts in the distant and recent past.

Module 4.1: Ecosystem Concepts and Processes

Key ecological concepts, ecosystem dynamics and resilience will be examined.

Module 4.1 Objectives:

Course participants will:

- Understand the concepts of ecosystems and their types
- Learn the ecosystem processes and dynamics
- Understand interaction between ecosystems and climate change.
- Learn the ecosystems resistance and resilience capacity to different changes including climate change

Module 4.1 Readings:

Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, Upper Saddle River, New Jersey (4th edition). Ecology and Ecosystems; pp 1-30

Chapman, J.L., and M.J. Reiss (2005). Ecology: Principles and Applications. Cambridge University Press (2nd edition). Ecosystems processes; pp 187-205

Townsend, C.R,. M. Begon and J.L. Harper (2003). Essentials of Ecology. Blackwell Publishing (2nd edition). Individuals, Populations, Communities, and Ecosystems. Pp 155-222

Module 4.2: Ecosystem Goods and Services

The MEA framework, introduced in Module 1, will be explored in more detail. The role of ecosystems and biodiversity in providing goods and services, supporting livelihoods, and enabling development will be explored. Human pressures on ecosystems and the resulting changes in ecosystems and ecosystem goods and services over past 50 years will be examined.

Module 4.2 Objectives:

Course participants will:

- Understand how the processes and interactions represented by the MEA framework can lead to changes in ecosystems that degrade the environment and threaten human well-being;
- Be able to identify many of the major pressures from human activities that act on ecosystems and biodiversity;
- Understand the rate, extent and character of human impacts on ecosystems and biodiversity and on ecosystem goods and services over the past 50 years.

Module 4.2 Readings:

Millennium Ecosystem Assessment (2003). Chapter 2: Ecosystems and their services. In *Ecosystems and Human Well-being: A Framework for Assessment*. Island Press, Washingtion, DC, pp. 49-70.

Millennium Ecosystem Assessment (2003). Chapter 3: Ecosystems and human well-being. In *Ecosystems and Human Well-being: A Framework for Assessment*. Island Press, Washingtion, DC, pp. 71-84.

Millennium Ecosystem Assessment (2005). Key questions in the Millennium Ecosystem Assessment. In *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC, pp. 25-102.

Millennium Ecosystem Assessment (2005). Appendix A: Ecosystem service reports. In *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC, pp. 103-122.

Kinzig, A., Perrings, C., Scholes, B. 2007 *Ecosystem services and the economics of biodiversity conservation*. Working paper (downloaded November 2007). http://www.public.asu.edu/~cperring/Kinzig%20Perrings%20Scholes%20(2007).pdf

Module 4.3: Mechanisms by which Climate Change Affects Ecosystems

A general overview of the mechanistic processes by which climate (under normal situation; in the absence of global climate change) affects species composition and distribution, biome composition and distribution as well as ecosystems processes and functions will be presented. Specifically, mechanisms by which climate change affects

species and biomes composition and distribution, ecosystems functions and processes will be covered.

Module 4.3 Objectives:

Course participants will:

- Understand at a basic level the main processes by which climate change affects species composition and distribution
- Learn generally how climate change affects different ecosystems in Africa and in the Albertine Rift in particular.
- Know the most prone (sensitive) ecosystems to the impacts of climate change in the Albertine Rift.
- Know other ecosystems non-climate stressors and how they contribute to the realized distant and recent past impacts of climate change.

Module 4.3 Readings:

Kirschbaum, M. and others (1995). Ecophysical, ecological, and soil processes in terrestrial ecosystems: a primer on general concepts and relationships. In R. Watson, M. Zinyowera, R. Moss and D. Dokken (eds.), *Climate Change 1995: Impacts, Adaptation and Mitigation of Climate Change*. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, USA, pp. 57-74.

Hewitt, G., and R. Nichols (2005). Genetic and evolutionary impacts of climate change. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 176-192.

Naeem, S., and others (2007). Predicting the ecosystem consequences of biodiversity loss: the Biomerge Framework. In J. Canadell, D. Patakki, L. Pitelka, eds., *Terrestrial Ecosystems in a Changing World*. Springer, Berlin, Hedeilberg and New York. pp. 113-126.

Additional Source Material for Instructors and Further Reading for Students:

Norby, R., and others (2007). Ecosystem responses to warming and interacting global change factors. In J. Canadell, D. Patakki, L. Pitelka, eds., *Terrestrial Ecosystems in a Changing World*. Springer: Berlin, Hedeilberg and New York. pp. 23-36.

Kirschbaum, M. and others (1995). Climate change impacts on forests. In R. Watson, M. Zinyowera, R. Moss and D. Dokken (eds.), *Climate Change 1995: Impacts, Adaptation and Mitigation of Climate Change*. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on

Climate Change. Cambridge University Press, Cambridge, UK and New York, USA, pp. 95-129.

Module 4.4: Climate Change Impacts on Ecosystems in the Distant and Recent Past

Both distant and recent climate change impacts in ecosystems will be presented. This will entail examination of changes in ecosystems and species distributions in response to climate changes from palaeo-records and from observations of the recent past.

Module 4.4 Objectives:

Course participants will:

- Understand that climate has had major impacts on ecosystems, species distribution and evolution in the distant past;
- Learn how ecosystems have been affected by climate in the more recent past; and
- Understand the evidence for human-caused climate change impacting ecosystems and species distributions.

Module 4.4 Readings:

Parmesan, C. (2005). Biotic response: range and abundance changes. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 41-55.

Root, T. and L. Hughes (2005). Present and future phenological changes in wild plants and animals. . In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 61-69.

Pounds, J., M. Fogden, and K. Masters (2005). Case study: responses of natural communities to climate change in a highland tropical forest. . In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 70-74.

Bush, M. and H. Hooghiemstra (2005). Tropical biotic responses to climate change. . In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 125-137.

Additional Source Material for Instructors and Further Reading for Students:

IPCC (2007b). Technical Summary, Current knowledge about observed impacts of climate change on the natural and managed systems. In M. Parry, O. Canziani, J. Palutikof, P. van der Linden, and C. Hanson, eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA, pp. 26-31.

Rosenzweig, C., and others (2007). Assessment of observed changes and responses in natural and managed systems. In M. Parry, O. Canziani, J. Palutikof, P. van der Linden, and C. Hanson, eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA, pp. 79-131.

Markgraf, V. and M. McGlone (2005). Southern temperate ecosystem responses. . In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 142-156.

Parmesan, C. (2006). Ecological and evolutionary responses to recent climate change, *Annual Review of Ecology, Evolution and Systematics*, 37: 637-639. http://cns.utexas.edu/communications/File/AnnRev_CCimpacts2006.pdf

Module 4.5: Biomes and Biodiversity of Africa and the Albertine Rift

The major biomes of Africa and the Albertine Rift will be examined. The focus will be on their distribution and the role of climate in determining their distribution; the diversity and endemism of their species; human uses of and pressures on ecosystems and biodiversity of the region; and recent changes in ecosystems, biodiversity as well as their goods and services.

Module 4.5 Objectives:

Course participants will:

- Be able to identify the major biomes of Africa and the Albertine Rift and major hotspots of species diversity and endemism; and
- Know the main pressures on ecosystems and biodiversity of the region.

Module 4.5 Readings:

Plumptre, A. J., Davenport, T. R. B., Behangana, M., Kityo, R., Eilu, G., Ssegawa, P., Ewango, C., Meirte, D., Kahindo, C., Herremans, M., Peterhands, J. K., Pilgrim, J. D., Wilson, M., Languy, M., and Moyer, D. 2007. The biodiversity of the Albertine Rift, *Biological Conservation*, 134: 178-194. http://webdocs.dow.wur.nl/internet/fem/uk/pdf/plumptre%20et%20al%202007.pdf

Olago, D. (2001). Vegetation changes over palaeo-time scales in Africa. *Climate Research* 17, no. 2: 105-121.

Justice, C., and others (2001). Central African forests, carbon and climate change. *Climate Research* 17, no. 2: 229-246.

Additional Source Material for Instructors and Further Reading for Students:

Balling, R. (2005). Interactions of desertification and climate in Africa. In P. Low, ed., *Climate Change and Africa*, Cambridge University Press, Cambridge, UK and New York, USA, pp. 29-40.

Gonzalez, P. (2001). Desertification and a shift of forest species in the West African Sahel. *Climate Research* 17, no. 2: 217-228.

Maitima, J., and D. Gumbo (2007). Land use in Sub-Saharan Africa. In L. Otter, D. Olago, and I. Niang, eds., *Global Change Processes and Impacts in Africa: A Synthesis*. East African Educational Publishers, Nairobi, pp. 109-130.

Module 5: Future Impacts of Climate Change on Ecosystems and Biodiversity

Module 5.1: Methods for Modeling Climate Change Impacts

An overview of methods for modeling climate change impacts on ecosystems and biodiversity will be presented and selected methods will be explored in detail, including computer laboratory exercises. The methods to be presented include single species ecological niche models, biogeography models, 'gap' models of dynamic changes in forest patches, and dynamic global vegetation models.

Module 5.1 Objectives:

Course participants will:

- Be able to identify the major approaches to modeling ecosystem and species responses to climate pressures;
- Understand the different purposes of the major modeling approaches and how the models work;
- Gain sufficient familiarity with one or two modeling approaches to be able to use and apply the models.

Module 5.1 Readings:

Hannah, L. (2003). Regional biodiversity impacts assessments for climate change: a guide for protected area managers. In L. Hansen, J. Biringer and J. Hoffman, eds., *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems*, WWF, Washington. Pp. 233-242.

Peterson, A., H. Tian, E. Martinez-Meyer, J. Soberon, V. Sanchez-Cordero, and B. Huntley (2005). Modeling distributional shifts of individual species and biomes. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 211-228.

Midgley, G. and D. Millar (2005). Modeling species range shifts in two biodiversity hotspots. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 229-231.

Betts, R., and H. Shugart (2005). Dynamic ecosystem and Earth system models. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 232-255.

Additional Source Material for Instructors and Further Reading for Students:

Midgley, G., W. Thuiller and S. Higgins (2007). Plant species migration as a key uncertainty in predicting future impacts of climate change on ecosystems: progress and challenges. In J. Canadell, D. Patakki, L. Pitelka, eds., *Terrestrial Ecosystems in a Changing World*. Springer, Berlin, Hedeilberg and New York. pp. 129-137.

Prentice, I.C., and others (2007). Dynamic global vegetation modeling: quantifying terrestrial ecosystem responses to large-scale environmental change. In J. Canadell, D. Patakki, L. Pitelka, eds., *Terrestrial Ecosystems in a Changing World*. Springer, Berlin, Hedeilberg and New York. pp. 175-192.

Desanker, P.V., C.O. Justice., G. Munthali., and K. Masamvu (2005). Requirements for Integrated Assessment Modelling at the Regional and National Levels in Africa to Address Climate Change. In. Low, P.S. (ed), *Climate Change and Africa*, Cambridge University Press, pp 260-270

Module 5.2: Methods for Social Assessment of Ecosystem Changes

Methods will be explored for assessing the relationship between human communities and the ecosystems on which they depend for goods and services, indigenous knowledge and practices for management of ecosystems, perceptions of climate and other pressures on ecosystems, vulnerability of human communities to changes in ecosystems, and capacities for adapting the management of ecosystems to changing pressures. Environmental assessment tools such as EIA, SEA and Environmental Review and Audit for highlighting the socio-economic value of functions and products of an ecosystem will be presented and analyzed. Participatory processes such as Participatory Rural Appraisal, Stakeholder Analysis and Consensus Building, will also be discussed.

Module 5.2 Objectives:

Course participants will:

- Be able to apply the methods learned during the course to gain an in-depth understanding of how human well-being is linked to ecosystem services
- Develop skills for assessing the relationship between human communities and the ecosystems
- Have a thorough grasp of how the economy is linked to the ecosystem services

- Understand how changes in ecosystem services affect supply and quality of social capital and technology, and
- Understand how poverty is linked to change in ecosystem services
- Learn on the use of historical sources in establishing ecosystem changes over time
- Understand the use of present land use/cover patterns in assessment of ecosystem changes
- Know the use of archaeological records (e.g. fauna and flora remains) in sheding the light about the distant and recent past changes in different ecosystems.

Module 5.2 Readings:

- Holling, C.S. (2003). Foreword: the backdrop to sustainability. In Berkes, F., J. Coolding and C,Folke (eds), *Navigating Social-Ecological Systems: building resilience for complexity and change*, Cambridge University Press, Cambridge, UK, pp. xv-xxi.
- Holling, C.S., and L.H. Gunderson (2002). *Resilience and Adaptive Cycles.* In, Gunderson, L.H. and C.S. Holling (eds), *Panarchy: understanding transformations in human and natural systems*, Island Press, Washington DC, pp. 25-62.
- Holling, C.S.,L.H. Gunderson and Ludwing, D. (2002). In quest of theory of adaptive change. In, Gunderson, L.H. and Holling, C.S. (eds), *Panarchy: Understanding transformations in human and natural systems*. Island Press, Washington DC, pp. 3-22.
- Millennium Ecosystem Assessment (2003). Summary. *Ecosystems and Human Well-being: A Framework for Assessment*. Island Press, Washingtion, DC, pp. 1-25.
- Millennium Ecosystem Assessment (2005). Summary for decision-makers, *Ecosystems and Human Well-being: Synthesis*, Island Press, Washington, DC, pp. 1-24.

Module 5.3: Assessments of Future Impacts of Climate Change

Findings of assessments of the future impacts of climate change on ecosystems and biodiversity will be explored.

Module 5.3 Objectives:

Course participants will:

- Understand the wide range and severity of potential climate change impacts on ecosystems and biodiversity;
- Learn about climate sensitivities and thresholds of different ecosystems; and
- Understand the major sources of uncertainty about the potential impacts of climate change;

Module 5.3 Readings:

- Fischlin, A. and others (2007). Ecosystems, their properties, goods and services. In M. Parry, O. Canziani, J. Palutikof, P. van der Linden, and C. Hanson, eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA, pp. 211-272.
- Mwandosya, M.J., Nyenzi, B.S., and Luhanga, M.L (1998). The Assessment of Vulnerability and Adapation to Climate Change Impacts in Tanzania, CEEST-Dar es Salaam, Tanzania: *Assessment of Climate Change Impacts on Tanzanian Forests; pp 187-214: Assessment of Hydrologic Resources Vulnerability and Adaptation to Climate Impacts in Tanzania; pp 27-57*

Module 6: Case Studies of Climate Change Threats to the Biodiversity of the Albertine Rift

Working in teams, course participants will develop case studies of climate change threats to the biodiversity of selected sub-regions of the Albertine Rift. The case studies will draw on available information to assess the nature and severity of climate change risks to biodiversity, the interactions of climate change with other pressures, and the implications for human communities in the region. The case studies will also identify major gaps in knowledge and sources of uncertainty that are likely to inhibit effective decisions for conserving biodiversity in a changing climate and develop recommendations of actions to address knowledge gaps and uncertainties. Each team will prepare a short report and will present its findings and recommendations to a mock governing board that is responsible for conservation in the sub-region.

Module 6 Objectives:

Course participants will:

- Be able to apply concepts learned during the course to understand climate threats to biodiversity in the regions in which they live and work;
- Develop skills for identifying knowledge gaps and developing assessment plans to address gaps in knowledge; and
- Improve their skills for communicating information about climate change, climate change risks to biodiversity.

2.2 Course 2: Conserving Biodiversity in a Changing Climate

Course description: Participants in this course will examine current conservation strategies in terms of their effectiveness in addressing changing risks under a changing climate and will learn to develop new and/or modified strategies where necessary to address these risks. Participants will also learn to use methods and tools that can assess ecosystem responses to climate variability and change and thus guide the development of

new/modified conservation strategies. Course topics include: The role of ecosystems and biodiversity in sustaining the planet and major stresses; traditional approaches to biodiversity conservation including legal and policy aspects as well as community scale strategies; effectiveness of traditional approaches; status of managed and natural systems in the Albertine Rift region; approaches to designing landscapes for protecting ecosystems and biodiversity under climate change; use of spatial analysis tools to guide landscape design; management strategies; policies and tools for protecting matrix areas; community participation; planning for long term monitoring and evaluation; and case study approaches to designing climate sensitive conservation strategies for the Albertine rift region. Participants will design a conservation plan that is sensitive to changing risks in a changing climate for an area of their choice within the Albertine Rift region.

Course objectives: The overall aim of this course is to generate strategies for adapting biodiversity conservation to changing risks under a changing climate by using existing/ new/modified conservation approaches, either singly or in any combination thereof, keeping in mind applicable legal and policy instruments, and accounting for the role of local communities.

The objectives of the course are:

- To develop an understanding of traditional approaches to biodiversity conservation and legal and policy instruments, which govern conservation at the international or national/regional/local levels
- To evaluate the effectiveness of traditional conservation approaches in terms of their benefits and shortcomings and in their ability to address changing risks due to climate change
- To determine goals and priorities for conservation under a changing climate
- To develop new and/or modified strategies for protecting areas of conservation importance under a changing climate
- To develop tools and plans for the long term monitoring of protected areas to ensure the effectiveness of conservation strategies

Course structure and sequence: The course is organized around 5 modules, of which modules 1 and 4 are further organized into a number of sub-modules. The modules and their sub-units are as below:

1. Need for protecting ecosystems and conserving biodiversity
2. Current biodiversity conservation strategies and their effectiveness
    2.1 Traditional approaches to biodiversity conservation
    2.2 Effectiveness of traditional approaches against various stressors
3. Extent and status of managed and natural systems in the Albertine rift
4. Protecting ecosystems and conserving biodiversity under a changing climate in the Albertine Rift region
    4.1 Approaches to designing conservation responses that address climate change risks
    4.2 Designing landscapes
    4.3 Management of protected areas

4.4 Protecting the matrix areas
4.5 Community inclusive approaches
4.7 Monitoring the effectiveness of adaptive strategies

5. Case Study: Designing conservation strategies for addressing climate impacts in the Albertine Rift region

Readings: Required readings are listed below for each of the modules and subunits and will be provided in paper copy to course participants at the start of the course. Many of these will also be available in electronic format before the course. Additional readings to explore course topics in greater detail are also listed, and many of these will be made available during the course.[1]

Module 1: Need for Protecting Ecosystems and Conserving Biodiversity

This module will briefly cover the material covered in Course 1 on the role of ecosystems in the provision of goods and services and thus in sustaining the planet and supporting human development. An understanding of areas of high species endemism including endangered species and landscapes will be developed. Major stresses on ecosystems and biodiversity and their observed impacts over the past 50 years and potential impacts in the future will be discussed.

Module 1 Objectives:

Course participants will:

- Understand the concept of ecosystems goods and services and the role of ecosystems in supporting human development
- Learn about the importance of areas of high endemic biodiversity
- Learn about major climatic and non-climatic stresses, including those with anthropogenic origins, that affect ecosystem functioning and threaten biodiversity
- Become familiar with major stresses that affect ecosystems and biodiversity
- Become familiar with course objectives, structure and requirements

[1] Note: This course is designed as a follow-on to the course Climate Change Risks to Ecosystems and Biodiversity. In case this course is taken independently of the first it is suggested that the participants read the following before the start of the course in order to be better equipped to handle course requirements:

- Millennium Ecosystem Assessment (2003). Summary. *Ecosystems and Human Well-being: A Framework for Assessment*. Island Press, Washingtion, DC, pp. 1-25.
- Millennium Ecosystem Assessment (2005). Summary for decision-makers, Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC, pp. 1-24.
- IPCC (2007a). Summary for Policymakers. In S. Solomon, D. Quin, M. Manning, Z. Chen, M. Marquis, K. Averyt, M. Tignor and H. Miller, eds., *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.
- IPCC (2007b). Summary for Policymakers. In M. Parry, O. Canziani, J. Palutikof, P. van der Linden, and C. Hanson, eds., *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.

- Become acquainted with other course participants

Module 1 Readings:

Millennium Ecosystem Assessment (2005). Summary for decision-makers. In *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC, pp. 1-24.

Millennium Ecosystem Assessment (2005). Summary for decision-makers. In *Ecosystems and Human Well-being: Biodiversity Synthesis*. Island Press, Washington, DC, pp. 1-16.

Battarbee, R., P. Cox, C. Freeman, J. Lawton, G. Mace, A, Mackay, D. Read and J. Shepherd (2007). Biodiversity-Climate interactions: adaptation, mitigation and human livelihoods, Report of an international meeting held at the Royal Society 12-13 June 2007, Royal Society, UK
Available: http://royalsociety.org/document.asp?tip=0&id=6830

Mainka, S. A., McNeely, J. A. and Lackson, W. J. (Posted March 11, 2008) Depending on nature: ecosystem services for human livelihoods, Heldref Publications, March/April 2008
Available:
http://www.redorbit.com/news/science/1290207/depending_on_nature_ecosystem_services_for_human_livelihoods/

Additional source material for instructors and further reading for students

Lockwood, M (2006) Values and benefits. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 101-115[2]

Module 2: Current Biodiversity Conservation Strategies and their Effectiveness

Students will learn about strategies and methods that are commonly employed for the conservation of biodiversity. International treaties, agreements and laws applicable to the protection of ecosystems and biodiversity will also be discussed. The extent of success of currently utilized strategies in meeting their objectives will be examined.

Module 2.1: Traditional Approaches to Biodiversity Conservation

Students will be presented an overview of the legal, policy and governance aspects of biodiversity conservation including international conventions and multilateral agreements and actions taken at the regional/national/local scales. Students will be introduced to the various methods of conservation employed and will learn about protected areas, their

[2] Note: this reading refers more specifically to the value and benefits from protected areas but does offer a good description, which can be applicable to natural systems in general

categories and their global distribution. The social context of conservation and the important role local communities have been playing both historically and in the present in conserving biodiversity and protecting ecosystems will be discussed.

Module 2.1 Objectives:

Course participants will:

- Learn about international treaties and agreements, most importantly the convention on biological diversity, and will develop an idea of actions taken at regional/national/local scales.
- Understand the concepts of in-situ and ex-situ conservation
- Develop an understanding of place based conservation methods i.e. protected areas and learn about protected area categories based the World Conservation Union (IUCN) classification
- Learn about the global distribution of protected areas
- Learn about the traditional role of communities in protected area management, the diverse kinds of community efforts as well as popular approaches to community engagement such as the Community Based Natural Resource Management (CBNRM) strategies

Module 2.1 Readings:

Lockwood, M (2006) Global protected area framework. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 73-100

Lockwood, M (2006) Social Context. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 41-72

Borrini-Feyerabend, G., Johnson, J. and Pansky, D (2006) Governance of protected areas. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 116-145

Kothari, A. (2006). Community conserved areas. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 549-573

Additional source material for instructors and further reading for students

Kothari, A. (2006). Collaboratively managed protescted areas. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 529-548

Escobar, Arturo (1998). Whose knowledge, whose nature? Biodiversity, Conservation, and the Political Ecology of Social Movements. *Journal of Political Ecology,* 5:53-82.

World Parks Congress (2003): WPC Recommendation 31. Protected areas, freshwater and integrated river basin management frameworks. Available at: http://www.iucn.org/themes/wcpa/wpc2003/english/outputs/recommendations.htm

Module 2.2: Effectiveness of Traditional Approaches Against Various Stressors

The effectiveness of existing protected areas in terms of biodiversity conservation, maintaining ecosystem resilience in the face of various non-climatic and climatic stressors, and in sustaining livelihoods and development will be examined. Students will also learn about the challenges associated with ensuring and maintaining protected area effectiveness. An assessment of the benefits and shortcomings of current approaches to conservation will be performed.

Module 2.2 Objectives:

Course participants will:

- Learn about the effectiveness of current protected area systems in protecting ecosystems and biodiversity against various stressors and therefore in supporting human development
- Become aware of some of the key challenges in maintaining protected areas
- Understand the strengths and weaknesses of traditional approaches to conservation, including in the context of climate change impacts

Module 2.2 Readings:

Naughton-Treves, L., Buck Holland, M. and Brandon, K. (2005). The role of protected areas in conserving biodiversity and sustaining local livelihoods, *Annual Review of the Environment and Resources,* 30: 219-252.

Dudley, N. and Stolton, S. (2003). Ecological and Socio-economic benefits of protected areas in dealing with climate change. In L. Hansen, J. Biringer and J. Hoffman, (Eds.), *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems*, WWF, Washington. Pp. 215-231.

Worboys, G., Winkler, C. and Lockwood, M. (2006) Threats to protected areas. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide,* Earthscan, London, UK and Sterling, USA, pp. 223-261

Lockwood, M., Worboys, G. L. and Kothari, A. (2006) Challenges and opportunities. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 677-681

Module 3: Extent and Status of Natural and Managed Systems in the Albertine Rift

A general understanding of the status of biodiversity and its conservation in Africa will be provided and a more detailed focus will be placed on the Albertine rift region, which will be studied in terms of current climatic and non-climatic stressors as well as projected impacts of climate change in the future decades. Current conservation practices in this region for the protection of ecosystems and biodiversity, including the degree of success of such programs will be examined. The ability of these approaches to address climate change impacts will be evaluated. In addition, applicable institutional, legal and policy aspects in this region will be explored, as will be the role of local communities and other stakeholders.

Module 3 Objectives:

Course participants will:

- Learn about the status of biodiversity conservation in the Albertine Rift region
- Evaluate the effectiveness of conservation programs in addressing climatic and non-climatic stressors here
- Become familiar with institutional, legal and policy aspects that inform conservation in this region
- Learn about the influence of local communities in conservation in this region
- Learn about the role of other stakeholders e.g. international/national NGOs and institutions, local/regional organizations, national/regional/local governments and officials, etc.

Module 3 Readings:

UNEP (2002) The state of Africa's environment and policy analysis: Part B: Biodiversity, *Africa Environment Outlook*, Earthprint Limited, UK, pp. 53-93

Plumptre, A. J., Davenport, T. R. B., Behangana, M., Kityo, R., Eilu, G., Ssegawa, P., Ewango, C., Meirte, D., Kahindo, C., Herremans, M., Peterhands, J. K., Pilgrim, J. D., Wilson, M., Languy, M., and Moyer, D. 2007. The biodiversity of the Albertine Rift, *Biological Conservation*, 134: 178-194.
http://webdocs.dow.wur.nl/internet/fem/uk/pdf/plumptre%20et%20al%202007.pdf

Mahinya, Stephen G. (2005). Assessment of ecological integrity of land use systems using birds and bio-indicators in Malagarasi-Muyovosi Ramsr Site, Western Tanzania. MSc. Dissertation, Sokoine University of Agriculture, Morogoro, Tanzania; 103pp.

Patterson, G. and J. Makin (eds) (1998). The state of biodiversity in Lake Tanganyika – A literature review. Chatham (UK): National Resources Institute; 134pp.

Rogers, P.J. (2002). Global Governance/Governmentality, Wildlife Conservation, and Protected Area Management: A Comparative Study of Eastern and Southern Africa. Paper presented at the African Studies Association 45th Annual Meeting, Washington DC, December 5

Goldman, Mara (2003). Partitioned nature, privileged knowledge: Community-based conservation in Tanzania. *Development and Change* 34(5); pp. 833-862.

Balint, P.J. (2006). Improving community-based conservation near Protected Areas. The importance of development variables. *Environmental Management* 38(1); pp. 137-148.

Cambell, L.M. and A. Vainio-Mattila (2003). Participatory development and community-based conservation. Opportunities missed for lessons learned. *Human Ecology* 31(3); pp. 417-437

Additional source material for instructors and further reading for students

Taylor, D. and Hamilton, A. (1994). Impact of climatic changes on tropical forests in Africa: implications for protected area planning and management. In, *Impacts of Climate Change on ecosystems and Species: Implications for Protected Areas*, Proceedings of the IVth World Congress on national Parks and protected Areas, Caracas, Venezuela, The World Conservation Union, pp. 77-94

Tutin, C.E.G. (2002). Parks in the Congo Basin: Can Conservation and Development Be Reconciled? In, J. Terborgh, C.V Schaik, L. Davenport and M. Rao (eds), *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, pp 76-85

Hart, T. (2002). Conservation in Anarchy: Key Conditions for Successful Conservation of the Okapi Faunal Reserve. In, J. Terborgh, C.V Schaik, L. Davenport and M. Rao (eds), *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, pp 86-96

Struhsaker, T.T. (1998). Causal factors of Tropical Deforestation and Recommendations, In, *Ecology of an African Rainforests: Logging in Kibale and the conflict between Conservation and Exploitation*, University Press of Florida, pp 310-343

Terborgh, J (2002). Overcoming Impediments to Conservation. In, J. Terborgh, C.V Schaik, L. Davenport and M. Rao (eds), *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, Washington, DC, pp 243-249

Salafsky, N., and Margoluis, R. (2002). Breaking the Cycle: Developing Guiding Principles for Using Protected Area Conservation Strategies. In, J. Terborgh, C.V Schaik, L. Davenport and M. Rao (eds), *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, Washington DC, pp 409-423

Schaik, C.V., and Rao, M. (2002). The frontier Model of Development and its Relevance to Protected Area Management. In, J. Terborgh, C.V Schaik, L. Davenport and M. Rao (eds), *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, Washington DC, pp 424-440

Brandon, K. (2002). Putting the Right Parks in the Right Places. In, J. Terborgh, C.V Schaik, L. Davenport and M. Rao (eds), *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, Washington DC, pp 443-467

Schaik, C.V., Terborgh, J., L Davenport, and Rao, M. (2002). Making Parks Work: Past, Present and Future, In, J. Terborgh, C.V Schaik, L. Davenport and M. Rao (eds), *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, Washington DC, pp 468-480

Module 4: Protecting Ecosystems and Conserving Biodiversity under a Changing Climate in the Albertine Rift region

This module will be devoted to understanding the manner in which response strategies can be designed to address the impacts of climate change on ecosystems and biodiversity in addition to the impacts of other pre-existing stressors as well as any synergistic outcomes. Each sub-module will address a key step in the process of designing conservation strategies suited to a more dynamic environment and students will be given the opportunity to participate in case study exercises aimed at conservation planning for the Albertine Rift region.

Module 4.1: Approaches to Designing Conservation Responses that Address Climate Change Risks

Students will be introduced to certain key guiding principles that can inform the design of conservation strategies under a changing climate. Students will also learn to define conservation targets based on the status of biodiversity and ecosystems in the local/regional context as well as the impact of other non-climatic stressors.

<u>Module 4.1 Objectives:</u>

Course participants will:

- Learn about key guiding principles to designing climate change responsive conservation strategies e.g. conserving existing biodiversity; reducing the impacts of non-climatic stressors; protecting and restoring habitats and maintaining habitat

connectivity; relying on analytical evidence to guide decision-making; and integrating adaptation and mitigation efforts (from Hopkins et al, 2007)
- Learn to use these guidelines to set broad conservation goals and priorities for their local/regional areas, keeping in mind institutional, legal and governance aspects.

Module 4.1 Readings:

Hopkins, J. J., Allison, H. M., Walmsley, C. A., Gaywood, M. and Thurgate, G. 2007. *Conserving Biodiversity in a Changing Climate: guidance on building capacity to adapt,* DEFRA, United Kingdom

Hannah, L., T. Lovejoy and S. Schneider (2005). Conservation with a changing climate. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 325-328.

Price, M. F. and Neville, G. R. (2003). Designing strategies to increase the resilience of Alpine/Montane systems to climate change. In. L. J. Hansen, J. L. Biringer and J. R. Hoffman (Eds.), *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems: Protected Areas,* World Wildlife Fund. Pp. 73-92

Module 4.2: Designing Landscapes

Students will learn about various databases and analytical tools that can be used for planning the design of landscapes for biodiversity conservation under a changing climate. This will enable them to learn to set specific targets for their eco-regions and determine the scope and boundaries of their planning areas.

Module 4.2 Objectives:

Course participants will:

- Learn about various modeling methods for determining climate change impacts on ecosystems and species and therefore on conservation targets (e.g. regional climate projections, modeling changes in species distribution, species range shift models, etc.)
- Based on these methods learn to determine future changes in conservation targets, keeping in mind the synergistic interactions of climate change impacts with non-climatic stressors
- Learn to determine the future distribution and boundaries of protected areas, including the importance of maintaining landscape connectivity
- Understand the need for a dynamic conservation plan in response to current and projected future distribution of species under a changing climate and informed by reserve planning tools (e.g. reserve selection algorithms)

Module 4.2 Readings:[3]

Hannah, L., T. Lovejoy and S. Schneider (2005). Designing landscapes and seascapes for change. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 329-341.

Hannah, L. (2003). Regional biodiversity impacts assessments for climate change: a guide for protected area managers. In L. Hansen, J. Biringer and J. Hoffman, eds., *Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems*, WWF, Washington. Pp. 233-242.

Module 4.3: Management of Protected Areas

The importance of planning and management for formally conserved areas will be discussed. Current strategies for biodiversity conservation and protected area management will be evaluated for their applicability and new/modified strategies developed where necessary. The need for spatial coordination across national/regional boundaries to ensure protection in the event of shifting margins of species ranges and habitats will be highlighted. Planning and regulatory tools that can address the impacts of non-climatic stressors will be discussed. The importance of designing cost effective strategies that maintain flexibility and reversibility will be addressed. Key stakeholders and their roles in the conservation planning and management process will be discussed.

Module 4.3 Objectives:

Course participants will:

- Understand the role of planning and management in protected area design and conservation
- Learn to evaluate current management tools in terms of their long-term applicability under a changing climate
- Understand the importance of spatial coordination
- Identify key stakeholders and their roles
- Understand the need for planning and regulatory tools that can address climatic and non-climatic stressors and can maintain flexibility and reversibility as risks change with a changing climate
- Identify additional costs in terms of staff, resources, training, and equipment needs.

Module 4.3 Readings:

Hannah, L. and Salm, R. (2005). Protected area management in a changing climate. In T. Lovejoy and L. Hannah (Eds.), *Climate Change and Biodiversity*. Yale University, New Haven, pp. 211-228.

[3] Note: It is suggested that participants refer to readings on methods and tools from Course 1, module 5

Lockwood, M. (2006) Management Planning. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide,* Earthscan, London, UK and Sterling, USA, pp. 292-327

Lockwood, M. and Quintela, C. E. (2006) Finance and Economics. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 328-358

Schaik, C.V., Terborgh, J., L Davenport, and Rao, M. (2002). Making Parks Work: Past, Present and Future, In, J. Terborgh, C.V Schaik, L. Davenport and M. Rao (eds), *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, Washington DC, pp 468-481

Module 4.4: Protecting Matrix Areas

Besides the need to protect formally conserved areas, participants will also be made aware of the important value of the matrix. A large amount the biodiversity currently occurs outside of any formal protected areas, in the matrix, which is currently subject to a variety of land uses. The importance of developing management strategies to protect the matrix as a part of a dynamic landscape conservation plan will be discussed in order to conserve its biodiversity and preserve its capacity to serve as a source of resources for certain species, or as a potentially new suitable habitat for others due to shifting ranges, or as migratory corridors. Methods and tools used for determining future species distributions and ranges and therefore for delineating matrix areas that will require protection will once again be applied here. The need for spatially and sectorally coordinated management responses and the role of key stakeholders will also be highlighted.

<u>Module 4.4 Objectives:</u>

Course participants will:

- Learn about the key role of the matrix as a source of biodiversity, as a source of resources for species, as a connective landscape, and as a potential suitable habitat for species under a changing climate.
- Learn to apply analytical methods and tools to determine the current and future functions of matrix areas in biodiversity conservation
- Understand the importance of periodic monitoring of climate induced changes as well as changes in other stressors in matrix areas, which are often under various land uses
- Learn about the various options for protecting matrix areas to preserve their structure and function
- Be informed about policy and regulatory approaches to protecting matrix areas

<u>Module 4.4 Readings:</u>

Da Fonseca, G. A. B., Sechrest, W. and Oglethorpe, J. (2005). Managing the matrix. In T. Lovejoy and L. Hannah (Eds.), *Climate Change and Biodiversity*. Yale University, New Haven, pp. 346-362.

Sandwith, T. and Lockwood, M. (2006). Linking the landscape. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 574-602

Module 4.5: Community Inclusive Approaches

The role of local communities as important stakeholders in the process of adapting biodiversity conservation strategies to address climate change impacts will be highlighted. Emphasis will be placed on approaches that can include the successful cooperation and participation of local communities, as they are likely to be more effective, especially in natural resource dependent communities and in the matrix areas where land-use is often mixed. Traditional community conserved areas will be evaluated for their ability to continue to offer a refuge for biodiversity.

Module 4.5 Objectives:

Course participants will:

- Evaluate traditional and current community conservation strategies in terms of their applicability for conservation under a changing climate
- Identify other community stakeholders that could potentially play a role in biodiversity conservation under climate change
- Identify current land-uses by local communities in areas that might need protection for biodiversity conservation under climate change and the ways in which these land uses can be made compatible with conservation objectives (are social appraisal tools like participatory rural appraisal useful here?)
- Evaluate the usefulness of popular approaches such as the CBNRM in aiding community participation for biodiversity conservation under climate change
- Identify policy and regulatory measures as well as incentives that could be used to elicit community cooperation and participation

Module 4.5 Readings:

Goldman, Mara (2003). Partitioned nature, privileged knowledge: Community-based conservation in Tanzania. *Development and Change* 34(5); pp. 833-862.

Balint, P.J. (2006). Improving community-based conservation near Protected Areas. The importance of development variables. *Environmental Management* 38(1); pp. 137-148.

Cambell, L.M. and A. Vainio-Mattila (2003). Participatory development and community-based conservation. Opportunities missed for lessons learned. *Human Ecology* 31(3); pp. 417-437.

Baldus, R.D., Kaggi, D.Th. and Ngoti, P.M. (2004). Community based conservation: Where are we now? Where are we going?' *Miombo,* **27**, 3-7.

Nelson, F., E. Sulle and P. Ndoipo 2006. Wildlife Management Areas in Tanzania. A Status Report and Interim Evaluation prepared for the Tanzania Natural Resource Forum. Final Draft.

Emerton, L. and Mfunda, I. (1999). Making wildlife economically viable for communities living around the Western Serengeti, Tanzania. Evaluating Eden Series, Working Paper No. 1.

Hill, C.M. (2002). People, crops and wildlife: A conflict of interests' in Hill, C., Osborn, F. and Plumptre, A.J. (eds.), Human-wildlife conflict: Identifying the problem and possible solutions. Albertine Rift Technical Report Series, Vol. 1. Wildlife Conservation Society; pp. 61-68.

International Resources Group (2000). Community based conservation experience in Tanzania: An assessment of lessons learned. Report prepared for USAID/Tanzania by International Resources Group, Washington, DC, USA. August, 2000.

Balint, P.J. and J. Mashinya (2006). The decline of a model community-based conservation project: Governance, capacity and devolution in Mahenye, Zimbabwe. Geoforum 37; pp. 805-815.

Additional source material for instructors and further reading for students

Borrini-Feyerabend, G., Johnson, J. and Pansky, D (2006). Governance of Protected Areas. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide*, Earthscan, London, UK and Sterling, USA, pp. 116-145

Tutin, C.E.G. (2002). Parks in the Congo Basin: Can Conservation and Development Be Reconciled? In, J. Terborgh, C.V Schaik, L. Davenport and M. Rao (eds), *Making Parks Work: Strategies for Preserving Tropical Nature*, Island Press, Washington DC, pp 76-85

Module 4.6: Monitoring the Effectiveness of Adaptive Strategies

Participants will learn that, while designing a conservation plan to address climate change impacts is critical, it is equally important at the same time to develop a system for periodic monitoring in order to track the success or failure of any management strategies that have been implemented. In addition a monitoring system can also track changing responses of biodiversity to changing climatic conditions and therefore to determine

changing conservation needs. Various tools that can be used for this purpose will be discussed.

Module 4.6 Objectives:

Course participants will:

- Understand the importance of monitoring for effective conservation planning to address a changing climate
- Understand the basics of designing a monitoring system that produces the desired results and is cost-effective
- Learn to determine what must be monitored i.e. focus on key target species, processes and resources
- Learn to select eco-regions or landscapes that must be monitored
- Learn to determine the frequency of monitoring required
- Learn to use various methods and tools for this purpose e.g. spatial analysis, survey methods, etc.

Module 4.6 Readings:

Hockings, M., Leverington, F. and James, R. (2006) Evaluating management effectiveness. In, M. Lockwood, G. L. Worboys and A. Kothari (Eds.), *Managing Protected Areas: A Global Guide,* Earthscan, London, UK and Sterling, USA, pp. 635-655

Hannah, L. and Salm, R. (2005). Protected area management in a changing climate. In T. Lovejoy and L. Hannah, eds., *Climate Change and Biodiversity*. Yale University, New Haven, pp. 211-228. [4]

Module 5: Case Study: Designing Conservation Strategies for Addressing Climate Impacts in the Albertine Rift Region

This module is designed as a hands-on activity where students will use the knowledge acquired from this course to design a conservation plan that is sensitive to changing risks under climate change for an area of their choice within the Albertine rift region. Students will be expected to use the tools and resources provided in this course to develop their designs and must include all the key considerations, including the need for periodic monitoring. This exercise includes presentation of the conservation plans developed during this activity.

Module 5 Objectives:

Course participants will work in groups and select an eco-region within the Albertine Rift region to design a conservation plan that must:

[4] Note: Repeat reading from Module 4.3; some sections from this reading are applicable to this module

- Identify broad goals and priorities
- Identify climatic and non-climatic stressors, both current and future, and be able to determine potential future impacts in terms of changing species distribution and ranges
- Identify matrix areas that important for future conservation needs
- Assess the applicability of current conservation strategies in that region to address climate risks in future
- Include a climate risk integrated management plan that considers future conservation landscapes, including matrix areas.
- Identify key stakeholder roles, including community participation strategies
- Identify policy/regulatory approaches
- Include a periodic monitoring plan identifying key targets and landscapes to be monitored, monitoring frequency and methodology
- Include an analysis of cost effectiveness

As a conclusion to this exercise, each sub-group will be expected to formally present their conservation plan to their colleagues.

2.3 Mode of Conducting the Course

The two courses will be conducted consecutively using lectures, case studies, field visits, group discussions, computer labs and seminar presentations.

2.4 Course Evaluation

At the end of the training program course participants will be evaluated through written assignments (e.g. written reports), assessed seminar presentations, and written examinations.

3. COURSE REQUIREMENTS

3.1 Admission of Participants

The courses are being offered on a pilot basis in July-August 2008 with support from the John D. and Katherine T. McArthur Foundation. Applications to participate were invited in February 2008 and selections made in April 2008. Priority was given to conservation professionals from countries of the Albertine Rift. The courses are now full for July-August 2008 and no new applications will be considered. It is intended that the courses will be offered periodically, both as intensive 3-week courses during the summer and also as courses in the regular curriculum of the masters of science degree in Natural Resource Assessment and Management (NARAM) at the University of Dar es Salaam. Announcements of future opportunities to participate in the course will be advertised via the web (http://pass-africa.org; http://www.ira.udsm.ac.tz; http://start.org). You may also contact (pass@ira.udsm.ac.tz; ira@ira.udsm.ac.tz) for information about future plans to offer the course.

3.2 Grading

Grading shall be in accordance with UDSM grading system. All students will be required to undertake examinations and pass both courses. Grades shall be given by one of the letters A, B+, B, C, D, and E. The pass grade for each of the courses taken shall be "B". The grades correspondence to marks (%) is shown below.

A = 70% - 100%	C = 40% - 49%
B+ = 60% - 69%	D = 35% - 39%
B = 50% - 59%	E = 0% - 34%

POTENTIAL EXTERNSHIP LOCATIONS

Montane Ecosystem

- Udzungwa Mountains National Park
- Kilimanjaro Mountains National Park
- Gombe National Park
- Amani Nature Reserve

Freshwater Ecosystem

- Momella Volcanic Lakes
- Rungwe Volcanic Lakes

Marine Ecosystem

- Chumbe Island-Zanzibar
- Mafia Insland Marine Park

Savanna Ecosystem

- Mikumi National Park
- Ngorongoro Conservation Area

Wetland Ecosystem

- Malagarasi-Muyovozi wetland