CLIMATE CHANGE THREATS TO BIODIVERSITY IN PAKISTAN

By:

M. Mohsin Iqbal and Arshad M. Khan

Global Change Impact Studies Centre,
National Centre for Physics (NCP) Complex
Quaid-i-Azam University Campus, Islamabad-44000
Email: mohsin.iqbal@gcisc.org.pk

ABSTRACT

Pakistan has a great diversity of landscape, people, culture, climate, seasons, ecosystems, etc: The landscape ranges from snow capped peaks at an elevation of > 8,000 m in the Himalayan Range in the north to Arabian Sea coastline in the south; agriculture ranges from lush green canal irrigated areas in the plains to hot dry deserts in Sindh and Balochistan; temperature ranges from well below freezing points in the HKH mountainous region to as hot as 52^0 C in the inland areas and annual precipitation ranges from >1000 mm in the northern humid areas to <150 mm in the hyper-arid areas of Balochistan. Such diversity has given rise to a variety of living organisms including flora, fauna, animals, birds, insects, etc. which provide ecological, recreational, cultural and aesthetic values besides providing economic benefits and services to human society. However, this large accumulation of biodiversity is now under threat as in many parts of the world as a result of, *inter alia*, climate change. The global climate has been changing in a phenomenal manner since the advent of the industrial revolution in mid 18^{th} century. According to the scientific assessments made by Intergovernmental Panel on Climate Change (IPCC), the average global temperature increased by 0.6^0C over the last century while it is projected to increase further by 1.8 - 4.0^0C during the current century.

Various studies indicate that climate change is affecting, directly or indirectly, the flora and fauna as well as their habitats leading to their displacement and in most severe cases, even extinction. Climate change is also affecting the competitiveness of different species by differently altering their growth, mortality rates and regeneration success rates. This may adversely affect synchronous functioning of life cycles of plants, animals and soil organisms. According to a study by Ministry of Environment and UNEP, 31 species of mammals, 20 of birds and 5 of reptiles are already endangered and many more are on the Endangered list. Under the unprecedented rate of climate change projected by IPCC for the current century, a wide array of species is unlikely to

adapt or migrate fast enough. Measures should, therefore, be adopted to protect the wildlife and native flora and fauna.

The paper describes threats posed to plant biodiversity and sensitive ecosystems by climate change and some initiatives to promote and conserve biological diversity in Pakistan.

Introduction

The Nature has bestowed Pakistan with a great diversity of landscape, people, climate, seasons, ecosystems, etc. The landscape ranges from snow capped peaks at an elevation of > 8,000 m in the Himalayan Range in the north to Arabian Sea coastline in the south; agriculture ranges from lush green canal irrigated areas in the plains to hot dry deserts in Sindh and Balochistan; temperature ranges from well below freezing points in the HKH mountainous region to as hot as 52^0 C in the inland areas and annual precipitation ranges from >1000 mm in the northern humid areas to <150 mm in the hyper-arid areas of Balochistan. Such diversity has given rise to a variety of living organisms including flora, fauna, animals, birds, insects, etc. which provide economic benefits and services to human society as well as ecological, recreational, cultural and aesthetic values.

The Convention on Biological Diversity

The Convention on Biological Diversity is dedicated to promoting sustainable development. It was signed by 150 government leaders at the Earth Summit held in Rio de Janero, Brazil on 05 June, 1992. The Convention recognizes that biological diversity is about more than plants, animals and micro organisms and their ecosystems – it is about people and our need for food security, medicines, fresh air and water, shelter, and a clean and healthy environment, in which to live.

Biodiversity

Biological diversity or Biodiversity refers to the variety of life on earth. According to United Nations Convention on Biological diversity, it includes diversity of ecosystems, species and genes, and the ecological processes that support them. Biodiversity is also defined as the average abundance of the original species at a given time compared with its original abundance when ecosystems were hardly impacted by people (UNEP, 2004). This paper will be limited mainly to plant biodiversity.

Plant Biodiversity

Some 5,500 to 6,000 species of vascular plants have been recorded in Pakistan including both native and introduced species (Nasir and Ali, 1970). More than two third of the endemics are found in the northern and western mountains (Ali and Qaiser, 1986). The Kashmir Himalayas are identified as a

global centre of biodiversity and endemism. Families with more than 20 recorded endemics are Papilionaceae (57 species), Compositae (49), Umbelliferae (34), Poaceae (32) and Brassicaceae (20). Almost 80% of the cultivated species have been derived from wild and semi-wild ancestors.

Agricultural Biodiversity

Agriculture involves growing of different plant species; hence promoting agricultural biodiversity is very important. Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agro-ecosystem. It includes the variety and variability of plants, animals and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes. Agricultural biodiversity is the outcome of interactions among genetic resources, environment and the management systems and practices used by farmers. This is the result of both natural selection and human interventions developed over millennia. (http://www.cbd.int/agro/about.shtml). Agricultural biodiversity provides not only food, income and livelihood but also raw materials for clothing, shelter, medicines, breeding new varieties, and performs other services such as maintenance of soil fertility and biota, soil and water conservation, and pollination, all of which are essential to human survival. Nearly one third of the world's land area is used for food production.

The following dimensions of agricultural biodiversity can be identified:

i) **Genetic resources for food and agriculture:** Genetic resources constitute the main units of production in agriculture, and include cultivated and domesticated species, managed wild plants and animals, as well as wild relatives of cultivated and domesticated species.

   a) Plant genetic resources: include crops, wild plants harvested and managed for food, trees on farms, pasture and rangeland species. In Pakistan, a variety of crops are grown, such as

   Cereal Crops: Wheat, Rice, Maize, Barley, Sorghum, Millet

   Fiber Crops: Cotton, Sunhemp

   Sugar Crops: Sugarcane, Sugar beet

   Pulses: Chickpea, Mung, Mash, Lentil, Moth

   Oilseed Crops: Cotton, Soyabean, Sunflower, Safflower, Sesame, Rapeseed, Mustard

   Vegetables: Potato, Spinach, Pumpkin, Gourd, Squash, Radish, Carrot, Okra, Brinjal

   Fruit Crops: Mango, Orange, Banana, Guava, Apple, Apricot, Peach, Plum, Melons, Lemon, Grapes, Pomegranate, etc.

b) ***Animal genetic resources***: include domesticated animals, wild animals hunted for food, wild and farmed fish and other aquatic organisms,

c) ***Microbial and fungal genetic resources***.

ii) **Components of biodiversity that support ecosystem services** upon which agriculture is based. These include a diverse range of organisms that contribute, at various scales to, *inter alia*, nutrient cycling, pest and disease regulation, pollination, pollution and sediment regulation, maintenance of the hydrological cycle, erosion control, and climate regulation and carbon sequestration.

iii) **Abiotic factors**, such as local climatic and chemical factors and the physical structure and functioning of ecosystems, which have a determining effect on agricultural biodiversity.

iv) **Socio-economic and cultural dimensions**. Agricultural biodiversity is largely shaped and maintained by human activities and management practices, and a large number of people depend on agricultural biodiversity for sustainable livelihoods. These dimensions include traditional and local knowledge of agricultural biodiversity, cultural factors and participatory processes, as well as tourism associated with agricultural landscapes.

- While agriculture contributes significantly to conservation and sustainable use of biodiversity, it is also a major driver of biodiversity loss. The Earth's biodiversity is being lost at an alarming rate, putting in jeopardy the sustainability of agriculture and ecosystem services and their ability to adapt to changing conditions, threatening food and livelihoods' security.

Benefits of Plant Biodiversity

Biodiversity is an important element for the sustenance of human life. It provides economic benefits and services to human society. It also provides ecological, recreational, cultural and aesthetic values. Plants are great source of medicines; 75% of the world population depends on plants for medicines; 2,100 plants contain anti-cancer components.

Drivers of Biodiversity Loss and Extinction of Species

Plant biodiversity is under pressure from two main factors;

Population Increase: The burgeoning population is putting pressure on plant resources to meet its needs of food and fiber. This has resulted in over-exploitation of the productive resources of land, water and air in some parts of the country. In Quetta, for example, which is famous for growing apple and grape

orchards, over-drawl of ground water supplies has caused the water table to drop below one meter with the result that fruit orchards are perishing. The recent refugee influx from neighboring Afghanistan along with their grazing animals has transformed the rangelands into completely denuded land surface. The area is now on the way to desertification.

Climate Change: Climate change has posed serious threats to biodiversity in recent years by exerting direct and indirect impacts on various plant species and by exacerbating the land degradative processes of waterlogging, salinization, and wind and water erosion. This is resulting in loss of plant and animal habitat or environment. Before we discuss the threats posed by climate change, it is important to define the basic terms of weather, climate, climate change, climate change profiles of Pakistan and the impacts it can exert on biodiversity.

Weather: The state of atmosphere at a given time and place, with respect to the variables such as temperature, moisture, pressure, etc. (Dictionary.com, http://dictionary.reference.com/browse/weather)

Climate: It is the average weather. Statistical description of mean weather conditions over a period of time of several years, typically 2-3 decades.

Climate Change: It is the climatic change in excess of natural variability, attributable to human activity. United Nations Framework convention on Climate Change (UNFCCC) defines climate change as 'A change of climate which is attributed directly or indirectly to human activity that alters the composition of global atmosphere and which is in addition to natural climate variability observed over comparable time periods. (http://www.wmo.int/pages/prog/wcp/ccl/faqs.html

Climate change occurs due to natural climate variability as well as anthropogenic (human) activity, particularly since the Industrial Revolution of 1780s (http://wmo.int/pages/prog/wcp/ccl/faqs.html). The natural variability is very slow while the variability brought about by anthropogenic influences is more rapid and fast. The anthropogenic influences include spiralling population, high pace of industrialization, increasing use of fossil fuel in industry and transport, deforestation and urbanization. The real causal agent of climate change, popularly known as global warming, is increase in the emissions of Greenhouse Gases (GHG), chiefly carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (IPCC 2007).

Changing climatic trends

The Inter-Governmental Panel on Climate Change (IPCC), the apex international body on climate change research, makes periodic assessments on the status of climate change. Based on its latest Assessment Report (AR4), published in November 2007, the future concentration of CO_2 was calculated.

The concentration in the atmosphere has increased from the pre-Industrial Revolution value of 280 ppm in 1780 to 385 ppm in 2008, and is projected to increase to 550 ppm by 2050. The global average temperature has increased by 0.6 °C during the last century and is likely to increase by 1.8 to 4 °C by the end of this century. The changes in rainfall are not uniform; in sub-humid and humid areas there will be increase in monsoon rainfall whereas in the coastal and hyper-arid areas there will be decrease in winter and summer rainfall (IPCC 2007).

Climate Change Profiles of Pakistan

(a) Past Trends

The past trends were determined by statistical analyses of past 50 years observed data (1951-2000) recorded by meteorological stations of Pakistan Meteorological Department. The mean temperature changes in six climatic zones of Pakistan are shown in Fig. 1.

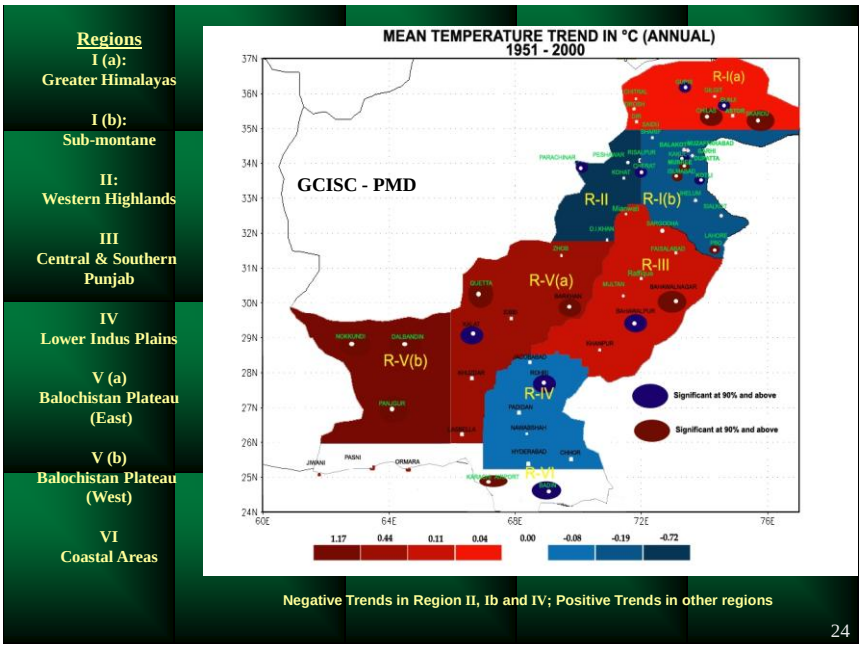

Fig.1: Changes (%) in mean annual temp. during 1951-2000 in different climatic regions of Pakistan.

It can be seen that there was maximum increase in temperature in Region IV (western Balochistan) followed by Region-V(a) (north eastern Balochistan), Region - III (Punjab) and Region-I(a) (Northern Areas). On the other hand, there was a negative trend of temperature increase in Region-II (Khyber Pakhtoonkha), I(b) and IV (Sindh).

The mean precipitation changes in six climatic zones of Pakistan are depicted in Fig. 2. There was negative trend of precipitation change in Regions II (lower part of Khyber Pakhtoonkha) and IV (Sindh) while a positive trend in the other regions. These are brought both by the monsoon and winter systems.

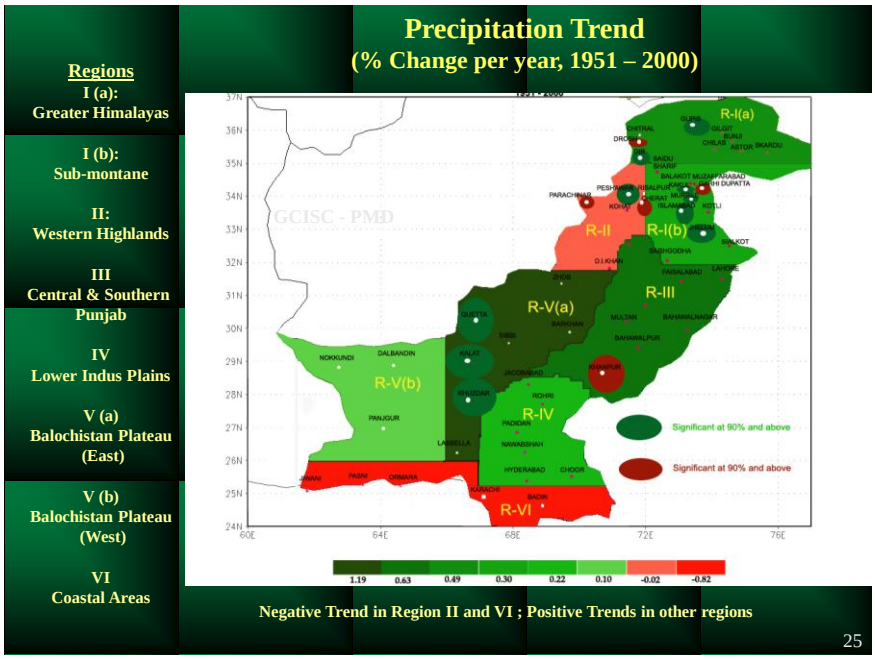

Fig. 2: Changes (%) in annual precipitation over the period 1951-2000 in different climatic regions of Pakistan.

(b) Projections

Using the outputs of an ensemble of 17 global circulation Models (GCMs), the climate change projections were made for Pakistan (Khan 2009), for the following time slabs:

Base Period: 1961-1990

Future 2020s: 2010-2039

2050s: 2040-2069

2090s: 2070-2099

These projections are based on coarse resolution of GCMs which are typically 300 km^2. According to these projections (Fig. 3), the temperature increase in Northern and Southern Pakistan, by 2080s under IPCC Scenario A2, would be 3.8 and 4.5° C, respectively which is higher than the global temperature of 3.4° C (Upper portion of Fig. 3). Similarly, under IPCC A1B scenario, the temperature in northern and southern Pakistan, by 2080s, would be in the order of 3.6 and 4.4° C which is higher than the average global temperature of 2.8° C

under this scenario (Lower portion of Fig. 3). Secondly, it is evident that under both A2 and A1B scenarios, the temperature will be higher in Northern Pakistan compared to Southern Pakistan.

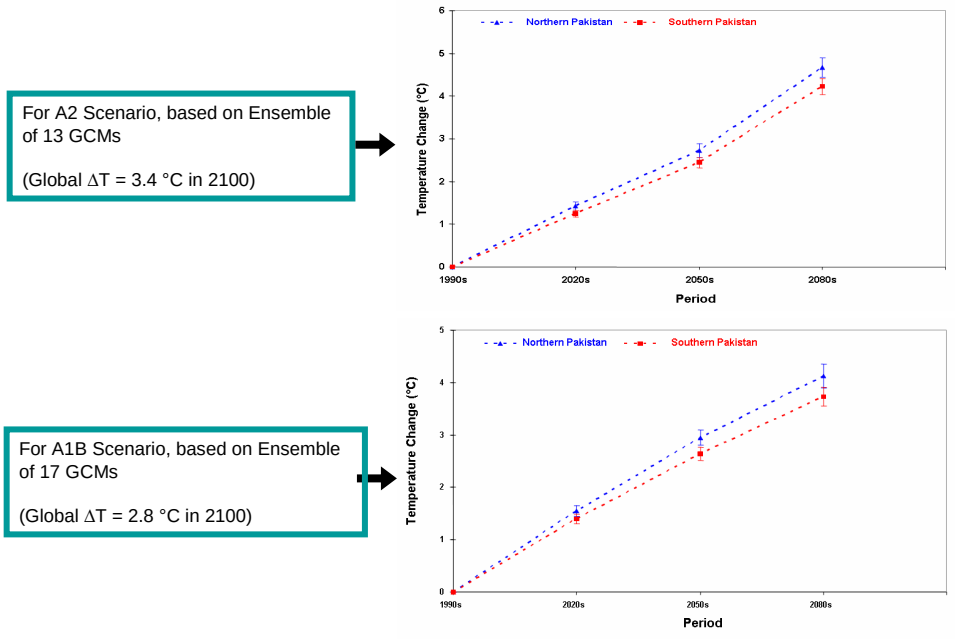

Fig. 3: Projected Changes in Average Temperature of Northern and Southern Pakistan towards the end of 21st century (Coarse Resolution Results).

Impacts of Climate Change related to Biodiversity Deforestation

There is growing recognition within the international community that deforestation and forest degradation in developing countries play a significant role as 'cause and effect' of climate change. When trees are growing, they absorb carbon dioxide from the atmosphere but when they are destroyed they release all the carbon dioxide back to the atmosphere, causing global warming. Deforestation is responsible for about 20% of global warming.

Forests are also a major repository of biodiversity; supply a wide range of goods and ecosystem services and provide livelihood to millions of forest-dependent communities. Unsustainable exploitation of forest resources in Pakistan has resulted in degradation of forest to the tune of 0.2 to 0.4% per annum during the past two decades.

Land Degradation

Land degradation is brought about by processes that turn the soil unsuitable or less suitable for optimum crop cultivation, or which result in physical loss of fertile soil material. The common processes of land degradation are:

Waterlogging: Rising of water table to near the soil surface to the extent that results in saturation of soil profile thereby inhibiting respiration of plant roots. In Pakistan, 5% of the land is affected by waterlogging to various degrees.

Salinity: Deposition of excessive salts at the soil surface or in the soil profile due to capillary action inhibiting germination and growth of plants. In Pakistan, 8% of land, mainly in Punjab and Sindh provinces, is affected by salinity and sodicity (presence of excessive sodium on the soil exchange complex).

Erosion: Detachment of fertile top soil layer due to the action of water and wind. In Pakistan, 17% of land is affected by water erosion and 8% by wind erosion. The extent of land degradation in Pakistan is given in Table 1.

Table 1. The extent of Land Degradation in Pakistan

Water Erosion	:	17%
Wind Erosion	:	8%
Salinity and Sodicity	:	9%
Waterlogging	:	5%
Low organic matter (<1%)	:	96%

The processes of land degradation are exacerbated by climate change; the wind erosion due to low rainfall and high winds, and water erosion as a result of high torrential rains. The water-logging is enhanced due to heavy rainfall and the resultant rise in water table height, and Salinity due to greater evaporation from land surface resulting in accumulation of dissolved salts on the soil surface.

Climate – Extreme Events

The extreme events triggered by climate change such as flash floods, heavy precipitation events, droughts, cyclones, hail storms, dust storms, etc have been on the increase in the recent past with their telling effects on life and property. The extreme events are hard to predict. According to IPCC (2007), their frequency and intensity is likely to increase in future. Such events destroy the plant and animal themselves, their habitats and their food.

Components of Biodiversity

1. Conservation of biodiversity

i) Establishment of Protected Areas

The biodiversity needs to be preserved and protected, against different threats, for use by the future generations. According to a study by Ministry of Environment and UNEP, 31 species of mammals, 20 of birds and 5 of reptiles are already endangered and many more are on the Endangered

List. Government of Pakistan has established 224 protected areas (mainly for wildlife species); 23 National Parks, 99 Wildlife Sanctuaries, 104 Game Reserves, and 16 unclassified areas. Also, 19 Wetlands have been included in the protected areas.

Extent of area under protection is 9,852,006 hectares, or 10.40% of the country area.

ii) Institutional Measures

- * Wildlife Enquiry Committee formed in 1968
- * NCCW (National Council for Conservation of Wildlife) formed in 1974
- * NCS (National Conservation Strategy) formed in 1992
- * Plant Genetics Resources Program established under Pakistan Agricultural Research
- Council (PARC), Islamabad. About 30,000 species of vegetables, cereals, oilseeds,
- medicinal and other plants documented.

iii) International Conventions and Agreements

Pakistan is signatory to virtually all of the major international agreements in the field.

2. Sustainable Use of Biological Resources

The diverse biological resources should be used in a manner which is sustainable and does not compromise on quality of environment or of productive resources.

3. Equitable Sharing of Genetic Resources

The wealth of genetic resources should be shared by all nations to meet the basic human needs of food, fiber and shelter, and to develop new resources under changing climate. The Plant Genetics Resources Program of Pakistan Agricultural Research Council (PARC), Islamabad has documented and catalogued about 1,080 species of vegetables, cereals, oilseeds, medicinal and other plants.

Models used to Study Biodiversity

Biome model (BIOME3)

The model was developed by **Global Systems Group School of Ecology**, Lund University, Sweden. BIOME3 is an equilibrium terrestrial biosphere model that has been implemented globally using a minimal set of just five woody and two grass plant types. In BIOME3, leaf area is expressed as leaf area index (LAI). A

small number of ecophysiological constraints is used to select the plant types that may be present in a particular climate. The model then calculates a maximum sustainable LAI and NPP (Net Primary Productivity) for each plant type.

Model output consists of a quantitative vegetation state description in terms of the dominant plant type, secondary plant type present and the total LAI and NPP for the ecosystem. This basic model output is classified into biomes for comparison with vegetation maps.
(http://adsabs.harvard.edu/abs/1996GBioC..10..693H)

California Urban and Biodiversity Analysis Model (CURBA)

The California Urban and Biodiversity Analysis (CURBA) model was developed as a tool to help urban planners to evaluate the possible effects of alternative urban growth patterns and policies on biodiversity and natural habitat quality. CURBA can help direct urban growth while promoting environmental and ecological quality. Its component Lifemapper (LM) produces a comprehensive archive of species' geographical distribution maps. It intends to re-architect the LM species data archive and update it with models derived from museum data. Therefore, a software package called DesktopGarp has been developed in order to allow the users to predict and analyze wild species distributions using GARP algorithm, choosing different parameters, environmental layers and custom statistical methods. This tool supports the community ecologists by modeling the a) Ecological niche, b) Species richness and abundances. Two of the most important concepts from the community ecology applied to biodiversity (http://gcmd.nasa.gov/records/CURBA.html)**.**

REFERENCES

- Ali and Qaiser, 1986. Quoted from http://www.wwfpak.org/p_environment_biodiversity.php, on June 10, 2010
- IPCC 2007. Climate Change 2007: Climate Change Impacts, Adaptation, and Vulnerability. Summary for Policymakers. Inter-Governmental Panel on Climate Change, Working Group-II, Fourth Assessment Report.
- Nasir and Ali, 1970. Quoted from http://www.wwfpak.org/p_environment_biodiversity.php, on June 10, 2010.
- Sheikh, M.M., N. Manzoor, M. Adnan, J. Ashraf and A.M. Khan. 2009. Climate profile and past climate change in Pakistan. GCISC Research Report 01 (GCISC-RR-01), Global Change Impact Studies Centre (GCISC), Islamabad.
- UNEP, 2004. Convention on Biological Diversity. Decision VII/30 Strategic plan: Future Evaluation of Progress. UNEP, Kuala Lumpur.