Impacts of Climate Change on Biodiversity Resources & Forest Ecosystems

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Abstract

Climate Change is a key challenge of biodiversity conservation. Impacts of climate change are significant on physiology, phenology and distribution of species, seasonal biological phenomenon of floral and faunal species, animal life cycle, migratory birds and wild animals, mountain ecosystems, wild animals' habitat as well as coral reefs habitat. Moreover, impacts of climate change are also on preservation of wild animals and plants in protected areas, shifting of bio-climatic zones, endangered & vulnerable flora and fauna and biodiversity hotspots. The change in hydrological cycle due to global warming affect on river run-off, accelerate water–related hazards and affect also on agriculture, vegetation, forests, biodiversity and health.

जैविक विविधता संरक्षणको लागि जलवायु परिवर्तन एउटा मुख्य चुनौतीको रुपमा देखिएको छ । जैविक विविधता सम्बन्धि परिवर्तनका मुख्य प्रभावहरु अन्तर्गत वनस्पती तथा जीवजन्तुको physiology, phenology र वितरण, मौसमी जैविक प्रक्रिया, जीवनचक्र, बसाई सर्ने चरा र वन्यजन्तुहरु, पर्वतीय पारिस्थितीकिय प्रणाली, वन्यजन्तुको वासस्थान, कोरल रीफ लगायत समुद्रि प्रजातीहरुमा परेको पाईन्छ । यसको साथै जलवायु परिवर्तनले संरक्षित क्षेत्रहरुमा रहेका वन्यजन्तु तथा वनस्पतीको संरक्षणमा कठिनाई, bio-climatic zones सर्ने संकट्टापन्न वनस्पती एवं जीवजन्तु र जैविक विविधता hotspots नासिने दर तिब्र पारेको छ । विश्वव्यापी रुपमा बढ्दो उष्णताले जलचक्रमा प्रभाव पारेको छ, परिणामस्वरुप बढ्दो भल, पानीसंग सम्बन्धित खतरा लगायत कृषि, वनस्पती, वनजंगल, जैविक विविधता एवं स्वास्थ्यमा नकारात्मक प्रभाव पारेको छ ।

Key Words: Carbon sequestration, Seasonal biological phenomenon, Shifting bio-climatic zones, Biodiversity hotspots

Introduction

Green house gases are a minor component of the atmosphere. We need the right amount to balance the heat. Too much or too little will cause damage to our environment. By the excessive use of fossil fuels, increased industrialization and various human activities are increasing the normal level of GHGs. This excess leads to more heat trapped, causing a rise in global temperatures and thus climate change will occur. The effect of heat trapping due to increasing the presence of green house gases in the earth's atmosphere is known as Green House Effect. This causes global warming, a temperature increasing process, which results in climate change. This climate change refers to any change in climate overtime whether due to natural variability or as a result of human activities. (Hannah et. al, 2007)

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The earth's surface absorbs a part of the incoming solar energy and the remainder is reflected back into the atmosphere. If all the heat were absorbed, it would get hotter and hotter. Green house gases in the atmosphere like carbon dioxide, ozone, methane, halocarbons and water vapor trap some of the reflected heat and reflect them back to the earth's surface. Thus, GHGs prevent all the reflected heat from getting lost and help to maintain a constant temperature of 15^0C (Liu & Rasul, 2007). This process is known as the natural green house gas effect. Without this process, the average temperature of our Earth would be -18^0C: an icebox with no liquid water, only snow and ice!

The annual average surface (1.5 meters) air temperature of the planet is probably the single most widely used indicator of the state of global climate (Liu & Rasul, 2007). The near surface air temperature averaged over all land, ocean and ice surfaces is estimated to have average 14^0C during the reference period 1961-1990. The surface air temperature during the decade of the 1990s averaged about 14.5^0C.The compilation of instrumental temperature since 1860 tells us that temperature has increased between 0.4^0C and 0.8^0C over the last 140 years (IPCC, 2001).

Globally, 1990s were the hottest decade and 2002 the second hottest year. It has been estimated that the Earth's surface temperature will rise between 1.4^0C and 5.8^0C between 1990 and 2100. The temperature rise is most accelerated near the poles. Many scientists estimate that the Arctic ice cover will disappear by 2080. In Nepal, the average temperature is increasing at the rate of approx. 0.06^0C annually. At present, Nepal makes up less than 0.4% of the world population and is responsible for about 0.025 % of annual green house gas emission. Unfortunately, while Nepal contributes least to the cause of climate change, we are among those at the highest risk from its negative impact (Mike, 2007).

Table 1: 20th century changes in the earth's atmosphere, climate and biophysical system

Indicators	**Observed changes**
Biological & physical indicators	
Global mean sea level	Increased at an annual rate of 1 to 2 mm during the 20th century.
Duration of ice cover of rivers and lakes	Decreased by about 2 weeks over the 20th century in mid and high latitudes of the Northern Hemisphere.
Arctic sea-ice extent and thickness	Thinned by 40 % in recent decades in late summer to early autumn and decreased in extent by 10-15 % since the 1950s in spring and summer.

Non-polar glaciers	Widespread retreat during the 20th century.
Snow cover	Decreased in area by 10 % since the global observations became available from satellites in the 1960s.
Permafrost	Thawed, warmed and degraded in parts of the polar , sub-polar and mountainous regions.
EI Niòo Events	Became more frequent, persistent and intense during the last 20 to 30 years compared to the previous years.
Growing season	Lengthened by about 1 to 4 days per decade during the last 40 years in the Northern Hemisphere, especially at higher latitudes.
Plant and animal ranges	Shifted pole ward and up in elevation for plants, insects, birds and fish.
Breeding, flowering and migration	Earlier plant flowering, earlier bird arrival, earlier dates of breeding season and earlier emergence of insects in the Northern Hemisphere.
Coral reef bleaching	Increased frequency, especially during EI Niòo Events.
Economic indicators	
Weather related economic losses	Global inflation – adjusted losses rose an order of magnitude over the last 40 years. Part of the observed upward trend is linked to socio-economic factors and part is linked to climatic factors.

Source: IPCC, 2001, 6p

Discussion

Impacts of climate change on biodiversity

Nepal's wealth in biodiversity earned its recognition as a National Showroom and Natural Biological Laboratory of the world (Banskota, 2007). Biodiversity is the sum of species, ecosystems and genetic diversity of Earth. Mountain ecosystems host a series of climatically different zones over short distances and elevations and have a range of micro-habitats and niches, therefore mountains are hotspots of biodiversity and priority regions for conservation.

Mountain biodiversity is also most sensitive to global warming and is now showing signs of fragmentation and degradation caused by exogenous forces such as temperature increase and human activities (Hannah et al. 2007).

Climate change is a key challenge of biodiversity conservation

Biodiversity is continually transformed by a changing climate. Fluctuating temperatures and changes in rainfall patterns are the main reason for habitat change. Climate largely determines the distribution of species, ecosystems and flora. Any climatic change will shift these distributions, which will be hampered by barriers and human presence. This could spell extinction for some species and ecosystems. The synergy between climatic change and habitat fragmentation, isolated island formation & invasive alien exotic species introduction is the most threatening aspect of climate change for biodiversity and is a central challenge facing conservation (Hannah et al. 2007).

Impacts on physiology, phenology and distribution of species

Changes in the physiology, phenology and distribution of species are evidence of changes to biodiversity that have occurred within the past few decades, directly attributable to recent temperature trends. Future changes are very likely to be greater, as both habitat fragmentation and climatic change intensify (Hannah et al. 2007). Changes in phenology have been witnessed in the advancement of springtime activities such as leaf production and flowering in plants, breeding in birds and arrival time of migrant birds. Such changes could lead to an impaired regeneration capacity of species (Parmesan, 2007) . The largest phenological changes will be more extreme at higher latitudes and altitudes because the warming of globe is more intense in these regions than nearer the equator.

Case study: Kafal early fruiting

According to D.R. Pant, reporter of Kantipur national daily newspaper states that Kafal (*Myrica esculenta*) berries took fruiting in the month of April which was usually in the past but now it takes place only from February. In the past, Kafal berries took fruiting in the April even at high altitude region of the district. Similarly, Rhododendron blooms in February, two months earlier, which should bloom in April in the past. Such events are usual in this year, throughout the country due to the impacts of climate change. According to a record of Meteorological Office, Dadeldhura district, there has a maximum temperature of 29^0C even at high altitude during the month of February while it seldom reaches 29-32^0C temperature even in the May and June .

Source: Kantipur national daily newspaper

Impacts on seasonal biological phenomenon of floral and faunal species

Many seasonal biological phenomenons such as plant growth, flowering, animal reproduction and migration depend on accumulated temperature–organisms require the appropriate amount

of heat at the required time to develop from one point to another in their life cycle. These phenomena are therefore expected to respond sensitivity to climate warming (Root and Hughees, 2007).

Impacts on animal life cycle

Animal life cycles also depend on climate. Warming is expected to allow insects and other ecothermic animals to pass through their juvenile stages faster, thus, becoming adults more quickly which could result in smaller body size and possibly allow some species to undergo more generations per year (Pernetta *et al.* 2007).

Impacts on migratory birds and wild animals

Climate variability and change affects birdlife and animals in a number of ways; birds lay eggs earlier in the year than usual and mammals are come out of hibernation sooner. Distribution of animals is also affected, with many species moving closer to-the poles as response to the rise in global temperatures. Birds are migrating and arriving at their nesting grounds earlier, and the nesting grounds that they are moving to are not as far away as they used to be and in some countries the birds don't even leave anymore, as the climate is suitable all year round (Thomas, 2007).

Long-distance migrants may be more vulnerable to global warming than other species. The proportion of long-distance migrant bird species will be decreased while the number and proportion of residents and short-distance migrants increased. The principal trends for breeding birds reflect a tendency for species characteristic of the lower mountain slopes to increase in abundance at higher elevations.

Thousands of Californian brown pelicans postponed migration to the south last year, leading researchers to believe that a climate change might have fooled the birds into staying north longer than usual. Some migratory species may be particularly vulnerable to mismatches between resource availability and life history. (http://netherlandsenvironmentalassessmentagency.org/natureandtheEnvironment/climatechange/Guidance climate change: consequences for flora and fauna .html)

Impacts on mountain ecosystems

Mountain ecosystems have a significant role in biospheric carbon storage and carbon sequestration, particularly in semi-arid and arid areas. Mountain ecosystem services such as water purification and climate regulation extend beyond geographic boundaries and affect all continents (Liu and Rasul, 2007).

Climate change is a major threat to biodiversity in mountain areas where migration of species is physically restricted. Alpine plant species on mountain ranges with restricted habitat

availability above the tree line will experience severe fragmentation , habitat loss or even extinction if they can not move to higher elevations , particularly after an increase of 2^0C (Dirnbock et al. 2003 as cited by Xu Jianchu et al 2007).

In the Himalayan region, people depending on alpine range resources, such as nomadic races, are likely to be worst affected (Mahat and Belbase, 2007) .

Despite the fact that deforestation is the second leading contributor of carbon emissions worldwide after the burning of fossil fuels, countries currently have few incentives for preserving their forests. However, deforestation is finally gaining attention in international discussions on climate change. Addressing deforestation must be a part of a comprehensive global climate change solution that addresses all major sources of carbon emissions. The world's developed governments should create a flexible framework that incorporates the actions of developing countries with meaningful incentives to encourage the preservation and restoration of forests. *(http://www.thenatureconservancy.org/climatechangeimpacts/whyreducingdeforestationiscrucial/html)*

Impacts on wild animal's habitat

Forests are being lost in an alarming rate. Species such as tigers, rhinos and elephants which need large areas for survival are threatened by habitat modification and destruction. Invasive plant species largely destroy wildlife habitat. Climate change favors the growth of invasive plant species.

Invasive plant species destroyed the wildlife habitat

Mr. Dipendra Baduwal, a reporter of Kantipur national daily newspaper states that the invasive plant species severely degraded the wildlife habitat by replacing the regeneration of native vegetation mostly edible grass species of rhino, deer and other other prey species of tiger. Invasive plant species destroyed more than 80% of the riverine forest and grassland habitat excluding the Sal forest. It disturbs the tiger–prey relationship since deep population is dwindling due to unfavorable habitat and poaching. Lowering the deer and other prey species will be ultimately the causal factors of extinction of tiger population from the protected areas. Climate change is one of the prominent factors for invasion of alien species in the protected areas since global warming supports the growth of exotic invasive plant species.

Source : Kantipur national daily newspaper

Impacts on wetlands

(http: // www.ramsar.org/wetlands and climate change / background paper from IUCN/ html.)

Wetlands cover nearly 10% of the earth's surface of which 2% are lakes, 30% bogs, 26% fens, 20% swamps and 15% floodplains. Mangroves further cover some 24 million hectares

(ha) and coral reefs are estimated to cover 60 million ha. The largest remaining areas of wetlands are in the high latitudes and the tropics. Agricultural expansion and other developments have destroyed many wetlands in temperate regions (http://www.ramsar.org). Climate warming will increase suitable habitats for the water hyacinth (*Eichhornia crassipes*), a noxious weed able to survive during winter .

Impacts on coral reefs

Coral reefs are the most biologically diverse marine ecosystems, but are very sensitive to temperature changes. Short-term increases in water temperatures in the order of only 1 to 2 degrees Celsius can cause "bleaching" of coral reefs. Sustained increases of 3 to 4° C above average temperatures can cause significant coral mortality. Restoration of these coral communities can require several centuries. A rising sea level and increasing storm surges also could harm coral reefs (http://www.ramsar.org).

Chronic levels of pollution, sedimentation and over-exploitation are stressing reefs beyond their natural ability to recover, with many showing obvious signs of destruction, e.g. few fishes, low coral recruitment, obvious death of living corals, increased bio-erosion and dominance by other organisms like algae. The major impact of climate change will be through bleaching of corals and other organisms, which will result in losses of coral cover (Wilkinson and Buddemeir, 1994, 102-103p). Climate change will affect those coral reef systems that are already under stress due to a range of pressures such as over-fishing, pollution, destruction and disease (Wilkinson, 1994).

Consequences of changing hydrological cycle on organisms

The change in hydrological cycle may affect river run-off, accelerate water–related hazards and affect agriculture, vegetation, forests, biodiversity and health (Beniston, 2003 as cited by Liu and Rasul, 2007). Wetlands will be affected in different ways by shifts in the hydrological cycle. These include changes in precipitation, evaporation, transpiration, runoff and groundwater recharge and flow. These changes will affect both surface and groundwater systems and impact wetland requirements, domestic water supply, irrigation, hydropower generation, industrial use, navigation and water based tourism. (http://www.ramsar.org)

Impacts on preservation of wild animals and plants in protected areas

The expected global warming will influence the distribution and abundance of many species in various ways. Specific information concerning the threat of global warming to individual species and protected areas is still rather fragmentary. Possibly owing to these complicating factors. Under the most optimistic scenario, at least 16 % of the existing reserves will encounter major difficulties concerning the protection of the present life-communities under changed climate conditions. The most pessimistic scenario implies problems for almost 60 % of the

existing reserves. Although these are very crude figures, they do indicate that there is a real threat to the survival of many life communities in existing reserves (Groot and Ketner, 1994).

Impacts on shifting of bio-climatic zones

A temperature increase of 3^0C corresponds with a change in bio-climatic zone of about 600 km. Examples from the past show that changes in distribution have been at most 100-200 km per century for trees with wind-born seeds (such as elm and maple) . For most deciduous trees (walnut, chestnut, oak) migration rates (actual as well as potential) of 10-50 km per century are more typical (Huntley, 1991 as cited by Groot and Ketner, 1994).

A shift in bioclimatic zones of 600 km in 100 years is clearly much faster than most plants can migrate, especially in the case of trees. Even "fast" species such as Spruce which may "migrate" up to 200 km per century, would have problems under the expected rate of climate change (Groot and Ketner, 1994).

Impacts on endangered & vulnerable flora and fauna

Endangered species and population of some animals may be adversely influenced by climate change. For example, sea turtles will be affected by sea level rise through disruption of nesting beaches, by temperature increases altering the sex ratio in hatching turtles and by major current shifts altering migration routes (Wilkinson and Buddemeir, 1994, 103p). The already endangered Mediterranean Monk Seals need beaches upon which to raise their pups and a rise in sea level could damage shallow coastal areas used annually by whales and dolphins which need shallow, gentle water in order to rear there small calves.

Impacts on biodiversity hotspots

The planet's 25 biodiversity "hotspots" are especially vulnerable to climate impacts. These special places provide homes to 44% of the world's plants and 35% of its vertebrates, in less than 1.4% of its land area. A doubling of atmospheric carbon dioxide, which estimates suggest could occur in about 100 years, could lead to extinction of as many as 43% of these areas' endemic species.

About 150 migratory birds have not seen

Mr. Abdullah Miya, Kantipur national daily newsletter states that about 150 migratory birds have not seen in the winter season of 2009 . There was less arrival of migratory birds due to altering of their habitats through climate change impacts. Due to the impacts of climate change, hatching and breeding have become faster than the earlier. According to one study of the North America, birds took 24 days for hatching before a decade, now it takes only 6 days. According to bird specialist, there has been decreasing insects and termites which affect the migratory birds as the hatching of birds have fasten but the availability of foods has become low.

Source : Kantipur national daily newspaper

Conclusion

Biodiversity is continually transformed by changing climate. The synergy between climatic change and habitat fragmentation, isolated island formation & invasive alien exotic species introduction is the most threatening aspect of climate change for biodiversity. Changes in the physiology, phenology and distribution of species are evidence of changes to biodiversity. Many seasonal biological phenomenon such as plant growth, flowering, animal reproduction and migration are sensitive to global warming. Warming is expected to shorten the life cycle of insects and other ecothermic animals. Climate change affects on migratory birds and wild animals by altering the time schedule. Climate change is a major threat to biodiversity in mountain areas where migration of species is physically restricted. Climate change favors the growth of invasive plant species which threatens the wildlife habitat. Climate change will likely affect waterfowl that are dependent on wetlands as their habitats, and may contribute to desertification processes. Climate change will affect coral reef systems that are already under stress due to a range of pressures such as over-fishing, pollution, destruction and disease. The expected global warming will influence the distribution and abundance of many species in various ways. Rising temperatures are changing weather and vegetation patterns across the globe, forcing animal species to migrate to new, cooler areas in order to survive. The rapid nature of climate change is likely to exceed the ability of many species to migrate or adjust. Global warming affects on shifting of bio-climatic zones. Endangered species and populations of some animals may be adversely influenced by climate change. The planet's significant biodiversity "hotspots" are especially vulnerable to climate impacts.

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