



Effect of climate change on biodiversity: A review

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Abstract

Biodiversity is essential building block of the services the ecosystem provides to society of human. Biodiversity is very important due to its role in ecosystem functioning but when it is eroded it is difficult to replace or recover it. Change in climate has reverse effect on the habitat fragmentation and habitat loss and synergistically take part in the biological diversity degradation at genetic, habitat and species level. Population that is present in the fragmented landscape is more susceptible to environmental drivers that include change in climate. Fragmentation and deforestation can causes restricted drought and localized shift in rainfall, increased risk of fire and limiting the movement of species with bioclimatic condition.

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Introduction

Most important question of 21st century in conservation and ecology is how do various stressors interact and relate on ecosystem and biodiversity (Sala *et al.*, 2000; Darling *et al.*, 2010). Biodiversity is very important due to its role in ecosystem functioning but when it is eroded it is difficult to replace or recover it (Backlund *et al.*, 2008). Biodiversity is essential building block of the services the ecosystem provides to society of human. Change in climate is critically affecting the ecosystem and biodiversity that contain changes in phenology, species distribution, primary production and growing season (Adger *et al.*, 2003).

For the biodiversity of earth, change in climate is potential threat. With comparison to other human based environmental changes such as increases greenhouse effect, disease, invasive species, overexploitation, pollution and direct effect of climatic changes are slow and problematic to measure. Change in climate will worsen the pressure already imposed on the environment (Kappelle *et al.*, 1999).

Habitat loss and climatic change processes simultaneously affect the biodiversity. Climatic change also causes habitat fragmentation and loss that causes loss in land dwelling species population. Fragmentation in habitat causes enhanced risk of extinction and spatial isolation (Fig. 1). Scattered vegetation causes gene flow between tree populations with response to the change in climate (Lemoine *et al.*, 2007; Breed *et al.*, 2011).

Change in climate has reverse effect on the habitat fragmentation and habitat loss and synergistically take part in the biological diversity degradation at genetic, habitat and species level (Backlund *et al.*, 2008). Population that is present in the fragmented landscape is more susceptible to environmental drivers that include change in climate (Lavergne *et al.*, 2010). Fragmentation and deforestation can causes restricted drought and localized shift in rainfall, increased risk of fire and limiting the movement of species with bioclimatic condition (Mantyka-pringle *et al.*, 2012).

The recent change in the climate change is rationalizing the animals and plants geographic distribution world-wide (Cheung *et al.*, 2009). Population dynamics of those populations that occupy the latitudinal margins of the dispersal variety are likely to be judgmentally significant in influential response of species to predictable change in climate (Hamp and Petit, 2005).

There are various components of change in climate that impose impact on all levels of biodiversity (Hampe and petit, 2005). Change in climate has the ability to lessen the genetic diversity due to rapid migration and directional selection that have effect on the ecosystem resilience and functioning (Bellard *et al.*, 2012).

Executing climate change alteration measures instantly is considered both to reduce considerably negative effect on biodiversity as well as on outdoor restoration in protected area management. This study aims to give answer why and how climate change affects the biodiversity.

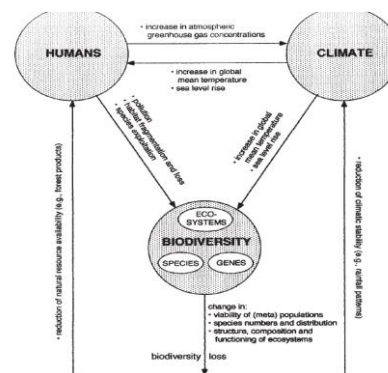


Fig. 1. Factors leading to loss of biodiversity.

1) Climate change impact on environment

Balance of planet has been changed due to the human activities. Due to human activities enhanced production of methane, cut down the trees that absorb carbon dioxide and burnt large amount of fossil fuels (Adger *et al.*, 2003). Enhanced level of greenhouse gases causes increased in temperature. By 2100 increase in 6 degree temperature occurs predicted by the intergovernmental panel on climate change. In the past earth's climate change so much that directly change the biodiversity and ecosystem (Cheung *et al.*, 2009).

A) Climate change and diminishing food security

Increased in temperature have effect on climate which in response have impact on environmental functioning. One important functioning of ecosystem is nutrient replenishment that is on risk because nutrient cycles and fertility of soil are at risk due to change in climate (Hampe and petit, 2005). These types of effects are essential for preserving the habitat and biodiversity but also have effect on the agriculture activity. With the harsh changes in the climate the dryness in soil become occurs which have impact on the carbon and nitrogen concentration that are important for the growth of plant (Bellard *et al.*, 2012). It also causes to change in the landscape. Change in climate and temperature can cause spreading of pests due to warmer areas. E.g in the forest of the kenai peninsula Alaska bark beetles are present that complete its two or three cycles instead of one cycle due to increase in temperature (Cheung *et al.*, 2009; Lavergne *et al.*, 2010).

B) Climate change and worse air pollution

Due to the bad air conditions it is expected that by the end of this century more than half of the population of worlds will face the enhanced stagnant atmospheric conditions. Stagnant air results due to the three meteorological conditions: day with no precipitation, light winds and lower atmospheric pressure (Hampe and petit, 2005). If the level of greenhouse gases increases significantly it is approximated that by 2099, 55% population of world will face the air stagnation. From 1986 – 2005 the areas of Amazon, Mexico and India faces 40 percent more air stagnation (Lavergne *et al.*, 2010).

2) Effects on land biodiversity

Increased temperature has impact on the world's polar region. Shrinking of the ice packs lessen the place of living for the puffins, penguins and Arctic creatures (Hampe and petit, 2005). When the melting of ice occurs it damages the ecosystem that is present on the coastlines. Temperature change also causes changes in migratory birds such as reproductive timing and mating cycles (Cheung *et al.*, 2009).

A) Disappearing Wildlife

The greater cause of species extinction is global warming according to the international studies. In this century it is approximated that 1.5°C average rise in the temperature which causes twenty to thirty percent of species at extinction risk (Hannah *et al.*, 2002). Not only individual species lost but ecosystem completely damage with increase in temperature. Many animals will be threatened when their habitat disturbed such as iconic animals (Bellard *et al.*, 2012). Following are the some examples:

i) Asian rhino

This species at risk due to change in the climate will disturb the weather patterns in Nepal and North India. Their food based on the annual monsoon due to rain but change in climate disturbs the rain patterns and drought occurs (Harley, 2011).

ii) Tigers

Due to habitat loss and poaching the number of tigers decline in the wild as less as 3200. Change in climate causes the risk of fire and increased level of sea and causes the fragmentation of habitat (Hannah *et al.*, 2002).

iii) Snow leopard

Best habitat for the snow leopard is Himalaya ranges. Warming of the Himalaya ranges occurred at 3 times the global average. Repeatedly increased hotness in the Himalaya ranges causes shrinkage of the treeline on the mountains. Due to all these reasons the fragmentation of habitat occurs as well as prey of snow leopard (Kumar and chopra, 2009).

iv) Orangutans

There are three basic risks for the orangutans such as illegal hunting, deforestation and forest conversion. Change in climate food shortage occurs due to the disrupt rainfall patterns (Kumar and Chopra, 2009).

v) African Elephant

In the Africa elephants drink 225 litres of water per day. In Africa variation in rainfall occurs, sometime heavy floods and sometime dry conditions. These variations make the environment less suitable for a species to live. Due to above reasons elephants may come in contact with humans or travel towards protected areas (Kumar and chopra, 2009).

vi) *Adelie penguins*

This penguin lives most of their life in Antarctic so known as true Antarctic penguins. Due to increase in temperature reduction in the quantity of ice occurs in regions of the continent. There basic food is breeds and krill that are under the sea ice. Reduction of ice means the food shortage of Adelie penguins occur (Kumar and chopra, 2009).

3) *Effect on ocean Biodiversity*

Increase in sea level causes change in temperature of ocean which leads toward several events. It has very much effect on the zooplankton that is necessary part of the oceanic food chain (Hannah *et al.*, 2002). Change in climate has effect on the extreme rainfall pattern, drought and flooding. That enhances the pressure on the lakes and rivers which provides the water for animals and people (Byg and salick, 2009). Ocean absorbs large quantity of carbon dioxide so known as carbon sinks. Enhanced temperature causes increase in the level of carbon dioxide so ocean becomes more acidic (Thomas *et al.*, 2004; Hijmans and garaham, 2006). This acidity affects the marine organisms especially the fish. Coral reefs are also facing risk due to decrease in oxygen that causes bleaching and ultimately death of the coral (Bellard *et al.*, 2012).

Melting of glaciers in the mountain regions has impact on the freshwater ecosystem. Himalayan glaciers fall in Asian rivers such as Indus, Mekong, Yangtze, Yellow and Ganges (Thuiller 2007; Harley, 2011). A great number of people depend on the glaciers for sanitation, hydroelectric power, drinking water and agriculture. If the rise in the global warming persists then by the end of 2025 Australian's Great Barrier Reef will be only 5 percent (Hannah *et al.*, 2002; (Laverne *et al.*, 2010).

4) *Effect of paleoclimate change on biodiversity*

The understanding of the effect of previous change in climate on animals and plants life is helpful in the modeling which forecast the upcoming change in ecosystem, species and communities (Mantyka-pringle *et al.*, 2012). Most notable changes occur over the million years in fluctuation between warmer and colder eras (Harley, 2011).

The ratio at which the temperature change of world occurs is forecasted to increase global temperature more rapidly as compare to the past 18000 years (Mantyka-pringle *et al.*, 2012). This is indicated that some species are not able to change their areas fastly to cope with change in climate (Hijmans and garaham, 2006). With the variations in temperature change occurs in vegetation belt. In costa Rica palynological research occurs which shows that during the latter glacial maximum cooling occurs from 7 to 8°C. Climate changes in Central America shows that variation in humidity is more effective as compare to the change in temperature during Holocene period (Chapin *et al.*, 2000). In northern hemisphere and Chile the dendrochronological studies reveal the importance of the trees in climate variation over the past hundred years. 70,000-12,000 years BP the period of last ice age, the changes occur on paleotropic rain forest in the Africa region (Stenseth *et al.*, 2002;Harley, 2011). From the East Africa the pollen fossil collections indicated the loss of vegetative zones with 6°C variation in temperature. The area of the lowland rain forest is disappearing toward small refuges with containing drought resistant vegetation (Byg and salick, 2009).

5) *Effect of modern climate change on biodiversity*

During the modern advancement various changes occurs on biodiversity. Some are as following: i) change in vegetation zones ii) change in species range iii) Effect of habitat fragmentation and climate change and iv) Effect on ecosystem functioning (Hannah *et al.*, 2002).

i) *Change in vegetation zones*

Due to change in climate the variations in global vegetation cover occur in the borders of the biomes. Warming of the earth occurs in the upper altitudes and latitudes. E.g. in the Finland the timber line increases 200m higher in Atlantic thermal period. In the future if the global conditions persist then montane cloud forest will grow at the place of the species rich tropic alpine vegetation (Harley, 2011; Mantyka-pringle *et al.*, 2012). In the new models of climate change it is shows that new plants will grow in response to the change in climate change. Change in the moisture causes more complex results.

If we take the example of the ecoclimatic zones it shows that variation in ecoclimatic zones of hilly areas are different within the latitudes and nonsymmetrical (Byg and salick, 2009).

ii) *Change in species range*

Climate change effect the phenology, physiology and interaction among species which results in geographic distribution shift. Change in ranges occurs in the Britain butterflies due to very small fluctuation in temperature (Chapin *et al.*, 2000). In the Swedish tundra the northward expansion of birch occurs due to the increase in temperature. Survival chances of species reduced if they do not modify themselves according to the geographic distribution. Extinction of 64 vascular plants occurs in Netherlands during the previous some years. Direct human impact and change in climate both have effect on the ecosystem to trigger the species distribution pattern (Visser *et al.*, 2008; Harley *et al.*, 2006).

In Netherlands phenology shifts causes the dispersal of huge number of Microlepidoptera which is also due to the change in climate. In the period from 1975-1994 the increase in temperature during spring causes shift in flight peak to 11.6 days before (Heller *et al.*, 2009). To check the sensitivity of the ecosystem some species act as bio-indicator due to their sensitivity to the change in climate. Species selection as bio-indicator based on the following factors: habitat constrains, sensitivity to climate, sustainability for monitoring, position according to range distribution, functional position in ecosystem and dispersal capacity (Walther *et al.*, 2002). Geographic information system can be used to study the composition of species and geographic distribution shift (Hijmans and garaham, 2006; Mantyka-pringle *et al.*, 2012). For the monitoring of the climate change ecotones or ecoclimatic transistors can be used due to their specie sensitivity to change in climate. Temperate timber lines, cold forests, tropical tree and rainforests are all example of the ecotone climate change (Onyango *et al.*, 1997; Harley *et al.*, 2006).

iii) *Effect of habitat fragmentation in climate change*

From the previous year fragmentation and destruction of habitat lead towards loss in biodiversity on global, regional and local scales.

Fragmentation in habitat related to the change in climate causes greater extinction that based on human encroachment alone Onyango *et al.*, 1997). Fragmentation in habitat causes species isolation and led to genetic variation reduction. It also inhibits the species dispersal and migration toward better habitat. Land fragmentations into minor units have greater effect on edges and also cause landscape with edges which contain forests (Chapin *et al.*, 2000; Wilby and perry, 2006). Population survival in fragmented areas depends on characters of matrix surrounded fragments, immigration potential and distribution of landscape. Corridors establishment within the fragments also act as response to management (Willis and bhagwat, 2009).

iv) *Effect on ecosystem functioning*

Ecosystem functioning depends on the interconnected activities of organisms such as nitrification, respiration, decomposition of litter and carbon dioxide fixation. It also has effect on the functioning of ecosystem by affecting the physiology of species such as moisture or temperature change (Harley *et al.*, 2006). Climate change also causes to disturb or tolerate the species to make species extinction by reducing the biodiversity of ecosystem. For the ecosystem process controlling the plant species act as necessary factor. Loss of functional group and species causes loss in services and functioning of ecosystem. Species loss in the ecosystem lessens the resilience and contracted the options for adjustment to change in climate (Onyango *et al.*, 1997; Kappelle *et al.*, 1999).

6) *Variation across Biomes*

Southern and tropical Biomes show greater changes due to landscape fragmentation. Climate change also has effect on the Arctic ecosystem. But on the grassland, savannas and Mediterranean ecosystems more than one driver have potential effect. Biotic exchange, climate and land use have impact on the freshwater ecosystem (Heller *et al.*, 2009). Use of land also has impact due to disproportionally livings of humans. Finally it causes variations in water ways including sediments, contaminants and nutrient input (Pecl *et al.*, 2017). Humans use water as sewage disposal and transportation corridors (Chapin *et al.*, 2000).

In the aquatic ecosystem biotic exchange is necessary as compare to the terrestrial ecosystem for unintentional and intentional release of organisms. On the streams and lakes Nitrogen and carbon dioxide deposition had low effect as compare to the terrestrial environment. Due to all above reasons the biodiversity of freshwater ecosystem reduces more rapidly (Harley *et al.*, 2006).

Use of land has the great impact in the tropical streams. While in the temperate streams both factors such as biotic exchange and use of land have greater impact. Change in climate has greater impact on the altitude and latitude regions to reduce the biodiversity (Harley *et al.*, 2006). Biodiversity of rivers and streams is greatly sensitive to the change in climate as compare to the lakes due to the greater runoff. Mediterranean and grassland ecosystems show low change in biodiversity because it is less sensitive. Alpine, desert and arctic ecosystems have adequate alteration in the biodiversity for reason that is definite to each biome (Sala *et al.*, 2000).

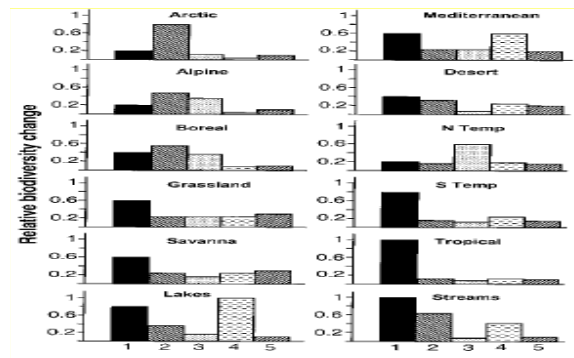


Fig. 2. variation across biome.

7) *Downstream and Global effects*

22% of whole people on Earth is persistent by Asia’s water tower, the important factor is lessen amount of water and enhanced temperature. It is estimated that by 2040 to 2060 temperature of Himalaya increases very much as compare to 1900. In the circulation of global atmosphere Great Himalaya has very important role (Heller *et al.*, 2009). Changes of environment in Himalaya have climatic effect that results in enhanced temperature and precipitation on large scale (Onyango *et al.*, 1997). In the Earth’s radiation budget snow cover and glaciation at low latitudes have important role.

In hot weather great land areas of Asia warmer as compare to the Indian Ocean which causes air flow and increased pressure gradient. Change is pressure lead towards reduction in snow cover and glacial (Chapin *et al.*, 2000).

Upsetting in the sea level due to global climate change has impact on mega deltas, migration and reduction in agricultural land. Productivity of the grassland ecosystem is very low than fluxes size which have impact on the net carbon flow that converts sinks of carbon dioxide to source of carbon dioxide (Heller *et al.*, 2009). Projected change in Tibetan Plateau ecosystems, from alpine steppe and desert to alpine meadow and shrub lands, is reason for the near-complete vanishing of permafrost with the potential cascading effect of releasing most of the region’s soil carbon (XU *et al.*, 2009; Pecl *et al.*, 2017).

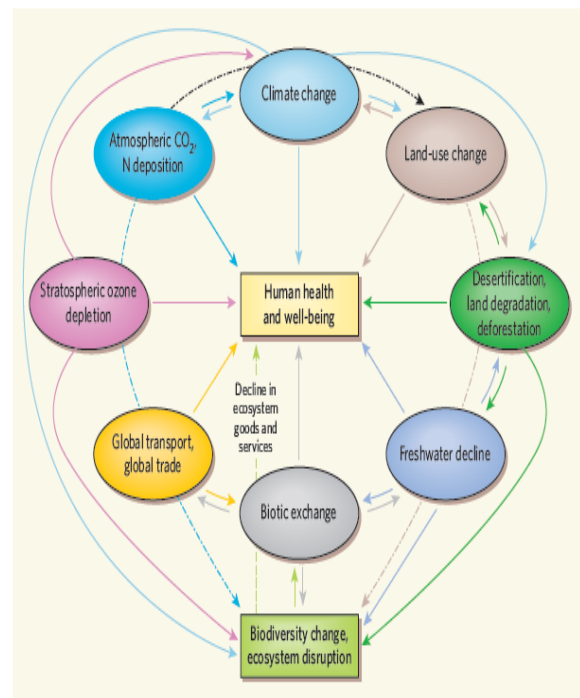


Fig. 3. Factors affecting, human health, ecosystem and biodiversity.

Conclusion

Diversity of living things on the earth is known as Biodiversity that is used to measure the health of the Earth. It provides great number of the benefits to the humans that take part in the 40 percent of economy of the world. It gives economic opportunities, basis for the medicinal advances and food security.

Functioning of the ecosystem and biodiversity levels causes ameliorating change in climate. Change in climate imposed the severe disruptions to the ecology of Earth that leads toward the biodiversity loss. In the future extinction will be very high. If we take action now to control the change in climate then we can get many benefits as well as reduction in biodiversity can be minimized. Continuity in climate change causes reduction in 50percent of animal and plant species which destroy the ecosystem globally.

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