



## REVIEW OF CLIMATE CHANGE AND ITS EFFECTS ON BIODIVERSITY

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### ABSTRACT

Globally climate change and loss of biodiversity are major environmental threats that we are facing today. Changes in species habitats compositions, and consequently changes in ecosystem functioning are some major effects of climate changes. There are various natural or anthropogenic activities that cause fluctuations in the climatic condition. Natural causes are volcanic eruptions, variability in the solar radiations, plate tectonic and orbital fluctuations of the Earth. While other are human activities that causes the climatic variations such as deforestation, over exploitations of natural resources, industrial toxic effluents, extensive agricultural practices, mismanagement of valuable resources and many more. When climate fluctuates from normal level, it has adverse effects on the biodiversity. Firstly it affects the temperature either increase or decrease at extreme level that leads to various changes within the ecosystem and then their interaction with wild or aquatic species causes disruption in different activities perform by the producers, herbivore and carnivore fauna. Due to climatic variations glaciers are starting to melt, increases the aquatic level which ultimately leads to the flooding conditions and produce harm to human being, destruct the habitat as well as disturbs the animals of aquatic ecosystem. On the other hand when the water of these melting glaciers enter into the sea it decreases its salinity which causes threats to the survival of many marine species. Ice covers in the upper surface of water also melts due to temperature increase and this phenomenon influence the productivity of phytoplankton upon which the whole marine life depends on. In addition it causes strong storms and tornados which made severe destructions, also drought due to less rains and prolonged heat waves influence badly on biodiversity. Several species are also affected by the threats of climate fluctuations as they adapt themselves or migrate for their survival. Other impacts of climate change includes early migration of birds and delayed return due to harsh weather conditions, changes in breeding cycle and the synchrony of two mutual species that are interlinked with each other in various aspects of predation and availability food. Species of sea turtle lost several nesting sites, due to sea levels rise and unsustainable coastal developments. In this paper we review natural causes and anthropogenic activities and their effects on biodiversity, terrestrial ecosystem, change on species phenology, population range and its composition, habitat fragmentations, affected functions of ecosystem, coral bleaching, migration of aquatic species, and rising sea levels.

**Keywords:** Terrestrial ecosystem, population range, habitat fragmentation, migration of birds, species phenology.

### INTRODUCTION

The continuous changing in weather patterns is termed as climate change. Now a days it is of main concern because it affects the world in several way. In 1990's many countries become the signatories of UNFCCC known as Kyoto Protocol whose aim is to reduce the carbon emission. According to which developed signatories countries have to reduce about 18% from total emission. Then new agreement was introduced in 2015 called Paris Agreement whose work is to make balance with the draft of action plan to limit global warming below 2°celcius (Rafi, and Riaz, 2018).

There are several natural and anthropogenic activities direct and indirect sources that causes climate change:

#### 1. Natural causes

##### a). Volcanic Eruptions

Different gases are expel out from the volcanic eruptions like carbon dioxide and sulfur dioxide also they discharge aerosols (ash, viruses, bacteria or dust) in the stratosphere. These aerosols are in the form of liquids and solids that floats freely in the atmosphere. Aerosols scatter in the stratosphere blocks the sunlight radiation and produce a cooling effect that may continue for 1-2 years (NASA, 2019).

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### b). Solar Variability

The solar production fluctuates through time depends on the quantity of sunspots that causes the climate change. These sunspots are darker areas on the surface of sun, appear due to lower temperature as compared to the surrounding area. These spots presents at the point where an intense magnetic field reduces the flow of gases that transmit heat energy from the sun's interior. Large quantity of these sunspots may contribute to warmer global climate, less appearance of sunspots indicates the cooler global climate. About 300 years ago, there was an epoch of decreased solar activity, called as "Little Ice Age" (NASA, 2019).

### c). Plate Tectonics

Tectonic plates carried landmasses at different latitudes. These modifications in the positions, effects the circulation patterns of sea water and air also produce fluctuations in the climate of continents. Coal mines are the best evidence that how the plate tectonics affects the climate. These mines were produced over millions of years ago in the regions of tropics, now they are found at higher latitudes.

Industrial revolution also play important role in climate change, the Northern Hemisphere has been warmed as compared to the Southern Hemisphere. The reason behind which is that the Northern Hemisphere have a greater quantity of Earth's continent, less of ocean than the Southern Hemisphere (NASA, 2019).

### d). Orbital Fluctuations

Three cyclical alterations in the orbit and tilt of earth were described by the Milankovitch in his theory that produced the modifications in climate. These modifications include; (1) alteration of Earth's orbit tool place at every 100,000 years, (2) produced tilt (obliquity) in the axis of Earth that took place at every 41,000 years, and (3) formation of wobbling (precession) in the axis of Earth about 23,000 years.

Glacial periods began when these three cycles regulate to favor an extended period in which the solar radiation become high in the winter season and become less in the summer season at 65°N latitude. In this case the temperature at northern latitudes increases as well as the high amount of precipitations in the air resulted in the snowfall. Cool summer at the northern latitudes promotes the formation of glaciers and inhibits the melting of winter snow (NASA, 2019).

## 2. Anthropogenic Activities

The other sources of climatic fluctuations impacted by the human activities are the disproportionate use of chemical fertilizers, secretion of greenhouse gases, fossil fuels

burning, deforestation, over exploitations and over grazing of livestock (Rafi and Riaz, 2018).

The carbon dioxide which is one of the greenhouse gas, confined heat in the atmosphere which then produce fluctuations in the climate. Greenhouse gases are naturally present on the earth, but anthropogenic activities further increased their quantity by deforestation, and industrial effluents. Greenhouse gases performs like a cover. The broadness of this cover is directly proportional to the warming of the planet Earth. Meanwhile, the extra amount of carbon dioxide are stored in the aquatic ecosystem of earth that leads the environment more acidic which not suitable for the organisms live their also causes threats to their survival (WWFa, 2019).

In the Arctic region, wild and marine fauna are also affected by the mining, spilling of oil, and other activities like drilling for the resources of gas and oil etc. Human activities also causing depletion of ozone layer which leads to the melting of glaciers in Antarctica and Arctic regions. Ultimately the water comes out from glaciers due to melting is subjected for rising of sea levels worldwide. The rise in the ocean level causing high threats to island countries like Sri Lanka and Maldives (Rafi and Riaz, 2018).

### Effects of Climate Change

As a result of effects of climate changing effect changes to ecosystems under the adverse effects climate change are likely to have significant and often negative economic, social and cultural consequences (Birdlife International, 2021). There are several effects of climate change that have been felt already, and by the time they will get worse. It is observed that the Global warming has increased nearly 1°C as compared to the pre-industrial conditions. There is a big importance of fluctuations in temperature and the increase of just half degree (or even less than half degree) of global warming have negative impacts on earth or biodiversity that ultimately leads to the survival of human in danger (Amnesty international, 2019). Some effects of climate change are as follows:

#### 1. Heat waves and Drought Conditions

Climatic fluctuations causes the severe drought and prolonged heat waves. Progressively, nevertheless, hot and dry places will become hotter and drier, and those places that were once temperate and had regular rainfall will become more and more sizzler and with less humidity.

These heat waves and droughts will become an increasingly important killer, (especially for the very young and the old ones) and puts much pressure on water availability and sewage systems, also reduce the ability of

a country to feed themselves or export agricultural products (Shafer, 2017).

## 2. Downpours and Storms

Torrential downpour and destructive storms will largely effects the agricultural areas, cities, shipping and electric power systems and the industries of countries by destructing them without the financial or human capital resources to return (Shafer, 2017).

## 3. Rise in the Sea Level

Due to climate change temperature start increasing that causes melting of glaciers which ultimately leads to the rise up of sea level and the increase sea level wont penetrate the light much deeper also effect the productivity of phytoplankton and disturbs the marine biodiversity (Shafer, 2017). In Pakistan the last 50 years, the annual mean temperature has increased by roughly 0.5°C, while Sea level along the coast of Karachi has risen approximately 10 centimeters in the last century (Chaudhry, 2017). Another earlier study Rabani *et al.* (2008) reported that the Sea level rise for Pakistan is estimated at 1.1 mm per year (mm/year) from 1856–2000 along the Karachi coast.

## 4. Melting of Glaciers

Ice caps, snowed areas and glaciers are melting day by day that covers 17% of Himalayan region (Dyurgerov and Meier, 2005; IPCC, 2007a). They are departure more rapidly in recent years (Ren *et al.*, 2004; Liu *et al.*, 2006; Zemp, 2008). Continues increase in temperatures causes the shrinkage glaciers present on Tibetan Plateau nearly from 500,000 km<sup>2</sup> to 100,000 km<sup>2</sup> by the year 2035 (Cruz, 2007; Ye and Yao, 2008).

## DISCUSSION

### Effects of Climate Change on Biodiversity

The variations among all living organisms present on earth and their interactions associated with marine, terrestrial and other aquatic ecosystems and the ecological interactions of their habitat. It includes variations within species, between different species, and many ecosystems (Heywood and Watson, 1995). Several components of climate change are anticipated to affect all the levels of biodiversity, from organism to biome levels (Parmesan, 2006).

There are three levels of biodiversity:

- 1) Species level
- 2) Ecosystem level
- 3) Genetic level

Earlier studies shows that throughout the world number of species are about 13 million from which only around 1.6 million species have been identified along with their

description (Heywood and Watson, 1995). Specific areas of world indicates the fast rates of species depletion leads to high levels of endemism which is called as hotspots found in the areas of tropical forest, Mediterranean sea and coral reefs (Myers, 1988).

Threats to biodiversity have a prolonged list among which some are over exploitation, industrial pollution, modification of habitat, alien species and population growth. Among these all the major threat that causes destruction to biodiversity is the Climate change which is due to natural as well as human activities.

Due to continuous climate change humans and other wild animals face increased threats for their survival. Disastrous storms, prolonged heat waves, severe drought, increasing aquatic levels, fluctuations in the temperatures of ocean, melting of glaciers and polar ice reduction these all are due to climate change and it influence upon the human life by altering their habitat and also affects their economy by disrupting biological diversity (WWFb, 2019).

Scientists believed that disruption of biodiversity leads to the destruction of ecosystems that ultimately effects the survival of human (Myers, 1979, 1989; Ehrlich and Ehrlich, 1981). A recent study (WWF, 2018a) reported that up to 86% of birds, 80% of mammals and 90% of amphibians could potentially become locally extinct in the Miombo Woodlands in Southern Africa, while 89% of amphibians could become locally extinct in southwest Australia. Green turtle, Leatherback turtle and Loggerhead turtle were reported in the Mediterranean area, due change of climate all three species are threatened (WWF, 2018b).

### Effect of Climate Change on Terrestrial Ecosystem

Warming due to the climate change may possibly shows four types of variations in species characteristics. (1) The population of species may vary at specific location, also they starts movements towards the areas that are suitable for the maintenance of their metabolic temperature. (2) The phenology like flowering and egg lying of different species were modified in the history due to the temperature fluctuations. (3) Change in the physical appearance and behavior of a species. (4) Shifting in the genetic frequencies (Root *et al.*, 2003).

### Effects of Climate Change on Species Phenology

The developmental pattern, species interaction and geographical distribution of amphibians and reptiles are highly affected by the fluctuations in climatic conditions as compared to the other ectotherms. The variations in temperature and moisture influenced upon their population status and reproductive success. The process of oogenesis and spermatogenesis in different species of

reptiles and amphibians based on seasonal temperature system.

The sex of offspring in reptiles are influenced by the variations in temperatures thus, it directly effects the composition of a population. The number of male and female offspring of Painted turtles (*Chrysemys picta*) largely dependent upon the mean temperature of July and the slight increase (2-4°C) in temperature can cause the birth of female offspring while the male sex would negotiate (Janzen, 1994; Rhen and Lang, 1998). Meanwhile the reproductive period in some species of amphibians that are found in Britain are also influenced by the winter warming (Beebee, 1995).

That variations modify the habitat of breeding ponds that sudden respond by the interaction of other species or predators, causes early migration of newts (*Triturus* spp.) in ponds, meanwhile frog (*Rana temporaria*) not able to significantly modify their phenology associated to reproductive cycle. Early-birth of embryos and larvae of frogs then remain uncover leads to extreme predation by newts.

The above mention points are great examples that indicates the effect of climatic fluctuations upon a specific species or population dynamics, composition including reproductive success and survival are very severe. Indirect influences also noticed upon the population composition of montane amphibian species (Pounds *et al.*, 1999).

Reduction in the acute population have been observed in the region of Western USA and Costa Rica which is associated with the epidemic disease and the alteration in the pattern of precipitations caused by the sudden increase in temperature (Pounds *et al.*, 1999; Kiesecker *et al.*, 2001). In addition, the population status of frogs and Anoline lizards (*Norops* spp.) are also reduced in Costa Rica due to the variations in climatic conditions (Pounds *et al.*, 1999).

High chances of competition for nestling sites between the birds, those migrated due to late arrival of spring season and other species whom arrived earlier (Both and Visser, 2001).

Some observations point out that the simultaneous development between oak bud burst and hatching of Winter moth (*Operophtera brumata*) are affected because of the warmer spring season in Europe that resulted in the imbalance of high food demands by Great tit (*Parus major*) nestlings and the availability of high level of insects population (Visser and Holleman, 2001; Visser *et al.*, 1998).

Further studies shows that the juvenile of large mammals are threatened due to extreme climatic conditions,

generally in winter, even though vulnerable upon population composition (Post and Stenseth, 1999; Milner *et al.*, 1999). The fertility and developmental patterns of Soay sheep (*Ovis aries*) (Forchhammer *et al.*, 2001) and Red deer (*Cervus elaphus*) (Post *et al.*, 1997) also affected by the long durations of warm winters related to NAO in the UK and Norway. And the affected conditions over population composition can only be observed after some time from months to years when the cohorts are able to reproduce (Post and Stenseth, 1999; Forchhammer *et al.*, 2001). Climatic fluctuations can directly affects the tropic level of producer, herbivore and carnivore by producing impacts on various compositions of their basic needs (Post and Forchhammer, 2001) and indirectly by the arbitration of interactions in the tropic level like wolf predation and moose herbivore (Post *et al.*, 1999).

### Effects of Climate Change on Population Range and Its Composition

Some studies reported that populations of several wild species have declined, and although in many cases climate change is believed to have contributed to the decline, attributing this is fraught with difficulty as it is likely to be only one driver amongst many (Birdlife International, 2021). Variations in the population distributions of butterflies in Britain have been observed due to minor increase in temperature which is less than one degree during the recent century (Ford, 1982). In addition, warming also causes the growth of birch towards north in the Swedish tundra during the first half of present century (Kullman, 1983). Nonetheless, species those are affected by the climate change have to migrate or adapt the change for the survival (Kappelle *et al.*, 1999).

Some specific species are sensitive to the climatic fluctuations, indicates the condition of environment called as bio indicators used to know the conditions of a whole ecosystem. (Kappelle *et al.*, 1999). These indicator species occupy six criteria are; (1) Constant habitat, (2) Position in a particular area, (3) Sensitive to the climatic variations, (4) Dispersal range, (5) Easily available for monitoring and (6) Functional position within the environment.

In the region of Western Europe and Netherlands different species of herbaceous plants, butterflies and birds are indicated as convenient for the purpose of bio indicators (De Groot *et al.*, 1995). Korean pine trees are long-lived, but change of climate can lead to reduced cone formation and increase the risk of loss of some species (Warren *et al.*, 2018).

Variations in the geographic range of particular species or its proportion can be easily determine by the prolong analysis of monitoring with the help of Geographic Information Systems- GIS (Heil and Deursen, 1996).

Climatic fluctuations and their effects may also be observed by the natural transitions of eco-climate or other eco-tones due to their highly sensitive nature to climatic changes (Kappelle *et al.*, 1999).

### **Habitat Fragmentations**

From the historic periods the disruption and fragmentation of habitat causes threats to the survival of species also decreased in the Biodiversity within local, regional or global ranges (Harris, 1984; Myers, 1989). The effects of habitat fragmentation associated with the climatic fluctuations may be result in the high rates of extinction (Myers, 1989; Peters and Lovejoy, 1992). Fragmentation effects upon the isolation of species population also decreased the genetic variability. It is also act as a barrier and inhibit the migration and distribution of particular species or population towards the habitat of their interest where they tolerate the temperature (MacArthur and Wilson, 1967; Peters and Lovejoy, 1992; Bierregaard *et al.*, 1997).

Native of an area which is a patch of fragmented habitat have to migrate and adjust their geographic range for their survival during climate fluctuations which rely on their migration potential also the size of patch, distance between two patches and level of connectivity by means of corridors, and the strength of barrier between two patches. Creating a potential barrier between to patches is the human way of managing the migration potential of animal but we not truly know about it, that either it increases the strength of migration or not. Also no proper research found on the topic like their width, position of placement in an area and the ratio (from edge to area) (Halpin, 1997).

### **Affected Functions of Ecosystem**

Under the effects of climate change several ecosystems are highly vulnerable such as alpine meadows in the Rocky mountains and some barrier islands (Khan, 2006). Due to the fluctuations in the climatic conditions the functions of ecosystem also affected by the change in the physiology of species due to the temperature fluctuations and humidity. This variations in the climatic conditions may influence upon species as either they are adapted to this situation or disrupt their interactions with other species or individual led to the extinction or migration towards the suitable habitat which causes the reduction or loss of biodiversity in a specific ecosystem (Kappelle *et al.*, 1999).

There are 80,000 plant species recorded in Amazon area. These plant help local water cycles and regulate the global climate, and sustain the rainforest's rich faunal life, but increasing of temperature all plant species at risk of local extinction (Warren *et al.*, 2018). Climatic variations also causes the separation within a species, effect upon

the heredity of a species and led them to the risk of extinction (Kappelle *et al.*, 1999).

### **Impact of Climatic Fluctuations upon Aquatic Ecosystem**

#### **ICE Cover Reduction**

The fluctuations in climatic conditions on northern hemisphere will decreased the ice covers from the lakes (Magnuson *et al.*, 2000), that effects different processes includes the light penetration associated with aquatic plants and algae, also increase the time period in which aquatic organisms may have threats of predation by birds and terrestrial animals (Rahel, 2008).

#### **Events of Coral Bleaching**

Climate change causes the increase in temperature which affects the coral reefs, including Australia's Great Barrier Reef by increasing their mortality rate, as they are severely sensitive to temperatures. This coral bleaching causes malnutrition, decreased and mortality of the coral reefs upon which many aquatic species are dependent (Fujita, 2013).

#### **Migration in Aquatic Species**

It is observed that the fishes of North Sea migrates furthermore towards the north or into deeper sea because of the increase in water temperatures. Several other species also suffer due to climatic changes or other problems. Decreased in the ice cover of ocean which is due to the high temperature has influenced the population distribution of penguin species in the region of Antarctic Peninsula (WWFb, 2019).

#### **Reduction in Mixing of Sea Water**

The mixing of sea water are of great importance because during the period of mixing different nutrients scattered throughout the water body and amount of nutrient become equal everywhere. Oxygen which is present in the surface water at high level also distributes to the deeper water but due to climate change the process of mixing water become decreased which causes the low level of oxygen in bottom that ultimately leads to many problems for bottom dwellers like difficulty in breathing or aerobic respiration (WWFb, 2019).

#### **Rising Sea Levels**

Due to the climatic fluctuations the polar ice and glaciers starts melting and water starts warming day by day that causes thermal expansion and if it continues then it is predicted that the global level of sea risen up during the next 100 years about 69 cm. This increase in water levels will disrupt and affect the marine life. The penetration of light will be limited at upper surface that influenced the productivity of phytoplankton upon which whole marine life dependent also the increase of water level can

contribute to increase amount of floods. The Rapid increase in sea level is also a threat for mangrove ecosystems because they need constant level of sea for their survival (WWF, 2019).

### **Mitigation Measures For Global Warming Renewable Energies**

We have to close the chapter of fossil fuels to control the climate variations and in contrast we can use solar energy, wind waves, biomass and geothermal energy (Global Warming Prevention, 2019).

### **Sustainable Use of Water and Energy**

We can use alternative for the water and energy sources that produce energy by the help of bulbs of LED light, and sustainable shower system these are of cheap cost with same quality (Global Warming Prevention, 2019).

### **Transport System**

To reduce the global temperature we can use local transport for public with the addition of hydrogen and electric transport leads to the reduction in the CO<sub>2</sub> (Global Warming Prevention, 2019).

### **Recycling**

Consumption of food, clothing, and cosmetics should be reasonable. Also recycling is the major thing upon which we can easily reduce the climatic variations at some level (Global warming prevention, 2019).

### **Banned Plastics**

Plastics made material should be banned or may introduce its alternate because it is the major threat at all levels.

### **CONCLUSION**

In last two years almost every part of the world, the Covid-19 pandemic caused devastating human, economical and social distress and has reinforced the need for urgent action on reversing ecological degradation. Drivers of biodiversity loss like climate change and unsustainable land practices disrupt the balance of nature and can raise the risk of zoonotic disease transmission. The urgent actions required to improving the conservation of all globally threatened plant and animal species have been identified. We can control the climate change at some extent at least the remaining biodiversity or natural resources we have be used sustainably so that the future of earth would be more protective for future generation. The Paris Agreement for climate change is aims to hold the increase in global average temperatures to well below 2 degrees Celsius, while striving to limit the increase to 1.5 degrees Celsius. All member countries filed nationally determined contributions indicating the climate actions they plan to implement by 2030.

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