CLIMATE CHANGE AND ITS IMPACT ON BIODIVERSITY

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Climate and Climate Change

The word ***climate*** refers to the long-term weather patterns within a defined region including temperature, humidity, wind, and amount and type of precipitation. Weather refers to hourly, daily, or weekly changes in the atmosphere, while climate is generally discussed, in terms of years, decades, centuries, and millennia.

Climate is the statistical description in terms of means and variability of key weather parameters for a given area over a period of time, usually about 30 years. Today, the commonly used term 'climate change' represents any change in climate over time, whether due to natural causes and/or as a result of human activities.

Climate change refers to significant and long-term changes to a region's climate. These changes can occur over a few decades, or millions of years. Climate change alters entire **ecosys**tems along with all of the plants and animals that live there. As cli-mate has changed throughout Earth's history, all living creatures have had to adapt, move, or die out. When these changes happen gradually, ecosystems and species are able to evolve together. A gradual change also gives species the opportunity to adapt to new conditions. But, when the change happens very quickly, like it is today, the ability of species to adapt quickly enough or relocate—assuming a suitable location exists—is a big concern.

GHGs and Climate Change

A major reason to implicate human or anthropogenic activities for climate change is the fact that these are closely linked with increasing concentrations of carbon dioxide, methane, nitrous oxide and other greenhouse gases (GHGs) known to trap the heat from solar radiation in the upper layers of the Earth's atmosphere.

Earth's atmosphere traps energy from the sun as heat and keeps our planet warm through a process called the **greenhouse effect**. Naturally occurring Green House Gases (GHGs) i.e. CO_2, CH_4, O_3 and water vapour**s** are responsible for slow increase in

earth's temperature, which is necessary. But now, human activities have caused a significant and continuing increase in the levels of **greenhouse gases** in the atmosphere. More greenhouse gases means the atmosphere traps more heat. The processes of industry and burning fossil fuels for energy and transportation both release carbon dioxide (CO_2), the most common greenhouse gas behind water vapor. Livestock and landfills generate methane (CH4), a potent greenhouse gas. Vast amounts of greenhouse gases are also released every day by volcanic eruptions and forest fires. Greenhouse gases from all sources mix in the atmosphere and affect the entire Earth.

In 1896, the Nobel Laureate Svante Arrhenius predicted that increases of atmospheric CO_2 from burning fossil fuels would lead to global warming. He had also made calcultions which suggested that doubling of CO_2 concentrations (then about 260 ppm) in the atmosphere would raise the temperatures of the Earth by about 2 to 6 °C. At present, the CO_2 concentration alone is about 398 ppm, leaving aside the other greenhouse gases arising largely from anthropogenic causes. The CO_2 plus the other heat-trapping gases form what is referred to as ''CO_2 equivalent'', which now is about 470 to 480 ppm (Swaminathan and Keshavan, 2012). All these support the estimate by the Intergovernmental Panel on Climate Change (IPCC) that the Earth will warm by 1.4–5.8 °C during the current century (IPCC, 2001). Paul Crutzen (2002) assigns the term 'Anthropocene' to the present, in many ways human-dominated, geological epoch, supplementing the Holocene—the warm period of the past 10–12 millenia.

Rising Temperature and its effects

As Earth warms and temperatures rise, regional climates are affected in different ways. Some areas of South and Southeast Asia are experiencing heavier monsoons and rising sea levels, while other areas, such as southern Africa and the American Southwest, are experiencing more severe droughts and crop failures.

Reduced snowpack and shrinking glaciers in the mountains mean less melting snow flowing into rivers, reservoirs, and lakes for fish and wildlife, and less water available for drinking and irrigation. Glaciers in the Himalayan Mountains supply year-round water to more than 2 billion people.

Warmer temperatures also produce increased evapo-ration, which leads to heavier rainfall and snowfall. But the increased precipitation is unevenly dis-tributed, leading to heavier rainfall in some loca-tions and droughts in others. Heavier snowstorms, stronger hurricanes, more intense heat waves, and extreme rainstorms and resulting flash floods are occurring more frequently around the globe (IFAW, 2013).

Warmer air temperatures also lead to higher ocean temperatures, and warmer oceans affect global ocean currents and associated weather patterns. The Gulf Stream—

a strong ocean current that brings warm water from the equator up the east coast of North America and across the North Atlantic to northern Europe—keeps winters in the United Kingdom as much as 9°F (5°C) warmer than they might otherwise be (IFAW, 2013).

International scientists suggest that the Gulf Stream will likely slow down as a result of climate change, reducing its warming effect. While global average temperatures continue to rise, the cooling effect due to the slowing of the Gulf Stream means that north-ern Europe may not experience as much warming as other regions (IFAW, 2013).

Impact on Animals

Warmer temperatures on land and sea, more intense storms and increasing numbers of floods, reduced snow pack and more frequent droughts, and rising sea levels: How will all of these climate changes affect life on Earth? Species have evolved to survive within certain temperature ranges and are able to tolerate variations in weather. The effects of climate change may push some species to the edge of extinction, while other species may flourish.

Warmer spring temperatures may cause birds to begin their seasonal migrations or nesting and cause bears to emerge from hibernation earlier than usual. When bears emerge before their regular food sources are available—80% of bears' diets are plants—they may starve or wander into towns in search of food. For those animals that rely on late summer plants to survive through the winter, warmer, drier summers may affect their ability to find enough food.

The annual flooding of the Brahmaputra River in the northwest corner of India has always been important to the health of Kaziranga National Park and the protected animals that live there, including elephants, rhinoceroses, and tigers. The increasing intensity of Asian monsoons in recent years has caused greater floods, displacing people and killing animals. Also, a 2012 study found that climate change could have a greater impact on Asian elephants dwindling numbers than previously thought. Researchers concluded that young elephants are particularly threatened by increasing temperatures, which can double their mortality risk. Elephants, like humans, reproduce later in life, so if calves die before they can mate, then the species will be unable to survive.

Animals that require cooler temperatures are shifting their ranges to higher elevations or towards the poles as the temperatures in their home ranges rise. The American pika, a small mammal related to rabbits and hares, is adapted to life in the alpine environ-ment. They are extremely sensitive to temperature and can die when temperatures reach only 78°F to 85°F (25.6°C to 29.5°C) (IFAW, 2012).

Though the exact impact of climate change on India's natural resources is yet to be studied in detail, pioneering studies show that endemic mammals like the Nilgiri tahr face an increased risk of extinction (Sukumar *et al.,* 1995). Further, there are indicative reports of certain species (e.g., Black-and rufous flycatcher (*Ficedula nigrorufa*) shifting their lower limits of distribution to higher reaches, and sporadic dying of patches of Shola forests with the rise in ambient surface temperatures.

The arctic fox lives in the open tundra, and preys on lemmings and voles that burrow underground. Mild winters and melting snow reduce the lemming and vole population by causing their burrows to collapse, thus limiting the arctic fox's major food source. As Arctic temperatures have risen, the red fox has expanded its range into the tundra, preying on the arctic fox and competing with it for food and habitat. And as the tundra's climate warms, experts predict it will be replaced by forest, which is an unsuitable habitat for the arctic fox. But shifting ranges is not always a problem—it can create opportunity, too. The red fox, for example, is taking advantage of the warming tundra to extend its range northwards. Anytime a new species enters a region, changes are inevitable. New species can bring parasites and diseases to which the resident species have no resistance. New species are also likely to disrupt the food web, either by predation or through increased competition (IFAW, 2012).

Sex determination in Reptiles : Temperature-dependent sex determination (TSD) is a type of environmental sex determination in which the temperatures experienced during embryonic development determine the sex of the offspring. It is most prevalent and common among amniote vertebrates that are classified under the reptile class. TSD differs from the chromosomalsex-determination systems common among vertebrates.

The eggs are affected by the temperature at which they are incubated during the middle one-third of embryonic development. This critical period of incubation is known as the thermosensitive period (TSP).

The warming of the habitats of species exhibiting TSD are beginning to affect their behavior and may soon start affecting their physiology. Many species begun to nest earlier and earlier in the year to preserve the sex ratio. It is likely that climate change will outpace the ability of many animals to adapt, and many will likely go extinct.

The following is a list of ten concerns related to climate change for nature and species. These threats are often interconnected and can exacerbate the many other exist-ing threats to wildlife such as habitat loss and fragmentation, invasive species, and disease.

- ✓ **Ocean Acidification:** We can only blame ourselves for the 30% drop in the pH of oceans—they absorb nearly a third of the carbon released into the atmosphere through human activity. This acidification renders some crustaceans and coral unable produce their protective shells and skeletons. Coral reefs, which serve as habitat for thousands of marine species, are being destroyed by bleaching due to ocean acidification. This destruction of marine life is a threat to the entire ecosystem humans included.

- ✓ **Extreme weather events:** Massive heat waves and drought have already grown more prevalent across the globe, expected to become more severe if the warming trend continues. In drought areas, habitats are altered, and plants and forests suffer from the lack of water. Increased wildfire activity due to hot, dry conditions poses a risk for safety of wildlife. It destroys important wildlife habitats, like the nesting habitat for Mexican spotted owls and forest habitat of endangered Amur tigers and critically endangered Amur leopards in Russia. Stronger and more frequent storms affect the distribution and concentration of the low links on the marine food chain—plankton and krill—thus having a domino effect on many ocean species.

- ✓ **Melting Sea Ice:** Arctic temperatures are rising twice as quickly of the rest of the world and sea ice is melting at an alarming rate. Some of the world's iconic species like polar bears, ringed seals, emperor penguins, and beluga whales all experience distinct pressures due to melting sea ice. For these and other species, disappearing ice disrupts the food chain, hunting habits, reproduction, protection from predators, and the ability to travel long distances—in other words, the foundations of their existence.

- ✓ **Sea-Level Rise:** Coastal wetlands are among the most productive of all natural ecosystems (Day *et al.*, 1989) and so the impacts of climate change will be extremely important in coastal regions and have ramifications far beyond them. In addition to the effects of rising temperatures and changes in rainfall, animals and plants in coastal habitats face another threat from climate change: rising sea level. This is due to a combination of melting polar ice caps, ice sheets and montane glaciers coupled with thermal expansion, wherein warm water occupies a greater volume than cold water. The IPCC predicts that in the next century, average sea level will rise by 0.18–0.59 m compared to the 1980–1999 levels (Parry *et al.*, 2007). Other climate models go even further, with estimates of 0.5–1.4 m – a rise that would inundate many low-lying areas. Human population and development pressure is in many cases likely to prevent coastal habitats from moving inland, thus leading to net habitat loss.

Such changes will have immediate impacts on many wildlife species (e.g. Michener *et al.*, 1997). Sea turtle populations are likely to be hit as their nesting beaches are inundated. It is predicted that a rise in sea level of 0.5 m will result in the loss of 32 percent of sea turtle nesting grounds (Fischlin *et al.,* 2007). Mangrove forests would seem to be preadapted to inundation, as they thrive in coastal locations below the high tide where their stilt roots are submerged in saline water on a daily basis. They cannot, however, survive permanent submersion due to rising sea levels, and mangrove die-off has been reported from several locations (e.g. Ellison, 1993).

The Sundarbans is the largest natural low-lying mangrove ecosystem in the world, distributed over 10 000 square kilometres. The sea level rise recorded over the past 40 years is responsible for the loss of 28 percent of the mangrove ecosystem. Modelling suggests that up to 96 percent of suitable tiger habitat in the Sundarbans could be lost in the next 50–90 years (Loucks *et al.*, 2010).

✓ **Disease and Pests:** Not only does climate change affect disease in human populations, it also alters the disease behavior in animals as well. The devastating amphibian disease chytrid fungus, likely exacerbated by warmer temperatures, has left many amphibian populations dwindling or extinct. Seasonal pests, like bark beetles in the US, breed longer in warmer weather and thirsty, drought-affected trees are more susceptible to infestation.

Temperatures in the Himalayan ecosystem are increasing at a rate of 0.9 °C annually, which is considerably higher than the global average of 0.7 °C per decade. Changes in the For example, mosquito nets are now needed in Lhasa, the administrative capital of the Tibet Autonomous Region of China. Residents of the city, located 3 490 meters above sea level, have reported seeing mosquitoes for the first time ever. There are similar reports of flies at Mount Everest base camp in Nepal. The presence of these insects suggests the possible spread of vector-borne diseases, such as malaria and dengue fever, to areas where cooler temperatures previously protected people from these threats (FAO, 2012).

✓ **Range Shift:** Ecological communities of plant and animal species—called "biomes"—are shifting as the planet warms. Some species are able to adapt and move while others cannot, and these will disappear with their disappearing habitat.

In the Mandakini Valley of northern India, scientists report that the oak forests have been invaded by pine trees (between 1 000 and 1 600 m), particularly on south-facing slopes. This phenomenon can also be observed in many other valleys of the region. Many sources of water, such as springs, have dried up because of the disappearing oak trees and invading pines (FAO, 2012).

- ✓ **New Species Interactions:** The climate-induced variation of species' range and related biome shifts cause previously unacquainted species to come into contact with each other. This results in competition for resources and changes in the way predators interact with their prey. For example, red foxes have moved northward toward a warming tundra and compete for prey with native Arctic foxes.

- ✓ **Invasive Species:** Climate change and invasive species are two major threats to biodiversity. Put them together and the repercussions are projected to be widespread. Climate change will provide new ways for invasive species to encroach on new territory. Natural disasters like storm surges and high winds, which increase in number and severity as the earth warms, spread non-native plants and insects to new territories. For example, the winds of the 2005 hurricane season likely introduced cactus moths to Mexico, where their presence threatens endemic cactus species.

  Virtually all ecosystems worldwide have suffered invasion by the main taxonomic groups including India The major invasive alien plant species include *Lantana camara, Eupatorium odoratum, Eupatorium adenophorum, Parthenium hysterophorus, Ageratum conyzoides, Mikania micrantha, Prosopis juliflora* and *Cytisus scoparius*.

- ✓ **Interrupted Seasonal Cycles:** So many species are dependent upon climate to guide the patterns of their lives—like mating, reproduction, hibernation, and migration, to name a few. As these patterns shift to reflect changing climate, it causes a ripple effect and hampers the health of the entire ecosystem. The altered timing of animal behaviors that are guided by weather—such as migration by birds, hibernation for bears, bats, and even alligators—will result in mismatched timing between species and their food sources. For example, caribou migration patterns have been disrupted by an earlier flowering season of their plant food source, leading to food shortage late in the season and depleted number of offspring.

  Indian agriculture normally referred to as a ''gamble with monsoon'' would become even more to weather behaviour vulnerable. With lesser precipitation and increased evapotranspiration, survival and productivity of agri-horticultural crops would become a serious problem. The coastal soil and aquifers would become salinized and staple food crops like paddy would come under severe stress. With every 1°C rise in temperature, yield of rice and wheat will decrease. A rise in sea water temperature will affect mortality of fish and their geographical distribution (Swaminatha and Keshvan , 2012).

- ✓ **Changes in Human-Nature Interactions:** Melting sea ice opens the Arctic for oil drilling, bringing ships into previously untouched territory of Pacific walruses. Expansion of agriculture and the need for water will lead humans to infringe on native wetlands, destroying habitat of countless plant and animal species. Increased drought activity will force koalas out of the safety of eucalyptus trees in search of water, exposing them to risk of death from road traffic.

Conclusion

There is a growing realization among decision-makers that biodiversity is not an optional bonus in human affairs, but the very foundation of our existence. Moreover, biodiversity conservation tailored to changing climatic conditions is not only necessary to help species and habitats to adapt to change, but such action is also likely to mitigate climate change (FAO, 2012). In terms of agriculture, there is a need for climate resilient farming systems. Climate literacy should be spread and a cadre of Community Climate Risk Managers should be formed in villages. The calamity of climate change should be converted into an opportunity for developing and spreading climate resilient farming techniques and systems (Swaminathan and Keshvan, 2012).

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