

**Review****CLIMATE CHANGE IMPACT ON MOUNTAIN BIODIVERSITY: A SPECIAL REFERENCE TO GILGIT-BALTISTAN OF PAKISTAN**

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**ABSTRACT**

Climate Change is not a stationary phenomenon; it moves from time to time, it represents a major threat to mountainous biodiversity and to ecosystem integrity. The present study is an attempt to identify the current knowledge gap and the effects of climate change on mountainous biodiversity, a special reference to the Gilgit-Baltistan is briefly reviewed. Measuring the impact of climate change on mountain biodiversity is quite challenging, because climate change interacts with every phenomenon of ecosystem. The scale of this change is so large and very adverse so strongly connected to ecosystem services, and all communities who use natural resources. This study aims to provide the evidences on the basis of previous literature, in particular context to mountain biodiversity of Gilgit-Baltistan (GB). Mountains of Gilgit-Baltistan have most fragile ecosystem and are more vulnerable to climate change. These mountains host variety of wild fauna and flora, with many endangered species of the world. There are still many gaps in our knowledge of literature we studied because very little research has been conducted in Gilgit-Baltistan about climate change particular to biodiversity. Recommendations are made for increased research efforts in future this including jointly monitoring programs, climate change models and ecological research. Understanding the impact of climate change particular to biodiversity of GB is very important for sustainable management of these natural resources. The Government organizations, NGOs and the research agencies must fill the knowledge gap, so that it will help them for policy making, which will be based on scientific findings and research based.

**KEYWORDS:** Mountainous biodiversity, Ecosystem services, Sustainable management, Wild Fauna

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**1. INTRODUCTION**

Climate is not a stationary phenomenon it varies from time to time. It is a product of weather which always experiences variations over space and time [1]. Climate change is resulting from a growing concentration of Greenhouse Gases (GHGs) and uses of fossil fuels and other anthropogenic activities has become a major worldwide concern [2]. Anthropogenic emissions of GHS such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and

nitrous oxide (N<sub>2</sub>O) have led to increases in their atmospheric concentration and cause warming of the lower atmosphere [3]. Human induced climate change threatens ecosystems and human health on global scale. Climate change has greatest impact on those countries that are already poor due to lack of resources and access to scientific information. Earth's average surface temperature rises are likely to surpass the safe threshold of 2°C [4]. The average temperature of today's world has already increased by 0.6°C from the middle of

the 1800s. The instrumental records from the past years have shown an increase in mean temperature all over the globe [4], with the global mean temperature increase at the rate of  $0.007^{\circ}\text{C decade}^{-1}$  over the last century [5]. The overall global mean sea level rose by 19 cm from 1901-2010 [6]. At present climate is changing rapidly, the atmosphere has responded to the increased inflows of  $\text{CO}_2$  and other GHGs through worldwide [7, 8].

The land use change brings number of changing in climatic pattern. Excessive deforestation leads to decrease in precipitation level and increase in surface temperature on global scale, thus it change whole global climatic model [9]. The scale of this change is so large and very adverse so strongly connected to ecosystem services, and all communities who use natural resources. Biodiversity change is now considered an important global change [10]. Since first "Intergovernmental Panel on Climate Change" (IPCC) it has been observed that earth global temperature has been increasing because of climate change, which is more dangerous for over all biodiversity. The altitudinal distribution of vegetation is expected to shift to higher elevation and some species with climatic ranges limited to mountain tops possibly will become extinct because of disappearance of their habitat or reduced migration potential [11]. Mountain Region are Considered as sensitive ecosystem. Climate Change represents major threats to the ecosystems integrity and global biodiversity. The consequences of these climatic changes have negative impact on number of wildlife and other natural ecosystems [12]. Mountains have most fragile ecosystem in the world [13]. Change in the global temperature and local precipitation might significantly

change the altitudinal ranges of some keystone species existing in the different ranges of mountainous areas, and create more stresses on the fragile ecosystem of mountainous areas [14, 15]. According to Nogues-Bravo *et al.* [16], it is difficult to estimate the exact effect of climate change on mountainous areas because of the doubts associated with the climatic scenario and also the presence of nonlinear feedback and the knowledge gap between the impacts. Many Studies show that the mountain ecosystems are more vulnerable to climate change [17, 18, 19]. According to Theurillat and Guisan, 2001, indicated that climate change in mountainous ecosystem are most noticeable in the areas such as at Boundary Ecosystems ("Ecocline") or at Eco tones, where two ecosystems are meet. Species can response either by migrating or through adaptation [20].

## 2. CLIMATE CHANGE IN PAKISTAN

South Asia is considered as one of the most susceptible regions for global climatic changing. In Pakistan there has not been such extensive research carried out regarding climate change and biodiversity as compared to other parts of the world. As Pakistan is an agricultural based country, the country depends on the Indus irrigation system, as Indus River is one of the key water carriers of South Asia rising from the Tibetan Plateau and the Himalayas [21]. The country is highly vulnerable to climate change, hence large floods, drought and biodiversity loss is expected in future [1]. According to a survey conducted by Khan *et al.* [2] about 40% of Pakistani's believe that climate is changing moderately while 60% of them believe that it has been changing harshly. Many studies indicate that change in climate affecting, directly or indirectly the whole

biodiversity and their habitats [22, 23, 24] leading to their displacement and in most harsh cases, even extinction. Change in climate also affecting the competitiveness of many species by changing growth, death rates and regeneration success rates [25]. However a vital problem in mountain ecosystem concern to climate change is the increased in the erosion and in reduction of the slope stability [14]. It is being found that change in climate has caused a shift in habitat from wet monsoon forest to savannah [26]. Many unique species of flora and fauna are also on the edge of extinction due changing in habitat conditions. Increase in high temperature and precipitation patterns can has also increase forest insects, pest and weeds which result in greater damage of forest vegetation, change the species composition and reduce the area of forest [26]. Globally the natural ecosystem has been affected by current climate change. Slatyer [27] stated that, the Australian natural ecosystem is more vulnerable to climate change, the particular impact will depends on the adaptation and resilience of individual species. Due to increase in warming at alpine areas [13, 18, 27, 28] the species which are already occupying the high altitudes areas have less possibility for up moving migration [29, 30]. Most of the species in particular ecosystem cannot adapt to the sudden climate change, in the cause forest, the species with very limited ranges, which have nowhere to migrate are more vulnerable to climate change. And the probability of species to higher altitudes to find the similar condition of those at present will certainly be limited by some other factors like water availability and soil type and many other external factors [31]. As from literature it is found that Pakistan in more vulnerable to climate change in coming decades. Most of the areas

in Pakistan are showing positive trend in temperature for the period 2011-2050 and maximum rise is expected in Gilgit-Baltistan, Central and Southern Punjab and lower KPK [32]. This Increase in rate of temperatures will increase the heat waves which have likely to be adverse effect on biodiversity and water resources in Pakistan [33]. As Pakistan is agriculture dependent country; change in climate is expected to decrease the crop production that would have a great effect on the livelihood of Pakistan [34].

### **3. CLIMATE CHANGE IMPACT ON MOUNTAIN BIODIVERSITY**

Mountainous ecosystems are Fragile [35] and more susceptible to climate change [36, 37]. Most of the global biological diversity hotspots are located in mountainous and coastal regions. Mountains are the most fragile environment on earth, and one of the major "experimental fields of nature" because of steep environmental slope, wilderness and habitat types, and rich for biodiversity and water and they also provide services with tangible economic value [16, 38].

Mountain ecosystems cover about one-fifth of the earth's continental areas [18] and so called storehouses of global biodiversity [39] these area host many threatened and endemic species of world so climate change is considered to be big threat to mountain biodiversity, because they are likely to be more exposed to extreme events of weather [40].

The hotspots of Himalayas, Karakorum and Hindu Kush (HKH) have a rich of species, gene pools and ecosystems which have global importance. Human-induced climate change is

predictable threat to species of Himalayas. These mountain environments are strongly affected by climate, due to their vertical (altitudinal) dimension [41, 42].

Environmental change is by now beginning in the high-altitude areas where glaciers are abundant. Accelerated glacier melting is only one of the continuing changes in regions of HKH, which faces many different pressures, among them the impacts of climate change [43]. Nogue's-Bravo et al. [16] have provided an assessment on surface temperature changes in mountainous area of the world. They projected that the average temperature change varied between "+3.2 1C (+0.4 1C/per decade) and +2.1 1C (+0.26 1C/per decade) for 2055 and +5.3 1C (+0.48 1C/per decade) and +2.8 1C for 2085 (+0.25 1C/per decade)". And it will expect to rise in northern latitude mountain systems than in mountains located in tropical and temperate zones [44].

Some of the world's most endangered and endemic species are found in mountain ecosystems [45]. Mountain ecosystems are more susceptible for small climate change. Because little change in climate can melts both the snow and ice to water. Many species can response to climate by adaptation, shifting of their geographic ranges, altering their abundance or vanishing altogether [46, 47]. Protected areas and national parks are the cornerstones of biodiversity and conservation and acting as valuable buffer against the impacts change. These areas are more vulnerable for climate change. Habitat fragmentation reduced the species movement and dispersal. Already many species are not able to survive without adequate protection of landscape [48]. Due to climate change many

species of wildlife are forced to moved away from their natural habitat [49]. However if distribution of species is controlled by variations in climatic conditions or soils within certain geographic area, dispersal processes may have little consequence [50]. Sala et al. [10] carried a study about global biodiversity scenarios, they investigate that little change in precipitation or temperature in arctic, alpine, boreal forest and deserts will bring large change in biodiversity and also in species composition.

By coming 2020 major loss of biodiversity is projected in ecologically rich area of the world. While the loss of biodiversity, extinction of species already happening [51]. Wetlands are best indicators of climate change. Global warming accelerates the rate of glacial melting which directly cause flooding. Loss of wetlands is a major problem because they provide a specific life support system to unique biodiversity [52].

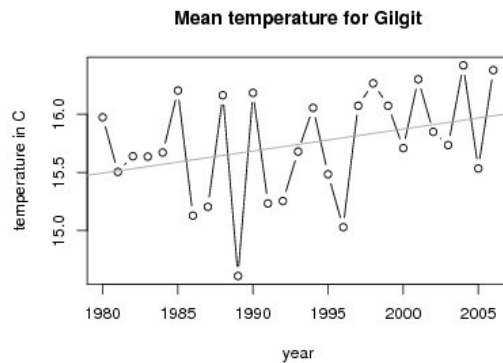
The mountains of Himalayas, Karakorum and Hindu Khush are more Vulnerable to Climate change [53, 54]. A most recent study conducted by Khan et al. [53] reveals that the mountains Karakorum, Himalayas and the Hindu Khush, which are the most vital source of water for Pakistan, are more vulnerable to climate change, so that there is great need of study on the alpine ecosystems and to develop strategies and management actions for the restoration purposes. Apart from the amount of flow in the rivers the excessive melting of glaciers affects the fauna and flora of mountainous areas, the indigenous species may become extinct and exotic species may get their part in the snowless environment. Human society and the alpine ecosystems are

interlinked [55]. It has been stated through many researches that, the mountain biota (tree line) is moving upward, due to global, climate warming, in many mountains system [56, 57, 58].

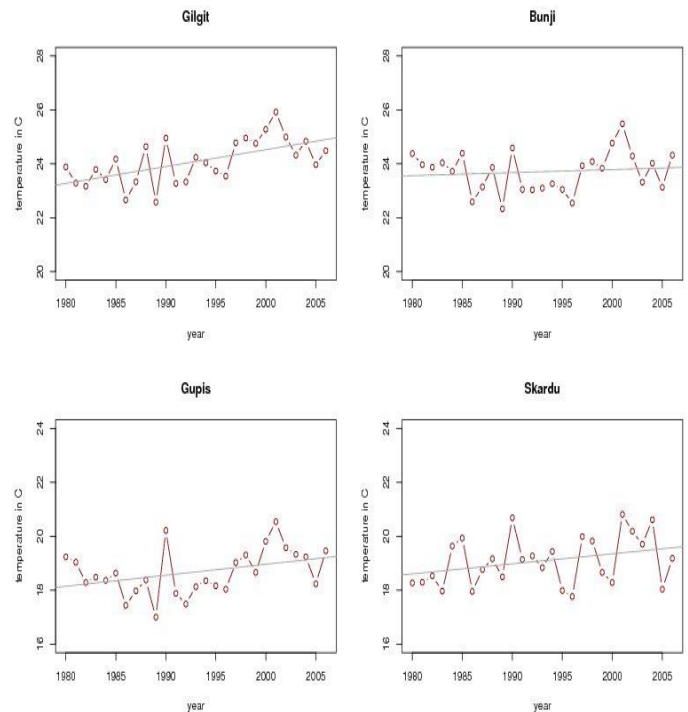
#### 4. CLIMATE CHANGE IN GILGIT-BALTISTAN

The climate of Earth is changing and the impacts are already being felt by biodiversity and wildlife habitats across the whole planet [59]. Very little research has been conducted in the Himalayan and Karakorum Highlands of northern Pakistan on the aspects of biodiversity and conservation [60]. Like other mountainous area of the world, climate changing is also taking place in Mountainous areas of Pakistan. In Gilgit-Baltistan (GB) the climate stations in Gilgit, Skardu, Gupis and Bunji shows increase in the total temperature in last two decades from 1980 to 2006, and increased by 0.440 C per decades observed. All most all the natural ecosystems are vulnerable to climate change in GB. The rapidly melting of glaciers causes habitat loss of many species and it cause damaged in migratory routs of many migratory species [61]. GB of Pakistan has seems to be increase in precipitation and temperature has shown different trends in different seasons. There found to be more rainfall than snow [62]. Through a detailed analysis of past records of different meteorological stations of the GB, it was observed that, the night temperatures are increasing in the Northern Areas (GB) of Pakistan [63]. According to a research conducted by Hussain et al. [64], the maximum temperatures have increased all around the year, especially in high mountainous regions in Pakistan during the period between 1971 to 2000. Climatic conditions vary widely in the GB, and are characterized by low annual

precipitation, a great range of mean monthly temperature values, low winter temperatures, and harsh frosts during portions of the winter season. Climate change is taking place in Gilgit-Baltistan. Information taken from different climate stations like Gilgit, Skardu, Gupis and Bunji an increase in mean temperature was observed between the years 1980 to 2006 by 0.19°C per decade [65].



**Figure 1:** Mean temperature in Gilgit for 1980 to 2006. An increase by 0.19 °C per decade has been observed (p<0.10) [65]



**Figure 2:** An increasing trend was found for maximum temperature from 1980 to 2006. Significant ( $p < 0.10$ ) was a warming by 0.63 and 0.41 °C decade<sup>-1</sup> for Gilgit and Gupis, respectively, and 0.37 °C decade<sup>-1</sup> for Skardu [65].

The HKH region is home to some of the world richest and varied ecosystems on the planet. These mountains are important sources of genetic diversity and resources such as timber minerals being an important source of livelihood for locals. Changes in the climatic conditions and the resulting changes in the availability of water have found adverse effect on biodiversity of these ecosystems [64, 66].

It was discovered that change in climate caused flash floods and river bank erosion in Skardu district GB. The flash floods emanating from glacial melting, leading to river bank which causes erosion and flooding of fields [67]. The general overview about the climate change and their associate hazards in Gilgit-Baltistan are loss of habitat, species extinction, less grasses in pasture, pest attacks, increased frequency of glacial melting, high turbid water, cold spell, GLOF, and destruction of water bank infrastructure are common ideals of the communities [68]. According to Ahmad (2010) the loss and deaths Markhor in Chitral are occurring due to disturbances and variations in the local environmental conditions, possibly triggered by climate change [69]. According to some elders in Gilgit-Baltistan a decade ago there were various birds and animal species which are now disappeared and less sited [70].

## 5. FUTURE DIRECTION

Climate change and its influence is on biodiversity is an important topic all over the world. On local scale in Gilgit-Baltistan some

Non-Government Organization like Worldwide fund for nature (WWF-P), United Nation Development Program (UNDP) and International Union for Conservation of Natural Resources (IUCN) has been trying to protect and conserve the natural resources of GB and has keen interest to implement the adaptation and mitigation strategies for the Gilgit-Baltistan. It is very imperative and necessary to conserve the mountainous biodiversity, because directly or indirectly we depend on it. Gilgit-Baltistan is gifted with umber of natural resources, such as wildlife, fertile soil, glaciers, fresh water and natural forest. The climate change has got a pressure on these natural resources particular to biodiversity in Gilgit-Baltistan (GB). Understanding the impact of climate change particular to biodiversity of GB is very important for sustainable livelihood development. The mountain communities of Gilgit-Baltistan are totally dependent on natural resources. These resources are under pressure due to over exploitation. Many communities have started migration to other areas to cope from climate change. There is need of scientific research, climate modeling and ecological research to provide pertinent recommendations for climate change adaptations at community level. Ecosystem based adaptation (EBA) and Community based adaptation (CBA) is needed to focus and important for the mountain poorest communities who are badly hit by climate change and who also disproportionately reliant on the ecosystem services.

## 6. KNOWLEDGE GAP IN KEY RESEARCH AREAS

There is knowledge gap about the climate change and its impact on different components of biodiversity, especially in

reference to Gilgit-Baltistan. Because there is no reliable data is available about the impact of climate on biodiversity of GB. After literature review we have found the following knowledge gap.

1. The effect of climate change is more adverse on aquatic life (fish fauna). This component of biodiversity is still need to be debated.
2. There is need of research on climate change impact on floral species, especially the ones which are economically important for the livelihood of GB. (fruit plants, vegetation, crops)
3. The impact of climate change on migration patterns of faunal species like, migratory birds and altitudinal migration of large mammals. ( snow leopard and ungulates of GB)
4. There is lack of understanding of climate change impact on high altitudes ecosystem of GB. Therefore its resources are over exploited which results in habitat loss and fragmentation, mismanagement of pastures and loss of important biodiversity.
5. The impact of climate change on range lands is still to be documented in GB.
6. The impact of climate change behavior of people of GB

## 7. CONCLUSION

An unavoidable conclusion form the above mentioned literature is that, the climate Change is not a static phenomenon, it is changing with time. The biosphere has been reacting to climate change and the effects are highly complex, in the shape of biodiversity loss. The impact of climate change is expected to increase in future. Most of the species are

moving towards poles and to higher elevations [71]. Many small mammals over the world are found to be niche specialist and are more vulnerable to climate change. These small mammals are considered as indicators of climate change [72]. As GilgitBaltistan is a fragile mountainous ecosystem, little change in climate alters the ecosystem services. Human being are directly depends on biodiversity for their survival. So it is necessary that biologists should need to make better understanding of what our living world will look like in the near future [73].

People of Gilgit-Baltistan are totally dependent on natural resources, so there is great need of policy implementation for better management of natural resources and livelihood support in the changing climate. The Government organizations, NGOs and the research agencies must fill the knowledge gap, so that it will help them for policy making, which will be based on scientific findings and research base.

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