

**Full length article****POTENTIAL IMPACTS OF CLIMATE CHANGE ON PLANT DIVERSITY OF HILLY AREAS OF AZAD KASHMIR AND THEIR MITIGATION: A REVIEW**

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**ABSTRACT**

Azad Kashmir has variety of mountain ecosystems which are rich in floral and faunal diversity. These ecosystems are fragile and are under stress due to various natural and anthropogenic pressures. Mountain ecosystems of Azad Kashmir are more vulnerable to global warming and are expected to show its impacts rapidly. Climate change may cause major changes in distribution ranges of different vegetation types. As a result of climate change, the area of three vegetation groups (alpine, grassland/arid woodlands and deserts) is expected to decrease and the areas of five types (cold conifer/mixed woodland, cold conifer/mixed forests, temperate conifer/mixed forests, warm conifer/mixed forests, and steppe/arid shrub lands) are expected to increase. Climate change is going to affect conservation of plant species and ecosystems by causing direct loss of plant species and intensify the effects of existing threats such as habitat degradation, deforestation and over-harvesting of plants by local communities, pollution and invasive species. These stresses, acting individually and collectively on species, communities and ecosystems, are depleting and will continue to deplete biodiversity. The negative impacts of climate change are multi-dimensional and wide-ranging. Their mitigation requires an integrated and coordinated policy response for conservation of plant resources. These measures include a regular monitoring and observation system, restoration of degraded habitats and forests, identifying new solutions involving cross-sectoral linkages to conserve biological diversity of Azad Kashmir by supporting the intricate and complex responses of species and ecosystems to climate change.

**KEY WORDS:** Azad Kashmir, floral diversity, climate change, conservation\*Corresponding author: (Email: [kakbar5813@gmail.com](mailto:kakbar5813@gmail.com))**1. INTRODUCTION**

Today, climate change is considered as one of the most challenging global environmental issues facing humanity. It has been reported to cause the death of 0.4 million people and global economic losses of more than US\$1.2 trillion each year [1]. Climate change is the result of human-induced accumulation of Green House gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) in the atmosphere and resultantly, increase in global atmospheric temperatures. In the past, the global

atmospheric concentration has increased from 280 ppm in 1753 (after the dawn of industrial era) to 400 ppm in 2013. Along with increase in CO<sub>2</sub> levels, the global mean temperature has increased by 0.74°C [2]. The recent studies show that earth's climate is changing unabated and global atmospheric concentration of CO<sub>2</sub> may go up to 1250 ppm and temperature can increase by 7°C by 2100 as compared to 1750 [3].

The global warming is not an isolated phenomenon and it may cause changes in other climatic parameters (precipitation

change, snow cover, humidity, sea level etc.). These climatic variations may impact global ecosystems by causing variation in different activities in symbiotic, bio-geo-chemical, parasitic and mutualistic relationships between different organisms and communities [3].

Climate change is a multidimensional global phenomenon with implications for nearly every sphere of human life. Today it has emerged as a critical scientific, development and economic global challenge due to its potential impacts on all kinds of living organisms, integrity of ecosystems and national and global economies [5, 6]. It is particularly so for Pakistan because Pakistan is highly susceptible to negative impacts of climate change, with a low capability to compete it by adopting necessary measures. Global warming is posing a serious danger to its water resources, agricultural production, biological diversity and energy security [7]. The adverse effects of climate change on Pakistan are expected to increase further in future as the world's mean temperature, which increased by 0.6 °C in the 20th century, is going to increase further by 1.1 to 6.4 °C by the last decades of the 21th century [8].

The state of Azad Jammu & Kashmir lies in the north of Pakistan. Pakistan including Azad Kashmir is projected to undergo warming at a rate higher than global average. During the 20<sup>th</sup> century, in Pakistan, average annual temperature increased by 0.6 °C, similar to temperature increase on the global level. However, at local level, the northern part of Pakistan including AJ&K experienced temperature increase higher (0.8 °C) than its southern part (0.5°C) indicating higher susceptibility of its mountainous regions to adverse effects of climate change [8]. According to another study, the temperature in Himalayan region has risen by 1°C since 1970s [9]. The studies based on different simulation models predict that Pakistan will face a temperature increase up to 1.3 -1.5 °C by 2020s, 2.5 -2.8 °C by 2050s, and 3.9-4.4 °C by 2080s, in line with an increase in average

global surface temperature of 2.8-3.4 °C by the end of this century [10].

This paper examines the possible impacts of climate change on plant diversity of the state of Azad Jammu and Kashmir, and more specifically the impacts of climate change on plants of its hilly areas and approaches needed for their conservation.

## 2. MAJOR CLIMATE CHANGE RELATED ISSUES FOR PAKISTAN AND AJ&K

The major threats to Azad Kashmir and Pakistan from climate change are mentioned as:

- Change in dynamics of monsoon;
- Rapid reduction in size of Hindu Kush-Karakoram-Himalayan (HKH) glaciers leading to reduced water in flows into the Indus River System (IRS) [11]; There are however, conflicting reports about the impact of global warming on the glaciers of Himalayas increasing uncertainty. Some workers claim that these glaciers are increasing in size due to increase in precipitation [12] whereas other claim that these glaciers are not affected by climatic changes and exhibit no significant change in size in the recent past [13].
- The water-storing capacity of natural reservoirs will decrease due to glacier melt and rise in snow line;
- Higher risks of natural disasters such as floods and droughts;
- The water storing capacity of major dams will decrease due to increased silting;
- The frequent occurrence of extreme water-stressed and heat-stressed incidents having negative impacts on crop yields in dry regions [14];
- Increase in upstream movement of ocean water in the Indus delta, having adverse impacts on the ecology and production of coastal areas; and
- Increased threats of sea level rise and cyclones to the human settlements along the sea coast including Karachi due to higher sea surface temperatures [15].

From these potential dangers, it is evident that climate change poses serious dangers to regional and global biodiversity by altering the patterns of seasonal temperature and precipitation. Furthermore, synergistic effects between global warming and other anthropogenic phenomenon such as pollution, habitat loss and fragmentation, over-exploitation of natural resources will make worse climate-induced changes for biodiversity [15].

### 3. GENERAL PROFILE OF AZAD JAMMU & KASHMIR

The state of Azad Jammu and Kashmir lies between longitude 73° – 75° and latitude 33° – 36° and its total geographical area is 13,297 km<sup>2</sup>. AJK falls within the Himalayan orogenic belt with hilly and mountainous topography characterized by deep ravines, rugged, and undulating terrain. The State can be divided into two geographical regions, the northern mountainous region (Neelum, Muzaffarabad, Hattian, Bagh, Haveli, Poonch, and Sudhnoti districts) and southern plain region (Kotli, Mirpur, and Bhimber districts). Main rivers are Jhelum, Neelum and Poonch. The altitude varies from 360 m asl to 6325 m asl in the north.

Despite its small size, AJK has a variety of climate types; from sub-humid sub-tropical, to moist temperate, dry cold temperate, very cold temperate to snow deserts in extreme north. The mean annual rain fall ranges from 800 mm to 1600 mm. The snowline in winter is 1,200 meter above sea level, while in summer it rises to 3,300 meters. The mean minimum and maximum temperature are 2°C and 40°C respectively with significant variations between different regions [16].

AJ&K has 224 glaciers with ice reserves of about 4.9 cubic km mainly in Neelum valley. Total area of glaciers is 109 km with average thickness of 24 meters. Major glaciers are Saranwali, Shonthar, Parbat, Dewarian, Rati Gali and Mianwitch. These glaciers and glacial lakes are present above 4000 - 4500 m altitude. There are 76 glacial lakes with total area of 545 ha [17].

AJ&K has a population of 4.3 million in 2013 with a population density of 320 persons per km. A major part of the AJ&K population lives in rural areas and their main professions are forestry, livestock and agriculture. Major crops are maize, wheat, rice while minor crops are grams, red beans, vegetables and oil seeds. Major fruits are apple, pears, apricot and walnuts. Along with farming, livestock rearing is a common practice. Agriculture and livestock income ranges between 30-40% of household earnings. The remaining share comes from other sources including employment, businesses and remittances received by the families of AJ&K living abroad.

### 4. PLANT RESOURCES OF AZAD JAMMU & KASHMIR

Azad Kashmir is blessed with rich diversity of forest and other plant resources. Forests cover 42.6% of the total area of the state [18]. The forest types include alpine, sub alpine, temperate conifer, sub-tropical and scrub (Table.1) [19]. Due to hilly terrains, the vegetation of Azad Kashmir exhibits an altitudinal zonation of plant communities.

#### 4.1 Alpine zone

The areas between the elevation of 3600m and 4000 m include alpine grasses and shrubs and are called alpine pastures. These areas experience very cold climatic conditions during greater part of the year. The growing season starts from May and ends in September. The alpine pastures include grasses such as *Poa spp*, *Bistorta affinis*, *Saxifraga sibirica* and herbs like *Draba trinervis* and *Euphorbia kanaorica*. At high altitudes of the Himalayan mountains in the state, due to low temperatures, some dwarf varieties of birch and junipers are found making a shrubby appearance. The common species are *Betula utilis*, *Rhododendron hypenanthum* and *Juniperus communis*.

Sub-alpine forests have open canopies including evergreen conifers and broad-leaved trees. *Betula utilis* and *Abies spectabilis* are the characteristic trees. Other

common species are *Viburnum*, *Salix*, and dwarf junipers.

**Table 1.** Types and area of forests in AJ&K

Forest Type/area (000 acres)	Main Plant Species
Alpine/ sub-alpine/370.2	<i>Juniperus communis</i> , <i>Betula utilis</i> <i>Abies spectabilis</i>
Temperate conifer forest/717.3	Blue pine ( <i>Pinus wallichiana</i> ), Fir ( <i>Abies pindrow</i> ) and Spruce ( <i>Picea smithiana</i> ), Deodar ( <i>Cedrus deodara</i> ) with broadleaved associates of Maple, Poplar, Horse Chestnut, Birds Cherry, Walnut, Oak and Birch
Sub-tropical pine/290.2	Chir pine ( <i>Pinus roxburghii</i> ), with broad leaved associate of Oak
Scrub forest/23.0	<i>Olea cuspidata</i> , <i>Acacia modesta</i> , <i>Pistacia khinjuk</i> , <i>Dodonaea viscosa</i> ,

## 4.2 Temperate Forests

The areas between 1500 to 3000 m are occupied by Himalayan temperate forests. The vegetation of these forests includes dominant species such as *Abies pindrow*, *Aesculus indica*, *Pinus wallichiana*, *Salix denticulata*, *Cedrus deodara*, *Taxus fuana*, *Viburnum foetans*, *Sarcococca saligna*, *Lonicera quinquelocularis*, *Achillea millefolium* and *Buxus papilosa*. On the lower elevations, plants such as *Quercus incana*, *Pinus roxburghii*, *Pyrus pashia*, *Cithara xylum spinosa*, *Diospyrus lotus* are found abundantly.

In the plains of the valleys, deciduous trees such as poplar, maple and vir (willow) are commonly found. These forests are main source of timber, fuel wood, charcoal and provide wood for construction of houses.

## 4.3 Subtropical Forests

The subtropical forests are abundant on the foot of the hills (below 1500 m) and their vegetation includes *Pinus roxburghii* as the only dominant pine tree with many

broadleaved trees. The common plants of these forests are *Morus alba*, *Melia azedarach*, *Dalbergia sissoo*, *Acacia modesta*, *Berberis lycium*, *Punica granatum*, *Ziziphus nummularia*, *Viola biflora*, *Taraxacum officinale* and *Cynodon dactylon*. These forests exhibit great diversity of plants owing to soil types and weather patterns. In addition to trees, other groups of plants such as xerophytic bushes, shrubs, vines, ferns and tall grasses are also found commonly [20].

## 4.4 Herbaceous Flora

In addition to trees, Azad Kashmir is rich in herbaceous plants and these have great medicinal values. There have been some extensive studies on ethnobotany of medicinal plants of different regions of Azad Kashmir and hundreds of medicinal plants have been reported in these studies [21- 26].

## 5. IMPACT OF CLIMATE CHANGE ON VEGETATION IN AZAD KASHMIR

All ecosystems are dependent on climatic factors for their survival and distribution. The studies of fossils [27] of extinct species and present times [28] prove that climatic variations can have significant effects on the survival and distribution of plant communities [29]. The projected climate change is going to affect the composition and distribution of plant communities [30]. The climatic changes related to the global warming (e.g., higher levels of atmospheric CO<sub>2</sub>, increased temperatures of aquatic and terrestrial ecosystems, changes in precipitation, increase in temperatures on regional levels) will have adverse effects on the timing of reproduction of plants, the duration of the growing season, species distributions and population sizes, and the incidence of pest and disease outbreaks.

Mountainous regions in Azad Kashmir, are more prone to negative impacts of climate change and are expected to show its impacts rapidly. The climate change may impact vegetation of hilly regions by shrinkage of cooler zones at higher altitudes and shifting of tree line to upper elevations

[31, 32]. These increases in temperature may bring changes in composition of mountain plant communities by favouring the spread of thermophilous species and decline in the populations of current low-temperature, dominant plant species [33].

Azad Kashmir, being a part of Himalayas is expected to experience a relatively higher rate of temperature increase than the global average (34). During 1961-2000, in the coniferous forests of Pakistan including AJ&K, a mean temperature increase of 0.56°C to 0.78°C was recorded with a greater increase in minimum temperature over maximum temperature. The highest increase in temperature was observed during winter and autumn. Greater increase in minimum temperature and warming of autumn and in sequence the winter may lead to early start and lengthening of growing season of plants [35]. These changes are going to affect the composition of plant assemblages and conservation of plants. According to a study carried out in the Indian occupied Kashmir, it was found that 35-40% of vegetation types will undergo shifting of their areas in future because of increase in temperature [36]. Out of different forest types, sub-tropical deciduous forests are expected to shift at a higher rate (42-47%) than moist evergreen forests (15%). Another study investigating the effects of global warming on different biomes of Pakistan, found that three biomes (alpine, grassland/arid woodlands and deserts) will decrease in their area and five biomes (cold conifer/mixed woodland, cold conifer/mixed forests, temperate conifer/mixed forests, warm conifer/mixed forests, and steppe/arid shrub lands) are expected to increase [37].

Due to climate change, grasslands and tropical deciduous forests in the region would be affected on large scale. Shrubs, temperate evergreen broadleaf forest, and mixed forest types would shift to higher altitudes currently under the snowy mountains regions. In addition, large tracts of land, presently under the permanent snow and ice cover, would disappear by the end of the century which might reduce stream flows, decrease agriculture productivity and biodiversity in the region [36].

The climate change will also affect the hydrology of the region by enhancing rate of glacial melting. Initially, increased melting will lead to increased flooding but will deplete the water resources rapidly. After 2-3 decades, this region may face decreased river flows as glaciers recede in size. The depletion of fresh water resources will lead to loss of vegetation, crop productivity and loss of biodiversity. Warm temperatures and shortage of fresh water will also affect the biodiversity of the region by favouring growth of pests, insects and weeds, and invasion of alien species (e. g; *Parthenium hysterophorus* is found spreading along roads in Azad Kashmir [38]. In summary, the main threats of global warming to plant communities of Azad Kashmir are:

- Reduction in productivity of the plant communities,
- Changes in floristic composition favouring thermophilous species,
- Extinction of species with narrow ecological amplitude,
- Increase in pathogens and pest of plants,
- Reduction in areas of forests and
- Loss of biodiversity including loss of phyto-diversity [39].

## 6. CONCLUSIONS AND RECOMMENDATIONS

- There is general consensus that climate change will have adverse impacts on conservation of species and ecosystems, at first by causing loss of biodiversity by its direct impacts and secondly, by amplifying the impacts of other anthropogenic activities such as habitat loss, over-exploitation of plant resources, environmental pollution and spread of invasive species. These factors, acting separately and collectively on flora, fauna and ecosystems, are depleting and will continue to deplete biodiversity.
- Azad Kashmir has very rich floral diversity and valuable forest resources which must be monitored, managed and protected.
- These resources are threatened by direct (effects on the distribution, lifecycles, habitat use, physiology and extinction

rates of individual species, effects on the structure and composition of ecosystems and communities) and indirect (increased forest fires, diseases, reduced water flows in rivers, ground water levels, floods) impacts of climate change.

- The hilly forests and ecosystems of Azad Kashmir are threatened by climate change because of ever-increasing anthropogenic pressures and their dependence on climate-related water resources (rain, snowfall). But these effects will vary between its different regions and are difficult to generalize.
- The current status of the programs and institutions dealing with climate change studies and their management is unsatisfactory. It needs to be enhanced to deal specifically with current known issues (water availability, weeds, pests) to develop adaptive management strategies. It should also help in making reliable predictions about future climate change challenges and provide effective solutions for the protection of the floral and vegetation resources of AJ&K.
- Pakistan and Azad Kashmir harbor nearly 6,000 vascular plant species. Its plant resources will continue to be of vital importance in supporting Azad Kashmir's sustainable future development by securing its food security and socio-economic stability. Furthermore, these resources are crucial as a source of medicinal substances and conservation of biodiversity under changing climatic conditions.
- The negative impacts of climate change are multi-dimensional and wide-ranging. Their mitigation therefore calls for an integrated and coordinated policy response for conservation of plant resources. These responses will need a complex, and multi-dimensional approach to save plant diversity from potential threats of climate change. Since there is a lot of uncertainty in projecting the impacts of climate change, the strategies to formulate adaptation and mitigation responses to climate change will remain unclear. It shows that conservation of plant diversity in changing climate scenario may Conservation of plant resources of Azad

Kashmir therefore, requires new perspectives to traditional conservation practices.

- Due to lack of reliable information and data on the scale of climate change and its impacts, a regular monitoring and observation system should be developed to record and evaluate climatic changes and their potential impacts on biodiversity.
- The plants and their associated ecosystems that are under immediate threat from effects of climate change may be assessed through integrated research to identify characteristics, traits and processes contributing to their vulnerability.
- The forests should be conserved by controlling deforestation and promoting afforestation due to their potential role as carbon sinks. These forests will also provide renewable and cheap fuel for domestic needs of neighbouring human settlements.
- The paradigm of natural resource management should be shifted from merely conserving current biological resources to managing and supporting the intricate and complex responses of species and ecosystems to climate change; and
- Identify potential win-win solutions and encourage cross sectoral knowledge and information sharing and transfer.

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