

Biodiversity hotspot of Bhutan and its sustainability

Aparna Banerjee and Rajib Bandopadhyay*

Biodiversity is measured at different levels of biological set up together with genes, species and ecosystems along with their interactions. There are a total of 34 biodiversity hotspots in the world, among which the Eastern Himalayan (EH) range is one of the richest with nearly 750,000 sq. km area covering Nepal, Bhutan, and the Indian states of West Bengal, Sikkim, Assam and Arunachal Pradesh, southeast Tibet (China) and northern Myanmar. Among these countries, Bhutan is the only one sharing all its land area as the EH region occupying a major share of 7.60% of the total EH area. Bhutan is part of 23 important bird areas, 8 ecoregions, important plant areas and wetlands with 2 Ramsar areas – Tashiyangtse and Wangdue. It is also among the exclusive biodiversity hotspots in the world where forest coverage has increased above 72% of the country's total area. The country is gifted with enormous forest cover of 70.46% of the total land part. It also has 10 protected areas (PAs) with biological corridors that are home to mass populations of vulnerable Takin, endangered one-horn rhino, pigmy hog, leopard, red panda, etc. and also varying bird species. Bhutan also has many hot-water springs which are believed to have medicinal properties to cure diseases. The EH is now experiencing widespread warming higher than 0.01°C per year. Due to global warming, slow melting of the EH glaciers may cause huge floods in Bhutan in future resulting into loss of keystone species. India may also be affected by these future floods. In order to achieve sustainable development using this unique biodiversity hotspot, management of PAs, use of non-timber products and less urbanization are required.

Keywords: Biodiversity, ecoregions, glaciers, sustainability.

THE biodiversity is measured by diversity of life on Earth, and is considered at different levels of the biological set up together with genes, species and ecosystems along with their interactions. In 1992, at the world summit held in Rio de Janeiro, Brazil, the importance of biodiversity was the main focus, which resulted in the Convention on Biological Diversity (CBD). The aims of CBD are 'conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits from the use of genetic resources'. But anthropogenic activities have resulted in massive loss in biodiversity, including disturbance of the ecosystem, global warming, sea-level increase, habitat destruction, and eroding of genetic diversity of species. Now a days, species are moving towards extinction at the highest rate since the mass extinction of dinosaurs. A 'biodiversity hotspot' is a biogeographic region which should be both an important pool of biodiversity and also threatened with

demolition. A biodiversity hotspot should fulfil two important criteria: it must comprise of at least 1500 endemic vascular plants and also have 30% or less of its natural flora, i.e. it should be threatened. Around the world, total biodiversity hotspots correspond to only 2.3% of the Earth's land area, but they still have more than half of the world's endemic plant species and nearly 43% of endemic mammals, birds, reptiles and amphibians species.

There are a total of 34 biodiversity hotspots (Figure 1) in the world of which the Eastern Himalayan (EH) range is one of the richest with nearly 750,000 sq. km area covering Nepal, Bhutan, the Indian states of West Bengal, Sikkim, Assam and Arunachal Pradesh, southeast Tibet (China) and northern Myanmar. The EH region is in the limelight as a part of crisis ecoregions¹, biodiversity hotspots^{2,3}, endemic bird areas⁴, mega diversity countries⁵ and Global 200 Ecoregions⁶. Also, 15% area of the EH comprises of 99 protected areas (PAs). From a total of 60 in the HinduKush-Himalayan region, the EH region has 25 ecoregions. This area is geologically young and shows high altitudinal variation resulting in the formation of the tallest alluvial grasslands among the world and subtropical broadleaf forest in the foothills to temperate

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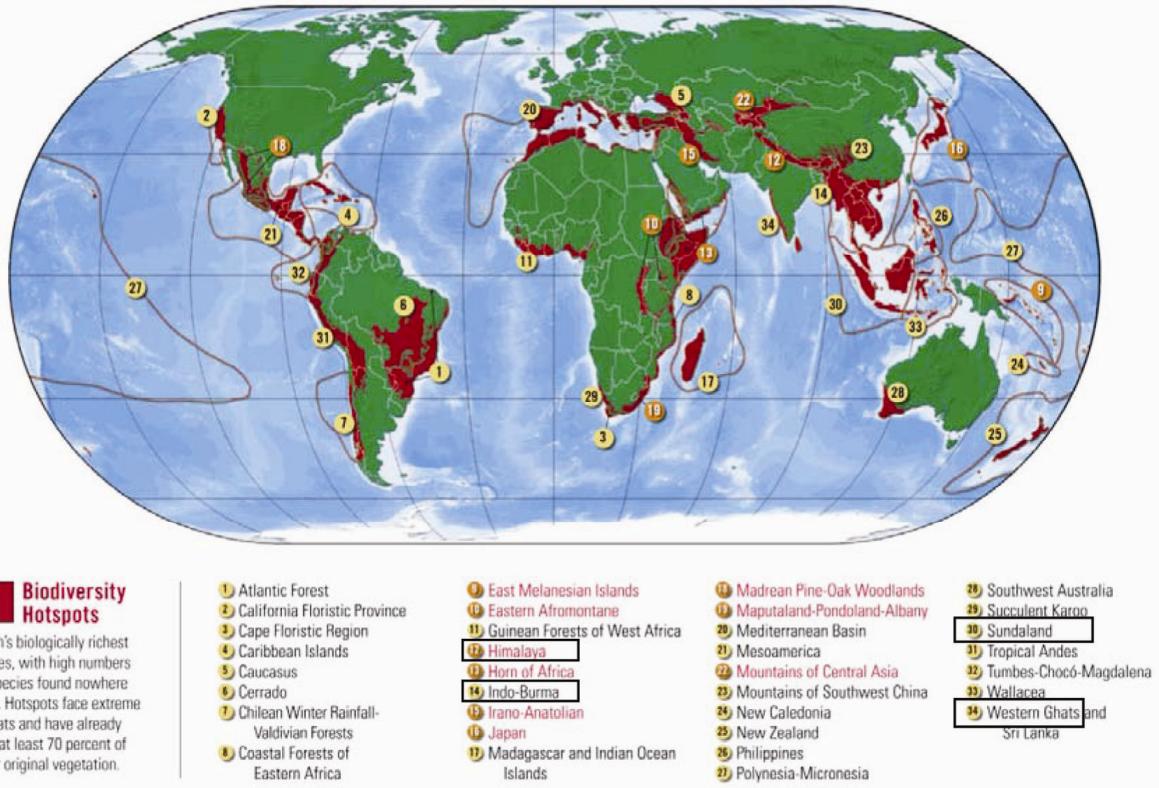


Figure 1. Thirty-four different biodiversity hotspots in the world (the four boxed hotspots are from India; www.conservation.org).

Table 1. The four biodiversity hotspots in India

Biodiversity hotspots	Indian area
Himalaya	Eastern Himalaya – West Bengal, Sikkim, Assam, Arunachal Pradesh Western Himalaya – Kashmir
Western Ghats	Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu
Indo-Burma	Andaman Islands and Meghalaya
Sundaland	Nicobar Island

broadleaf forest in the midhills, conifer forest in the higher hills and alpine meadows above the tree line. The Indo-Burma hotspot itself is home to 7000 endemic plants and has 1.9% of the world's total endemic vertebrates. More than 7000 plants species, 175 mammal species, and above 500 species of birds have been recorded from the EH, which alone consists of many endemic and endangered flora and fauna. Thus the EH biodiversity hotspot is unique; but it is also threatened due to deforestation and habitat fragmentation, animal poaching, mining, construction of roads and dams, pollution due to agrochemicals etc. The EH falls between 82.700–100.310E lat. and 21.950–29.450N long. Out of the 34 biodiversity hotspots in the world, 4 are part of India (Table 1).

Among all the countries bearing the EH biodiversity hotspot region, Bhutan is the only country which shares all its land area as the EH region; it occupies 7.60% of the total EH area. Bhutan is a small, non-coastal country with a total area of 38,394 sq. km positioned on the

southern slope of the EH. Spanning two major Indo-Malayan and Palaearctic biogeographic realms, Bhutan is comprised of 23 important bird areas (IBA), 8 ecoregions, important plant areas (IPA) and wetlands, with two Ramsar sites – Tashiyangtse and Wangdue. With varied ecosystems and eco-floristic zones, Bhutan is home to a broad range of flora and fauna. According to Article 5:3 of The Constitution of the Kingdom of Bhutan: 'The Government shall ensure that, in order to conserve the country's natural resources and to prevent degradation of the ecosystem, a minimum of sixty percent of Bhutan's total land shall be maintained under forest cover for all time.'

Climate

The climate of Bhutan is extremely diverse. This variation in climatic conditions and average temperature is maintained by two main factors – the vast differences in



Figure 2. Different types of vegetation in Bhutan. *a*, Subtropical vegetation at Chukha. *b*, Temperate forest near Dochula. *c*, Alpine zone at Chele la.

altitude in the country, and influence of the North Indian monsoons. Mountain peaks are permafrost and lower valley regions are cool in summer owing to the high-altitude terrain. In the far northern part of the kingdom, the weather is cold during winter. In the central areas of the country, the climate is cooler, changing to deciduous and temperate forests with warm summers and cool, dry winters. However, southern Bhutan has a hot, humid, subtropical climate, static the whole year. Overall temperature varies between 15°C and 30°C throughout Bhutan. The Indian summer monsoon stays from late June to late September and is mostly limited to the southern border areas of Bhutan, resulting in heavy rain and high humidity in the region. They bring 60–90% of total rainfall of the western region. Annual precipitation varies extensively in different areas of the country. The northern border area near Tibet gets about 40 mm of precipitation per year, which is mainly snow. In the temperate central regions, a yearly average of 1000 mm precipitation occurs, whereas 7800 mm/yr precipitation is registered in the humid, subtropical south, resulting in thick tropical forests and savannas.

Ecoregions

Bhutan is among the 234 globally outstanding ecoregions of the world, according to a comprehensive analysis of global biodiversity by the World Wildlife Fund. Bhutan is also an exclusive biodiversity hotspot in the world where forest coverage has increased to 72% of the country's total area. It has six major agro-ecological zones equivalent to certain altitudinal ranges and climatic environments; alpine, cool temperate, warm temperate, dry subtropical, humid subtropical and wet subtropical. The country is gifted with large forest coverage of 70.46% of the total land area. Bhutan is also unique for its conservation policy and its varied altitudinal and climatic range. The country can be broadly divided into the following three zones (Figure 2): (i) alpine zone (4000 m and above) with no forest cover; (ii) temperate zone (2000–4000 m) with conifer or broadleaf forests, and (iii) subtropical zone (150–2000 m) with tropical/subtropical environment. The forest types include fir, mixed conifer,

blue pine forest, chir pine, broadleaf with conifer, highland hardwood, lowland hardwood, and tropical lowland forests. Around 60% of the plant species found in the EH is present in Bhutan alone. Presently, 10 PAs (Figures 3 and 4) serve as the key resource of biodiversity wealth.

Hot-water springs

The geo-tectonic set-up of Bhutan, the fault map zones and the epicentre of seismicity indicate the anomalous nature of different types of geothermal distributions in the country. Hot springs locally called Tshachus (hot water) are found all over the Kingdom (Table 2). These hot springs have been used since ancient times by the Bhutanese people to cure various diseases from arthritis to body ache and even sinus, as they are believed to have medicinal properties. Thermophilic and hyperthermophilic bacteria, fungi, micro and macro algae, and archaea are common habitats of hot-water springs. Research on microscopic population in hot-water springs will help to understand better the diversity of prokaryotic life.

Flora and fauna

Bhutan has about 5603 flowering plant species under 220 families and 1415 genera, and is also comprised of about nearly 300 medicinal plant species and around 46 rhododendron species in different PAs (Figure 5). Magnolias, junipers, orchids, gentian, *Daphne*, giant rhubarb and trees such as fir, pine and oaks are common in Bhutan. In March–April, i.e. during the flowering season, rhododendron, jasmine, *Wisteria*, *Camellia*, *Pelargonium*, *Stellera*, *Primula*, *Pachystachys*, etc. flower in the valley up to a certain altitudinal range.

Due to the strict conservation efforts and well-maintained PAs (Table 3), Bhutan has flourishing populations of some of the rarest animals on earth and hence is also classified as one of the last biodiversity hotspots in the world. Some high-altitude species like snow leopard, Bengal tiger, red panda, langur, Himalayan black bear, sambar, wild pig, barking deer, blue sheep and musk deer are found at an altitude of 3000–4000 m. In the tropical

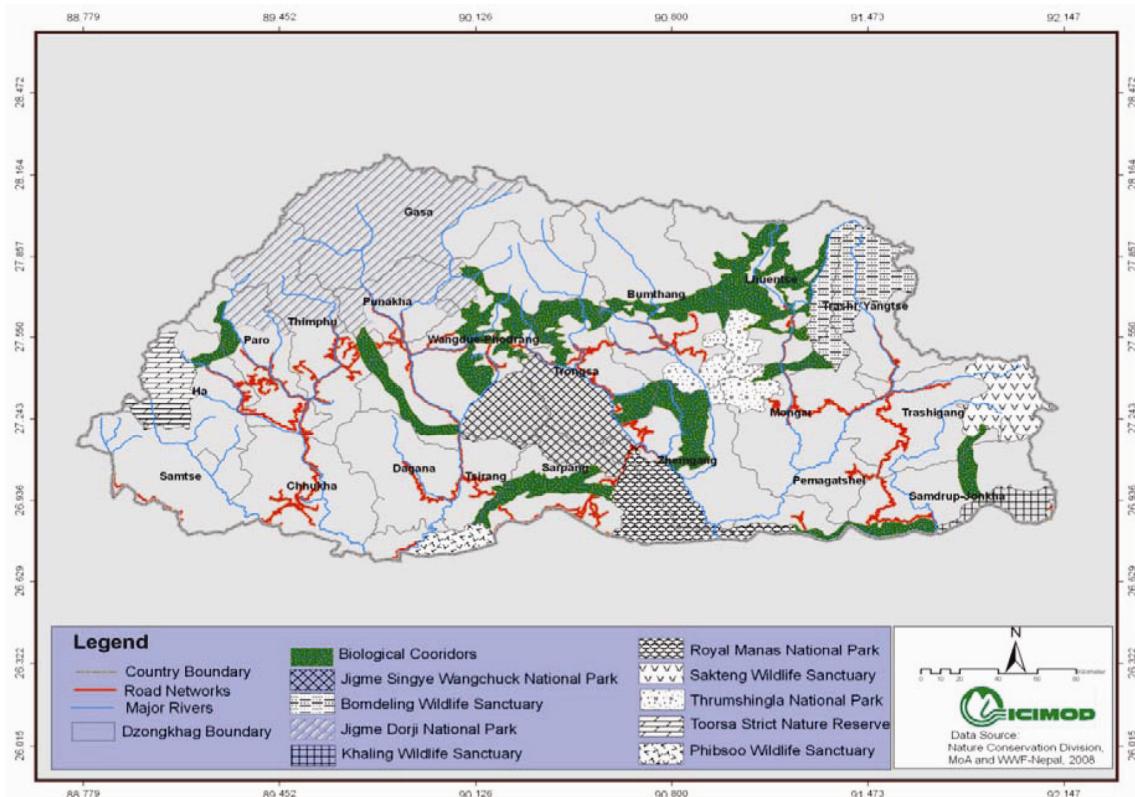


Figure 3. Map showing the protected areas and biological corridors in Bhutan¹⁵.

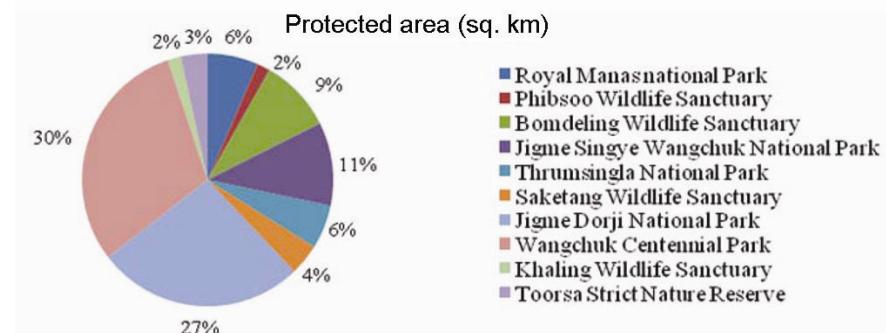


Figure 4. Pie chart showing the percentage of ten protected areas in Bhutan where Wangchuk Centennial Park (yet to be operational) has the largest area while Khaling Wildlife Sanctuary has least area coverage.

forests of southern Bhutan, clouded leopard, one-horned rhinoceros, elephant, water buffalo and swamp deer are common. The subtropical climate of Royal Manas National Park supports a large population of endangered Royal Bengal tiger (*Panthera tigris tigris*), one-horn rhinoceros (*Rhinoceros unicornis*), pygmy hog (*Sus salvanius*), Asian elephant (*Elephas maximus*), and Asiatic water buffalo (*Bubalus bubalis*). Whereas the Thrumshingla National Park is considered as distinctive as it has a blend of all diverse vegetation zones of Bhutan – Alpine zone: above 4000 m; subalpine conifer zone: 2600–4200 m; temperate coniferous forest: 2100–3000 m; cool

temperate broadleaf forest: 2000–2900 m; warm temperate broadleaf forest: 1000–2000 m, and subtropical zone: 150–1000 m. The Royal Bengal tigers has been recorded at more than 2950 m amsl here. Red panda (*Ailurus fulgens*), Himalayan black bear, leopard and musk deers are also recorded from here (Figure 6).

Bhutan has a huge diversity of bird species of 221 global endemic bird areas. Till now, more than 670 bird species have been recorded. Additionally, 57% of Bhutan's globally threatened birds and 90% of the country's rare birds are dependent on forests. Bhutan is also home to about 16 bird species that are endangered worldwide,

Table 2. Important hot-water springs in Bhutan

Hot-water spring	Place	Cure for diseases according to local belief	Temperature (°C)	Latitude and longitude
Gasa	Gasa	Headache, migraine, sinus	—	28°1'6.9204"N, 89°55'31.1628"E
Laya	Gasa	—	—	28°1'6.9204"N, 89°55'31.1628"E
Wachi	Gasa	—	—	28°1'6.9204"N, 89°55'31.1628"E
Dur	Bumthang	Body ache	—	27°38'30.6204"N, 90°40'38.2980"E
Dunmang	Zhemgang	—	—	27°8'38.0580"N, 90°41'25.2708"E
Gelephu	Sarpang	—	—	26°52'14.0016"N, 90°29'8.0016"E
Chu Boog	Punakha	Skin disease, tuberculosis	43.5	27°35'31.5132"N, 89°52'47.0856"E
Koma	Punakha	—	—	27°35'31.5132"N, 89°52'47.0856"E
Kurtoe mkhem-pa Jong gnyes ¹⁶	Lhuntshe	Indigestion, urinary tract infection, rheumatoid arthritis, polio, sexually transmitted diseases	40.2	27°39'53.7156"N, 91°10'33.9600"E
Yonten Kuenjong	Lhuntshe	—	—	27°39'53.7156"N, 91°10'33.9600"E

— indicates data not available.



Figure 5. Bar diagram showing that Jigme Singye Wangchuk National Park and Royal Manas National Park have the highest number of plant species recorded. As the protected areas belong to temperate broadleaf and subtropical regions respectively, greater humidity and rainfall have resulted in more species variation, which slowly decreased in higher altitude alpine forests.

including the White bellied heron, Pallas Fish eagle, Blyth's kingfisher, etc. It also has about 415 resident bird species. These birds are altitudinal movers, flying up and down the mountains depending on the season. During winter, about 50 migratory bird species have been recorded, e.g. buntings, waders, ducks, thrushes, etc. Around 40 species are partial migrants, such as swifts, cuckoos, bee-eaters, fly catchers and warblers. Phobjikha valley in Wangdue Phodrang and Bomdeling in Trashi Yangtse are also two particularly important habitats of the endangered black necked crane.

Takin, which is vulnerable worldwide and under threat of extinction⁷, is recognized in four subspecies: *Budorcas taxicolor bedfordi* (golden takin), *Budorcas taxicolor taxicolor* (Mishmi takin), *Budorcas taxicolor tibetana* (Sichuan takin) and *Budorcas taxicolor white* (Bhutan

takin)⁸. Till now no census has been carried out for counting total takin population in Bhutan, but it is believed that takin species are scattered throughout the forested and unforested mountain slopes of Bhutan's northern border. A few populations are known to occur on both sides of the upper catchment of Mo Chu⁹. Within Bhutan, Jigme Dorji National Park is the main takin population area, but it is also found in northern Wangdue and Bumthang districts.

Sources of threat to biodiversity

Bhutan emits approximately 1.5 million tonnes of carbon annually, and its vast forest coverage absorbs approximately 6.3 million tonnes, leaving it with a carbon emission of -4.7 million tonnes, thus distinguishing it as one

Table 3. Outline of the total protected areas and their biodiversity in Bhutan¹⁷

Protected area	Year of establishment	Plant species number	Mammal species number	Bird species number	Area (sq. km)	Ecosystem
Royal Manas National Park	1996	4500	65	362	1057	Subtropical
Phibsoo Wildlife Sanctuary	1993*	637	20	496	278	Subtropical
Khaling Wildlife Sanctuary	2003	NA	NA	458	273	Subtropical
Bomdeling Wildlife Sanctuary	1998	440	26	294	1520	Temperate
Jigme Singye Wangchuk National Park	1995	5000	50	391	1730	Temperate and upland broadleaf
Thrumshingla National Park	2000	622	69	350	905	Temperate and sub-alpine
Sakteng Wildlife Sanctuary	2003	203	18	389	650	Temperate and sub-alpine
Jigme Dorji National Park	1993	1434	28	317	4319	Temperate, sub-alpine and alpine
Toorsa Strict Nature Reserve	1993*	NA	NA	404	561	Temperate, sub-alpine and alpine
Wangchuck Centennial Park	2008*	244	23	134	4914	Temperate and alpine

*Indicates the protected areas have been established but are not yet operational.

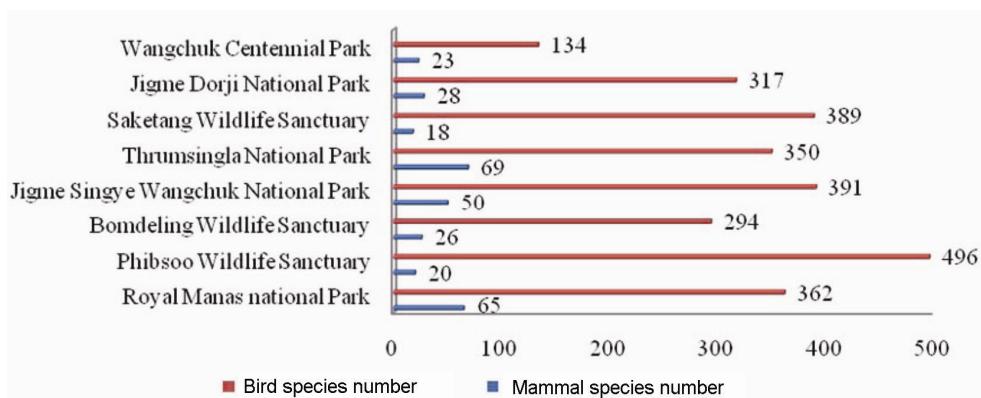


Figure 6. Bar diagram showing number of birds and mammals recorded from protected areas of Bhutan. Phibsoo Wildlife Sanctuary has the highest number of birds recorded. Though Phibsoo is the second smallest protected area (278 sq. km), its subtropical climate may help the large bird populations. Royal Manas National Park and Thrumshingla National Park have the highest number of mammals recorded from subtropical, and temperate, and sub-alpine climate respectively.

of the few countries in the world with negative carbon emissions. However, Bhutan's status as a negative carbon emitter does not make it immune to the impacts of climate change. In fact, its location in the Himalaya renders it more vulnerable to the impacts of climate change because global warming trends are higher and the impacts are magnified by the extreme changes in altitude over small distances¹⁰. In addition, it has become increasingly evident that those likely to bear the brunt of climate change are the world's poorest countries and in particular, the poor and marginalized communities and people who depend almost exclusively on natural resources and have reduced capacity to adapt due to their vulnerable situation¹¹.

Conclusion

The EH is facing extensive warming now a days. The warming rate is higher than the normal rate of 0.01°C per year. Using normal seasonal dichotomies, the highest

warming rate is in winter and cooling trends are observed in summer. A progressive warming with elevation is observed and zones >4000 m experience the highest warming rates¹². As the Himalaya has the largest concentration of glaciers outside the polar region, these glaciers are freshwater reserves and provide water for nine major river systems in Asia – a lifeline for about one-third of the world's total humanity. There is also clear evidence that the Himalayan glaciers are melting at an alarming rate in recent decades. This is resulting into major changes in freshwater flow and has a major impact on drinking water supplies, biodiversity, hydropower, industry, agriculture, etc. with extensive implications for the people of this region and the total environment of the Earth. Approximately 15,000 glaciers (with a total area of 33,340 sq. km) and 9000 glacial lakes throughout Bhutan, Nepal and Pakistan, as well as selected river basins in China and India were reported in a study conducted by the International Centre for Integrated Mountain Development, Nepal, United Nations Environment Programme and the Asia Pacific Network for Global Change

Research. Pho-Chu sub-basin of Bhutan has witnessed devastating glacial lake outburst floods earlier. The global mean temperature is expected to increase between 1.4°C and 5.8°C over the next 100 years. The Himalayan glaciers are diminishing at rates ranging from 10 to 60 m/yr and many small glaciers (<0.2 sq. km) have already disappeared. In the Pho Chu sub-basin of Bhutan Himalaya, some glacial lakes have changed in size, as high as 800% over the past 40 years. River-level increase finally results into floods and obliteration of livelihood and keystone species with an overall impact on biodiversity¹².

The Namdapha Nature Reserve is one of the largest PAs of the EH biodiversity hotspot and supports rich floral and faunal diversity. This virgin forest cover has considerably reduced and become patchy due to human settlement, jhum cultivation, massive extraction of forest product, hunting of rare and endangered fauna, and uncontrolled fishing from the river¹³. Systematic conservation planning can help identify the species that are in immediate need of conservation and will result into minimized biodiversity loss. Recycling of nutrients, regulation of microclimate and local hydrological processes, suppression of undesirable organisms, detoxification of harmful chemicals, use of non-timber forest products, decrease in ecological footprint and sustained use of mountain and forest area will probably help in the maintenance of biodiversity in Bhutan, thus saving the ecological balance of EH. All major rivers in Bhutan depend on snowmelt for flow. Therefore, changes in snow cover due to climate change will influence availability and distribution of water. Over a quarter of total land area of Bhutan remains under snow in winter, which is declining over the last decade. Interannual and seasonal trend of snow-covered area in Bhutan from 2002 to 2010 is also on a decline. In compliance with the Western Himalaya, snow cover in spring is also decreasing as detected by remote sensing technology¹⁴. Using remote sensing technology, monitoring the increasing greenhouse gas emission, prior detection of natural hazards like floods, landslides, earthquakes, etc., total biomass estimation of the biodiversity zone is possible and will help in overcoming the future biodiversity loss in a big way. Also, Bhutan's adaptation on minimum 60% of the total land area to be forest-covered for lifetime, is a major step for a country to preserve its natural habitat and resulting into biodiversity conservation. In order to maintain the sustainability of any biodiversity hotspot, we need to ensure that the forest areas are maintained as well as decrease in ecological footprint.

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