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Sustainability of Biodiversity in Bhutan

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***Abstract*: Biodiversity is the variety of life on Earth. The Eastern Himalaya biodiversity hotspot (EH) is part of 36 biodiversity hotspots of the world. EH is around 7,50,000 km2 covering Bhutan, Nepal, southeast Tibet (China), northern Myanmar, and the Indian territories of Assam, Arunachal Pradesh, West Bengal, and Sikkim. The whole of Bhutan (38,394 km2) falls in the EH biodiversity hotspot. The exclusive biodiversity is heaven for biodiversity as the country's total forest cover exceeds 70 %. Bhutan's five National Parks, four Wildlife Sanctuaries, one Strict Nature Reserve, and Biological Corridors are home to some of the globally endangered species like Chinese Pangolin (Manis pentadactyla), Great Hornbill (Buceros bicornis), Red Panda (Ailurus fulgens), Black-necked Crane (Grus nigricollis), White-bellied Heron (Ardea insignis), Bhutan Takin (Budorcas taxicolor whitei) and Bengal Tiger (Panthera tigris tigris). The country is home to around 300 medicinal plants, raw materials for the country's traditional medicine. The glaciers in the Bhutanese Himalaya are retreating at a fast rate. The management of Protected Areas, using non-wood products, going green, and waste management at the individual level are essential for biodiversity sustainability.**

***Keywords*: Biodiversity, hotspot, glaciers, Bhutan, protected areas, Himalaya.**

1. Introduction

Biodiversity or Biological Diversity is 'the variety of life' and alludes to variety at all degrees of biological organization [19]. A lot more proper meanings of biodiversity have been proposed, which foster this basic one. Of these, maybe the most significant and extensive is that contained inside the Convention on Biological Diversity (CBD). More than 150 countries endorsed this binding treaty on the fifth day of June 1992 at the United Nations Conference on Environment and Development, held in Rio de Janeiro. It came into power roughly a year and a half later [50].

The Convention states that:

'Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.' The variety of life is communicated in a variety of ways. Some feelings of this variety can start to be made by recognizing distinctive vital components. These are the essential building blocks of biodiversity. They can be partitioned into three levels: (a) genetic diversity, (b) organismal diversity, and (c) ecological diversity [22]. Genetic diversity incorporates the parts of the genetic coding that structure living beings (nucleotides, chromosomes, genes) and variety in the genetic make-up between individuals inside a populace and between populaces. Organismal diversity incorporates the ordered chain of command and its parts, from individual upwards to species, genera, and some. Ecological diversity envelops the sizes of natural contrasts from populaces, through specialties and territories, on up to biomes. Even though introduced independently, the groups are connected and share components similarly (for example, populaces show up in every three) [14]. The CBD aims to conserve biological diversity, sustainable utilization of its components, and excellent and fair sharing of the advantages from utilizing genetic resources [34]. However, anthropogenic activities have brought about an enormous misfortune in biodiversity, including the unsettling influence of the ecosystem, a worldwide temperature alteration, habitat destruction, increasing sea level, and disintegrating diversity of species [33]. These days, species are moving towards elimination at the most special rate since the mass extinction of dinosaurs. A biodiversity hotspot is a biogeographic district that ought to be both a significant pool of biodiversity and compromised with destruction. A biodiversity hotspot should satisfy two significant measures: it should include no less than 1,500 endemic vascular plants, and 30% or less of its flora should be threatened [25]. The Earths' total biodiversity hotspot is just 2.3% of the Earth's territory [21]. However, they have the more significant part of the world's endemic plant species and almost 43% of endemic vertebrates, birds, reptiles, and creatures of land and water species [9].

With the addition of The North American Coastal Plain, the Earth has 36 biodiversity hotspots [27] (figure 1). The Eastern Himalayan (EH) biodiversity hotspot range is extravagant, with an almost 750,000 km2 region covering Bhutan, Nepal, southeast Tibet (China), northern Myanmar, and the Indian territories of Assam, Arunachal Pradesh, West Bengal, and Sikkim [5]. Around 38 million people live in the Eastern Himalayan biodiversity hotspot. The region is likewise an ecotourism area of interest, filling in as an escape from the overpopulated focal points of Asia where the rich biodiversity of the highlands can be investigated. The Eastern Himalayas are at the intersection of two continental plates, which served as a conclusive factor in the significant degrees of biodiversity and endemism that connived from the two areas [44]. The Eastern

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Himalayan area is additionally the gathering point of three biogeographical realms, to be specific, the Indo-Malayan, Sino-Japanese, and the Palaearctic realm [1]. The highlands have vibrant biodiversity, high endemism, and 163 globally threatened species, including the densest populace of Bengal tigers and the herbivores on the mainland: Black-necked Crane (Grus nigricollis), Asian Elephant (Elephas maximus), and more prominent One-horned Rhinoceros (Rhinoceros unicornis) [38].

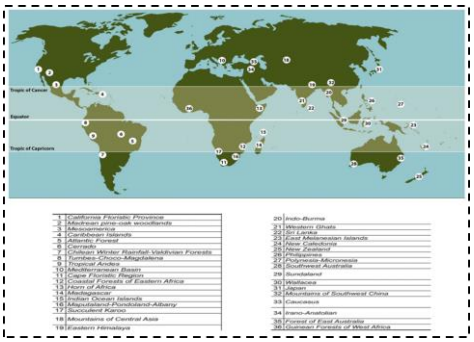

Fig. 1. Thirty-six biodiversity hotspots in the world [32] [23]

The EH region is at the center of attention as part of an emergency ecoregion, biodiversity hotspot, endemic bird region, ecologically diverse countries, and Global 200 Ecoregions. Additionally, 15% space of the EH involves 99 protected areas (PAs) [6]. From a sum of 60 in the Hindukush Himalayan area, the EH locale has 25 ecoregions. This region is topographically young and shows high altitudinal variation bringing about the arrangement of the tallest alluvial grasslands and subtropical broadleaf forests in the lower regions to the quiet broadleaf woods in the mid-slopes, conifer timberland in the higher slopes, and snow-capped glades over the treeline. The Indo-Burma hotspot itself is home to 7,000 endemic plants and has 1.9% of the world's complete endemic vertebrates. More than 7,000 plant species, 175 warm-blooded animal species, or more than 500 types of birds have been recorded from the EH, which alone comprises numerous endemic and endangered fauna and flora[4]. In this manner, the EH biodiversity hotspot is novel; however, it is likewise undermined because of deforestation, logging, habitat fragmentation, poaching, mining, streets and dams, contamination due to agrochemicals, climate change, and so on. The EH falls between 82.700E to 100.310 E latitude and 21.950 N to 29.450 N longitude [46]. Among all the countries falling in the region of EH biodiversity hotspot, Bhutan is the only country that shares all of its lands with EH biodiversity hotspot; it covers 7.60% of the total area of the EH biodiversity region. Bhutan is a land-locked country with a total area of 38,394 km2. The country is home to around 11,248 species [38]. Bhutan's rich and green forest covers 71% of the land, under the five National Parks, four Wildlife Sanctuaries, one Strict Nature Reserve, Community Forests, and biological corridors linking different protected areas (figure 5). The greater part (51.44 percent) is secured by law, and exercises are limited under particular conditions [53]. The nation's scene is overwhelmed by mountain environments and changes inside 170 kilometers from heights of around 130 meters in the lower regions to more than 7,500 meters above sea level along the top edge of the Himalayas. The Constitution commands keeping 60% forest cover for all times to come [41]. Bhutan's forests comprise broadleaf (45.9 %), mixed conifer (13.5 %), fir (6.0 %), chirpine (2.6 %), and blue pine (2.6 %). Other land uses and land covers incorporate bushes (9.7 %), snow cover (5.4 %), rough outcrops (4.2 %), alpine scrub (3.4 %), cultivated agriculture land (2.8 %), and meadows (2.5 %) [17].

Bhutan is universally perceived as an innovator in nature preservation and as a hero for the climate. The nation has approved global conventions like the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention on Biological Diversity (CBD), the United Nations Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), the United Nations Convention to Combat Desertification (UNCCD), and the Ramsar Convention on Wetlands. Bhutan is the only carbon-negative nation worldwide—around 2.2 million tons of CO2 equivalents are discharged yearly[26]. However, since its forests, more than 6.3 million tons of CO2 equivalents are sequestered every year. In the Nationally Determined Contribution (NDC) submitted to the COP21 (Conference of the Parties) of the UNFCCC in December 2015 in Paris, Bhutan reaffirmed to remain carbon neutral and seek a low-emission improvement way on the side of the responsibilities of the Paris Agreement [37].

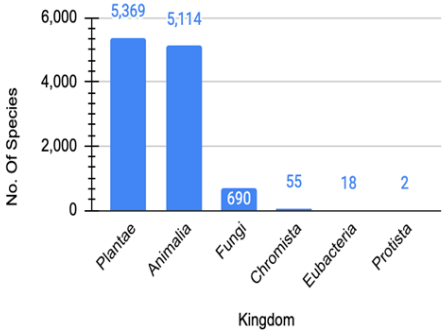

Fig. 2. Number of species by Kingdom

1) Flora and Fauna

Bhutan records 11,248 species in all taxa of biodiversity, 136 (1.20 %) are globally endangered [31]. Out of 11,248 species, 5,369 (47.73 %) is categorized under Kingdom Plantae, 5,114 (45.47 %) under Kingdom Animalia, 690 (6.13 %) under Kingdom Fungi, 55 (0.49 %) under Kingdom Chromista, 18 (0.16 %) under Kingdom Eubacteria, and 2 (0.02 %) under Kingdom Protista [31] [35] (Figure 2). There is no record of species belonging to Kingdom Archaebacteria. Bhutan's documentation of biodiversity is at a beginning phase. Somewhere in the range of 2009 and 2017, Bhutan recorded 16 plants, 4 snails, 4 moths, 3 fishes, 2 bugs, 2 aphids, 1 stonefly, and 1 dragonfly that were a new record for science [35]. Additionally, Bhutan likewise recorded 566 new species, including 119 moths, 108 fishes, 101 plants, 65 honey bees and wasps, 59 dragonflies and damselflies, 35 snails and slugs, 44

reptiles and amphibians, 14 crabs, 5 birds, 5 cicadas, 4 butterflies, 4 beetles, 2 bryophytes, and 1 true flies around the same time [20]. The new species record for Bhutan has happened at a pace of 62 species each year (62.88%). A considerable lot of the species are not yet found and reported in Bhutan, and there is a requirement for much exploration to record the unseen species (to science and Bhutan) and to comprehend species number and variety [38].

Bhutan is home to 5,369 plant species, which is around 47.73 percent of the total species found in the country [35]. The country is home to around 300 medicinal plants, 4,978 tracheophytes (seed plants and ferns), 367 bryophytes (mosses, liverworts, and hornworts), 23 charophytes (Algae), and 1 green algae (Figure 3) [35]. Blue poppies (Meconopsis gakyidiana - national flower of Bhutan), rhododendrons, pine, oak, orchids, magnolias, daphne, and junipers are common in Bhutan. 49 plant species found in Bhutan are listed as Extinct in the Wild, Critically Endangered, Endangered, and Vulnerable under the IUCN Red List of Threatened Species [31] [35].

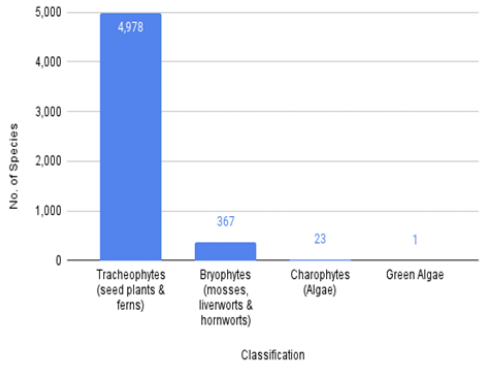

Fig. 3. Number of species in Kingdom Plantae

Bhutan has one of the most substantial conservation policies in the world. Because of the policies and conservation efforts, Bhutan is home to some of the rarest animals in the world. The Himalayan Kingdom is home to around 5,114 animal species, which is 45.47 percent of the species reported from the country [15]. The country shelters 1,148 vertebrates species, 455 invertebrates species (excluding insects), and 3,511 insect species (Figure 4). 86 animal species are listed in the IUCN Red List of Threatened Species as Vulnerable, Endangered, and Critically Endangered. Black-necked Crane (Grus nigricollis), Chinese Pangolin (Manis pentadactyla), Bengal Tiger (Panthera tigris tigris), Snow Leopard (Panthera Uncia), Bhutan Takin (Budorcas taxicolor whitei), Ludlow's Bhutan Swallowtail (Bhutanitis ludlowi), Golden Mahseer (Tor putitora), Gharial (Gavialis gangeticus), White-rumped Vulture (Gyps bengalensis), and White-bellied Heron (Ardea insignis) are some of the globally endangered species found in Bhutan [31] [35] [13].

2) Ecoregions

Bhutan is among the 238 worldwide exceptional eco-regions of the world [47]. Bhutan is likewise an elite biodiversity area of interest on the planet, where forestland inclusion has expanded to 71% of the nation's total area. Bhutan is likewise special for its protection strategy and its shifted altitudinal and climatic reach. It has six significant agro-ecological zones comparable to certain altitudinal reaches and climatic conditions; wet subtropical, humid subtropical, dry subtropical, warm temperate, cool temperate, and alpine. The nation can be comprehensively separated into the following three zones: (i) subtropical zone (150 - 2,000 meters); (ii) temperate zone (2,000 - 4,000 meters), and (iii) alpine zone (> 4,000 meters) (Dey et al., 2020). The forest types are tropical lowland forests, lowland hardwood, highland hardwood, broadleaf with conifer, chirpine, blue pine, mixed conifer, and fir. Around 60% of the plant species found in the EH are available in Bhutan alone [51]. 10 PAs (figure 5) fill in as the secret weapon of biodiversity riches.

3) Climate

Bhutan's environment is assorted than that of some other likewise measured areas on the planet. The environment changes with altitude, creating striking meteorologic differences, and various openings to daylight and dampness loaded breezes bring about complex local varieties. Three central climatic regions can be recognized: (i) the alpine tundra area of the Great Himalayas; (ii) the cooler areas of Lesser Himalayas; and (iii) the moist, hot, subtropical lot of the Duars Plain and its adjoining lower regions [8]. A calm and cool environment happens just in the central mountain valleys. For example, in Thimphu, west-central region, in January, high temperatures are generally in the low around 2-12° C; in July, Thimphu's temperatures are to some degree hotter, ordinarily ascending to the mid-60s F (around 19° C) and dropping to the mid-50s F (around 13° C). The rest of the nation encounters either outrageous warmth in the Duars or excessive cold in the north [48].

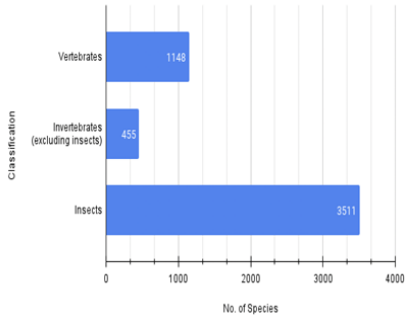

Fig. 4. Number of species in Kingdom Animalia

4) Protected Areas

Bhutan has a network of 10 Protected Areas: Wangchuck Centennial National Park (WCNP); Royal Manas National Park (RMNP); Phrumsengla National Park (PNP); Jigme Singye Wangchuck National Park (JSWNP); Sakteng Wildlife Sanctuary (SWS); Phibsoo Wildlife Sanctuary (PWS); Jomotsangkha Wildlife Sanctuary (JWS); and Jigme Khesar Strict Nature Reserve (JKSNR) [29] (figure 5, figure 6, and table 1). The ten Protected Areas are interlinked with Biological Corridors to allow the free movement of wild animals. The Protected Areas cover 51.44 percent of the total land area of Bhutan.

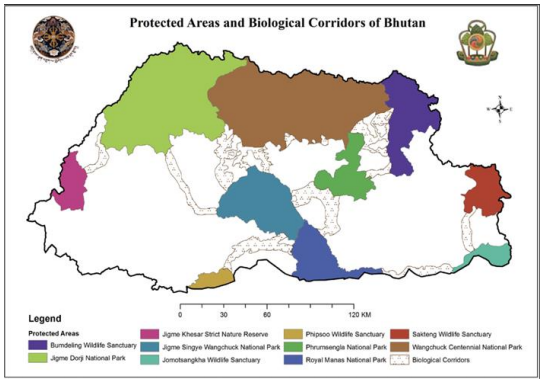

Fig. 5. Map of Bhutan's Protected Area

Biological Corridors were first established in 1999 and offered as a gift to the Earth from Bhutan. There were at first 12 corridors with absolute inclusion of 3,660 km2 associating each of the nine of Bhutan's PAs [9]. However, with the foundation of Wangchuck Centennial National Park in 2008, three passages (corridors) were subsumed [7]. Bhutan's Corridors address an intense and imaginative vision unbeatable by some other country on Earth. Consequently, Bhutan can be appropriately brought up as a world forerunner in endeavoring to utilize Corridors as a financially dependable procedure to save meta-populaces of wide-ranging species, advance quality streams for all species, and permit species from adjusting to environmental change. The corridor's areas were picked to adjust many elements, including the danger of forest fires, movement examples of keystone species, the trouble of landscape, living space condition, human effects, and the corridor passage's shape. The longest is the North Corridor, with a length of 76 km, and the briefest is the 16 km association between Phrumsengla National Park [49].

2. Traditional Ecological Knowledge

Traditional Ecological Knowledge (TEK) has become broadly embraced as a hotspot for enhancing areas like sustainable agriculture, conservation management, and climate change responses [11]. TEK has been described as a hotspot for reexamining human associations with their surroundings [30]. Indigenous people and their TEK have acquired consideration because of their capacity to address climate change at the grassroots level [28] [24]. A developing assortment of examination and worldwide approaches discusses features of how this information framework could add to life on land under Sustainable Development Goal (SDG) 15 and Climate Action in SDG 13 by recognizing environmental (climate) change, responding, and adjusting to its effect, subsequently supporting worldwide adaptation activities. Native people groups express TEK as a "lifestyle"; instead of only information concerning how to live, it is about the natural living of life [40]. Subsequently, TEK is a significant articulation of the native culture and is inseparably connected to their practices[16]. Their insight and the executives are about the qualities that shape and work with their reactions to the component of worldwide climate change [2]. For native individuals, TEK is the base of their strength, i.e., their ability to adjust to ecological change and vulnerabilities dependent on an inside and out comprehension of the land [45].

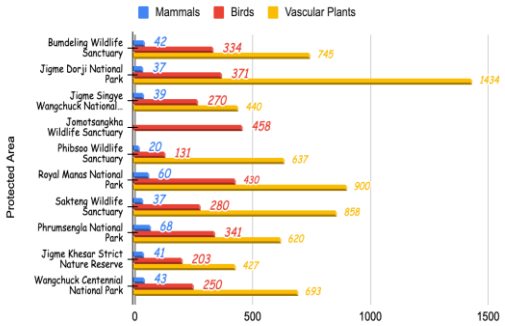

Fig. 6. No. of mammals, birds, & vascular plants in PAs

Bhutan could conserve its rich biodiversity without much destruction before opening its door to the outside world, international bodies, protocols, and conventions. The secret to such success without scientific approaches is because of religion and traditional ecological knowledge. While environmental practices and religious beliefs can be at odds with one another in a reductionist worldview, both are adjusted with the help of ecological protection in the Himalayan country of Bhutan. Government reports affirm that the country's particular consecrated cosmology, a mix of Animism, Bön, and

Table 1
Protected Areas of Bhutan with its total area, % covered, and the Dzongkhag it touches

Protected Area	**Total Area (sq. km.)**	**% covered**	**Dzongkhags**
Bumdeling Wildlife Sanctuary	1,521	3.96	Lhuntse, Mongar, Trashiyangtse
Jigme Dorji National Park	4,316	11.24	Gasa, Paro, Punakha, Thimphu, Wangdue Phodrang
Jigme Singye Wangchuck National Park	1,730	4.51	Sarpang, Tsirang, Trongsa, Wangdue Phodrang, Zhemgang
Jomotsangkha Wildlife Sanctuary	334.73	0.87	Samdrup Jongkhar
Phibsoo Wildlife Sanctuary	268.93	0.70	Dagana, Sarpang
Royal Manas National Park	1,057	2.75	Pemagatshel, Sarpang, Zhemgang
Sakteng Wildlife Sanctuary	740.6	1.93	Trashigang, Samdrup Jongkhar
Phrumsengla National Park	905.05	2.36	Bumthang, Lhuntse, Mongar, Zhemgang
Jigme Khesar Strict Nature Reserve	609.51	1.59	Haa
Wangchuck Centennial National Park	4,914	12.80	Bumthang, Gasa, Lhuentse, Trongsa, Wangdue Phodrang
Biological Corridors	3,307.14	8.61	Haa, Paro, Thimphu, Punakha, Wangdue Phodrang, Sarpang, Tsirang, Zhemgang, Trongsa, Mongar, Bumthang, Trashigang, Lhuntse, Samdrup Jongkhar
Royal Botanical Park, Lamperi	47	0.12	Punakha
	19,751	51.44	

Vajrayana Buddhism, has secured Bhutan's regular habitat, permitting around 71 % of the country to stay under forest cover. The far and wide confidence in spirits and gods who possess the land shapes how subordinate asset networks conceptualize and connect with the land. Local beliefs uncover a profound liking for and care of nature [3]. Along these lines, nearby beliefs support the pioneer objectives of natural protection while emerging from a distinctly unique philosophy. The Bhutanese case features the possibilities for both combination and interface intrinsic in the unstable crossing points of conventional natural information and logical epistemologies of the climate. Documenting the traditional ecological knowledge from every place of Bhutan is necessary. It will allow decision-makers to formulate policies that will benefit the local people and the environment. The status of TEK will also be documented, and plans for reviving it can be possible if the TEK is declining.

3. Threats to Biodiversity

Bhutan's status as a carbon-negative country doesn't keep it safe from climate change. The country is home to one of the highest unclimbed mountains (Gangkar Phuensum, 7,570 meters) in the world, but the pollution from the region is accelerating the melt of snow and glaciers. A recent report published by National Centre for Hydrology and Meteorology [36] showed that Bhutanese Himalayan Glaciers are retreating at an accelerating rate. The burn of climate change will likely be faced by developing and under-developing countries. The increasing pollution from the transportation sector, construction industry, burning agricultural waste within the country, and transboundary pollution will affect Bhutan's most substantial social and environmental health.

The growing amount of municipal solid waste will pose threats to biodiversity as well. There are laws and approaches set up to direct and arrange waste administration, yet it does not demonstrate power. The plastic boycott strategy flopped multiple times. All the difficult work of the public authority and related offices went to no end. This issue demonstrates reality in regards to the administration of waste. The board of waste is turning into an issue in Bhutan [39]. Bhutan produces around 861 metric tons of waste each week[12]. If the information shows that the waste age has expanded over the years, individuals cannot deal with the waste appropriately. Clean Bhutan, a Non-Government Organization (NGO) that plans to Zero Waste in Bhutan by 2030 [10], has gathered around 5,900 metric tons of waste from December 2014 to February 2018 [10]. Bhutan orders waste into 5: e-waste; medical waste; hazardous waste; non-hazardous waste; and other waste (agriculture waste, industrial waste, municipal waste) [42]. The Royal Government of Bhutan is working intimately with all related offices and bodies to forestall and lessen the volume of waste age, advance isolation, reduce, reuse, and recycle, and deal with the loss in an environmentally sound way. A lot of drives and exercises are done to become zero waste by 2030. The nation encourages waste management business ventures in avoiding, assortment, isolation, and reusing of waste [43]. The Waste Prevention and Management Regulation 2016 substituting or eliminating, recycling, reusing, reducing, treating, recovering, and properly disposing of waste.

The cases of poaching, illegal logging, construction of massive dams over fragile mountain valleys, excessive use of chemical fertilizers in agriculture practices, discharge of untreated water into rivers, and corruption are posing significant threats to the sustainability of Bhutan's biodiversity. The small animals and insects are invisible for researchers interested in Bhutan Himalaya biodiversity. A significant portion of the fund is directed towards mega-fauna and several plant species. The country has not been able to document the entire species occurring in the country. Environmental education is low as Environmental Science subject is kept as an option in Middle Secondary Schools, Higher Secondary Schools, and Undergraduate programs. If the country wants to sustain the natural environment, then basic environmental things should be taught compulsorily to every young mind. If young minds are taught about the world's environmental issues, some breakthrough solutions might come up from the young minds. It also helps students live a sustainable life, appreciate nature, and work on its conservation.

4. Conclusion

The Eastern Himalaya is warming faster than its regular rate of 0.010C every year. The glacier's retreat is accelerating every year, and many small glaciers have already disappeared. The Himalayan region is the source of fresh water for the one-ninth population of the world. The rivers in Bhutan depend on snowmelt, and if climate change alters the rate of glacier melt, it will threaten water availability and distribution. The Constitution of Bhutan mandating its citizens to keep forest cover above 60 % for all times to come is a significant step to combat climate change and the sustainability of Bhutan's biodiversity. Environmental education is essential to educate young minds about the importance of sustainability and biodiversity conservation.

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