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CLIMATE CHANGE IMPACT ON PLANT BIODIVERSITY OF ARUNACHAL HIMALAYA: A REVIEW

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Abstract

Climate Change (CC) is widely recognized as the major environmental challenge facing the entire planet at present. Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (AR5) revealed that, the average global surface temperature is likely to rise by 0.3 to 4.8 °C and sea levels would rise by between 26 and 82 cm (10.4 and 32.4 inches) by the end of this century. The above increase in temperature will create substantial impacts on health, agriculture, forests, water resources, coastal areas, biodiversity and ecosystems. The Himalayan region is among the most fragile ecosystems in the world and is under severe threat from climate change. However, as per the IPCC assessment report, the Himalayan region has been identified as a data deficient in terms of climate monitoring. The region is a rich repository of rare, threatened, endangered and endemic species, hence threats to biodiversity arising from climate change are very sensitive. Arunachal Pradesh is the largest mountain state in North-East India and popularly known as paradise of botanists as it contains nearly 50 % of the total flowering plant species (about 5000 spp. of angiosperm) of the country and over 500 medicinal plant species. The floral wealth of state is still unexplored due to remoteness, inaccessibility, tough topography and harsh climatic conditions although, the state holds great potential for new plant discoveries. Indigenous communities are highly dependent of plant biodiversity for sustenance and livelihood. Plant biodiversity of the state is facing is various anthropogenic threats and further aggravated by climate change impact. Considering the climate change impact, there is very urgent need of conservation of plant biodiversity particularly rare, endangered, threatened and endemic (RETE) species of the state. This paper review the status of plant diversity, forest resources, climate change impact and suggest measures for conservation of plant biodiversity of the state.

Keywords: Plant biodiversity; Arunachal Himalaya; Climate change; Conservation

INTRODUCTION

Climate change is one of the major global challenges of the 21st Century. Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has highlighted that warming of the climate system is unequivocal. The report concluded that human activities over the past 50 years have warmed the planet, and recent anthropogenic emissions of greenhouse gases are the highest in history. IPCC has projected that the surface temperature will continue to rise over the 21st century due to human-induced global warming. Therefore, heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions. The ocean will continue to warm and acidify, and global mean sea level to rise. Scientists have indicated that the net damage costs of climate change are likely to be significant and to increase over time. Climate change has already shown significant impact on ecosystems, biodiversity, economies and communities in the planet. It will create greater risks to disadvantaged people and marginalized communities of less

developed areas. The Himalayan region is among the most fragile ecosystems in the world and is under severe threat due to climate change. Scientific studies have projected that climate change would produce cascading effects on water resource, biodiversity, ecosystem composition and functioning and human livelihoods in the Himalayan region (Cruz et al., 2007; Xu et al., 2009). The Himalayas global average surface temperatures are increasing and snow cover and ice extent are reducing. Scientists have predicted that the Himalayan region will experience rise in temperature and rainfall by the end of this century. However, as per the IPCC assessment report, the Himalayan region has been identified as a data deficient in terms of climate monitoring (IPCC, 2007). Climate change impact on Himalayan ecosystems is less studied due to limited availability of long-term climate data for the region. Though, It is pertinent to mention that Himalayan region is a rich repository of rare, threatened, endangered and endemic species, hence threats to biodiversity arising from climate change are very sensitive (Karma et al., 2010). Eastern Himalayan region has been considered a mega biodiversity hotspot in the world. Located at the tri-junction of Indo-Chinese, Indo-Malayan and Palaearctic biogeographic realms, the region exhibits diverse hilly terrain with wide altitudinal range. The biodiversity of the Eastern Himalayan region is facing numerous anthropogenic threats aggravated with climate change impacts.

Arunachal Pradesh is the largest Himalayan state in North-East region of the country, covers a geographical area of 83,743 km^2. It is situated between $23^0$28' and $29^0$30' N latitude and $90^0$30' and $97^0$30' East longitude. The state is uniquely situated in the transition zone between the Himalayan and Indo-Burmese regions, being recognized as one of the 25 mega biodiversity hotspots of the world (Myers et al., 2000) and also among the 200 globally important ecoregions (Olson and Dinerstein, 1998). In addition to this, Namdapha National Park area of the state has also been recognized by International World Conservation Union in the year 1995 as one of the major centers of plant diversity (IUCN, 1995). The state is considered as a "paradise of the botanists" due to huge repository of enormous floral diversity. The unique phytogeographical, topographical and climatic conditions of the state provide ideal condition and habitat for rich and unique floral elements. The forests of the state support rich floral diversity due to the varied climatic conditions, altitudinal ranges, wide ranging physiography and diverse ecosystem types. The recorded forest cover of the state is 66,964 km^2, which constitutes 79.96 % of states geographical area of the state. Culturally, the state is also quite rich being home to 26 major and more than 110 minor tribal communities. Tribal communities live in close association with forests and highly dependent on numerous forest products for their livelihood. They have developed various indigenous traditional knowledge systems for sustainable utilization and management of forest resource through a long series of practical interventions and observations transmitted from generation to generation (Kanwal et al., 2016). Scientific studies have proved that the climate change is one of the major threats for plant diversity of the world. Scientific research have highlighted that the climate change has already altered species geographical range distribution in many parts of the world. IPCCC has also emphasised that a large fraction of species will faces increased extinction risk due to climate change during and beyond the 21^{st} century. Himalayan plants are highly sensitive to climate change due to very narrow

geographical distribution range. Diversity of plants and number of endemic species are very high in Himalayan region as compared to other mountain region of the world. Arunachal Pradesh state is home of myriad plant species comprising of tree ferns, bamboos, orchids, rhododendrons, several botanical curios, rare, endemic, primitive flowering plants, medicinal and many economically important species. The state holds great potential for new plant discoveries, at present the floral wealth is still unexplored due to remoteness, inaccessibility, tough topography and harsh climatic conditions. Climate change will affect the floral diversity of the state particularly rare, endangered, threatened and endemic species due to their restricted distribution and narrow habitat ranges (Bharali et al., 2011, Kanwal et al., 2013). Considering the floral diversity values and climate change impact in Arunachal Pradesh, the present paper has been conceived to review the floral diversity status, future scenario of climate change, threat to plant diversity due to climate change and suggest measures for plant diversity conservation in the Arunachal Pradesh.

MATERIALS AND METHODS

Study Area

Arunachal Pradesh is the largest state of the NE region of India in terms of geographical area and very wide elevation range between 50 m to 7000 m asl. The state with a population of approximately 13.82 Lakh (approximately 0.11 % of India's total population) and the density of population is very low about 17 per km^2 compared to the national density of India at 382 per km^2 (Census 2011). It shares major geographical land area of the Northeast region. The state has a long international border with Bhutan to the west (160 km), China to the north and north-east (1,080 km) and Myanmar to the east (440 km). It stretches from snow-capped mountains in the north to the plains of Brahmaputra valley in the south. Arunachal Pradesh is drained by mighty rivers like Siang, Dibang, Lohit, Kameng, Subansiri, Tawang to form together the mighty Brahmaputra River which drains through the State of Assam to finally converge into the Bay of Bengal. The rainfall of Arunachal Pradesh is amongst the heaviest in the country receiving more than 3500 mm in a year. The state receives rainfall over a period of 8 to 9 months excepting in winter, however, most of rainfall is between May and September. Winter months have average temperatures in the range 15 °C to 21 °C, and the monsoon month temperatures are in the range of 22 °C to 33 °C, and the summer months temperatures sometimes are higher well over 37 °C (Anonymous, 2011). The indigenous community of the Arunachal Pradesh mainly depends on agriculture and forest resources for their sustenance and livelihood requirement. The vegetation of Arunachal Pradesh falls under four broad climatic categories and can be classified in five broad forest types with a sixth type of secondary forests. These are tropical forests, subtropical forests, pine forests, temperate forests and alpine forests. In the degraded forests bamboos and other grasses are of common occurrence.

Methodology

Extensive and intensive literature review was carried out to document the status of plant diversity, forest resource, climate change scenario and impact of climate change on plant diversity in Arunachal Pradesh. The published literature such as research articles, journals, books, reports, thesis, brochure, monographs, etc. were concerned. The information was also obtained from government websites such as Ministry of Environment, forest and Climate

Change (MoEF&CC), State forest departments, Forest Survey of India (FSI), National and State Biodiversity Boards etc. Additional papers were located by searching the reference sections of these articles/reports. Discussion with subject experts and local communities were also carried out through brainstorming workshops, focused groups talks and personal interviews to get the first hand information on Climate change impact on plant diversity of the state.

RESULTS AND DISCUSSION

Status of Plant Biodiversity

Arunachal Pradesh is popularly known as cradle of all flowering plants as it contains nearly 50 % of the total flowering plant species (about 5000 spp. of angiosperm) in India (Takhtajan, 1969). The flora of state comprises about 29 species of Gymnosperm, 452 species of Pteridophytes and large number of other lower plants species (Sinha, 2008) (Table 1). The state is recognized as 'Orchid Paradise' because of having the highest concentration of orchid species. Out of about 1350 species of orchids known so far from India, about 558 species (about 40 % of the country) of orchids belonging to 144 genera are reported from Arunachal Pradesh (Rao, 2010). The state also harbours about 119 taxa of *Rhododendron* (out of 132 taxa known from India) out of which 12 species are endemic (Mao et al., 2017). *Rhododendron* is considered as a prominent biological indicator of climate change. Researchers have observed the change in flowering phenolgy of *Rhododendron* due to climate change. Besides this, there are about 57 species of bamboo, 18 species of *Hedychium*, 16 species of *Quercus*, and a large number of ferns and lichens occur in the state (Bhuyan et al., 2007; Sinha, 2008). The state is home of many important endemic species such as *Acer oblongum* var. *microcarpum*, *Acer sikkimense* var. *serrulatum, Aconogonum pangianum, Begonia aborensis, B. scintillum, Capparis pachyphylla, Coptis teeta, Hedychium longipedunculaturn, Illicium cambodianum, Lysimachi acongestiflora var. santapaui, Maesa arunachalensis, Merrillio panaxlisteri, Paphiopedilum wardii, Pholidota watii, Primula subansirica, Pternopeta lumsenii, Pueraria bella, Rhododendron santapaui, Rhynchoglossum lazulinum, Schefflera venulosa, Tricarpelema glanduliferum*, and *Wallichia triandra* (Chowdhery, 1997; Nayar and Sastry, 1987, 1988, 1990; Chowdhery et al., 1996, 2008; Chowdhery, 2008). These endemic species may face severe endangerment under the impact of climate change because of their narrow biogeographical range of distribution and very limited population size. Large number of primitive Angiosperms such as *Altingia excelsa, Aspidocarya uvifera, Betula alnoides, Decaisnea insignis, Euptelea pleiosperma, Exbucklandia populnea, Haematocarpus validus, Holboellialatifolia var. angustifolia, Houttuynia cordata, Magnolia caveana, M. griffithii, M. hodgsonii, M. pterocarpa, Pycnarrhena pleniflora, Tetracentron sinense and species of Camellia, Magnolia, Michelia, Rhododedron etc.* occur in the state, Therefore it is considered centre of evolutionary development of Angiosperms (Chowdhery, 2008).

Table 1: Floral Statistics of Arunachal Pradesh

Plant Groups	No. of families	No. of genera	No. of species
Angiosperms	192	1295	4117
Dicotyledons	165	970	2986
Monocotyledons	27	325	1131
Gymnosperms	8	18	29
Pteridophytes	43	133	452

(Source: SFRI, 2008)

Medicinal Plants Diversity

Tribal communities of state use numerous plants species for ethnobotanical purpose; so far more than 500 species of medicinal plants are catalogued from the state (Haridassan et al., 2005). Some important high altitude (above 1000 m asl) medicinal plants species of state are *Taxus baccata, Illicium griffithii, Aconitum ferox, Aconitum heterophyllum, Coptis teeta, Gymnadaenia orchidis, Panax sikkimenis, Panax pseudoginseng, Panax bipinnatifida, Picrorrhiza kurroa, Prodophyllum hexandrum, Valeriana jatamansi*. While, lower altitude important medicinal plants are *Aquilaria agallocha, Emblica officinalis, Gmelina arborea, Oroxylum indicum, Terminalia arjuna, Terminalia bellirica, Teminalia chebula, Bixa orellana, Acorus calamus, Andrographics paniculata, Catheranthus roseus, Costus specious, Cymbopogon citraus, Piper mullesua, Piper peepuloides, Rauvolfia serpentine, Withania somnifera. Dioscorea floribunda, Gloriosa superba, Piper longum, Piper nigrum, Tinospora cordifolia.* Medicinal plants wealth state cannot only cure different ailments but can also be potential source of economy to the state. As per IUCN Conservation Assessment and Management Prioritization criteria (CAMP, 2003), 44 medicinal plant taxa of state have been categorized under red list category. Out of total recorded taxa, 6 critically endangered, 12 endangered, 17 vulnerable, 8 near threatened, 3 least concern and 1 data deficient were observed. Rare, endangered and threatened (RET) species of state are *Aconitum ferox, Abies densa, Aconitum heterophyllum, Amentotaxus assamica, Aquilaria malaccensi, Bergenia ciliata, Brucea mollis, Cephalotaxus griffithii, Cibotium barometz, Cinnamomum tamala, Coptis teeta, Dendrobium nobile, Drosera peltata, Elaeocarpus sphaericus, Embelia ribes, Flickingeria fugax, Fritillaria cirrhosa, Garcinia pedunculata, Gentiana quadrifaria, Gymnadenia orchidis, Gymnocladus assamicus, Gynocardia odorata, Homalomena aromatica, Hydnocarpus kurzii, Illicium griffithii, Mahonia napaulensis, Malaxis muscifera, Nardostachys jatamansi, Oroxylum indicum, Picrorhiza kurroa, Piper betleoides, Piper boehmeriaefolium, Piper pedicellatum, Piper peepuloides, Pleione maculata, Podophyllum hexandrum, Polygonatum verticillatum, Rauvolfia serpentina, Rheum nobile, Rhododendron anthopogon, Smilax glabra, Swertia chirayita, Tacca integrifolia, Taxus wallichiana, Tropidia curculigoides, Valeriana hardwickii , Valeriana jatamansi.* These species are more vulnerable to climate change impact because of small natural population size and various other anthropogenic stresses.

Forest Covers and Protected Areas in Arunachal Pradesh

The recorded forest cover of the state is 66,964 km^2, which constitutes 80 % of states geographical area of the state (Anonymous, 2017). As per forest canopy densities classes, the area covered by very dense forests is 20,721km^2, moderately dense forests is 30,955 km^2 and open forests is 15,288 km^2 (Table 2). The forest of Arunachal Pradesh falls under five major categories of vegetation viz., tropical, subtropical, temperate broad-leaved and temperate coniferous, sub-alpine and alpine forests. Detailed accounts of floristic of these forests are found in Champion & Seth (1968) and Kaul and Haridasan (1987). Besides above, Kaul and Haridasan (1987) have also identified the secondary forests in the state consisting of degraded forest, bamboo forest and grassland. These diverse range of forest provides very idle habitats of various plant species. At present, the forest in

Arunachal Pradesh is facing several threats and biotic pressures in the form of shifting cultivation, grazing, forest fires, commercial monoculture plantations, and illegal extraction of forest products and diversion of forest land for developmental projects. The State has considerable area (around 11.82 % of geographical area of the state) under protected area network (PAN), whereas national average is below 5 % (Kumar and Chaudhry, 2015). There are two National Parks, eleven Wildlife Sanctuaries, one biosphere reserve and two tiger reserves in the state.

Table 2: District wise forest cover of Arunachal Pradesh (area in km^2)

District	Geographical Area (GA)	2017 Assessment			Total	% of GA	Change w.r.t ISFR 2015	Scrub
		Very dense	Mod. Dense	Open forest				
Changlang	4,662	1,754	1,372	866	3,992	85.63	-30	5
Dibang Valley & L/Dibang valley	13,029	1,691	4,925	2,616	9,232	70.86	-35	8
E/Kameng & W/Kameng	11,556	3,433	4,667	2,178	10,278	88.94	-96	29
E/Siang	3,603	881	1,268	731	2,880	79.93	6	10
Kurung Kumey & L/Subansiri	9,548	2,943	4,060	1,379	8,382	87.79	-20	29
Lohit & Anjaw	11,402	1,978	3,981	1,642	7,601	66.66	-24	12
Papum Pare	3,462	966	1,509	716	3,191	92.17	-20	3
Tawang	2,172	341	448	388	1,177	54.19	-19	28
Tirap	2,362	714	700	521	1,935	81.92	-17	77
U/Siang	6,590	1,564	2,452	1,353	5,369	81.47	0	17
U/Subansiri	7,032	1,800	2,624	1,147	5,571	79.22	16	26
West Siang	8,325	2,656	2,949	1,751	7,356	88.36	49	3
Grand Total	83,743	20,721	30,955	15,288	66,964	79.96	-190	247

(Source: SFR, 2017) [Legends: L: Lower; E: East; W: West; U: Upper]

Risk of Climate Change Induced Impact on Plant Diversity

The rich bioresources obviously make Arunachal Pradesh a biodiversity rich mountainous state. The state is most vulnerable and likely to experience the wide-ranging effects of climate change like other mountainous region of the globe. As per Indian Network for Climate Change Assessment (INCCA) report, the Indian Himalayan Region annual mean surface air temperature is projected to increase from 0.9±0.6 °C to 2.6±0.7 °C in the 2030s (MoEF, 2010). Researchers have also observed that during the last century the maximum temperature increased over North East India by 1°C during winter and 1.1°C during the post-monsoon month. There have been small increases in rainfall during winter, pre- and post-monsoon seasons (Dash et al., 2007). Arunachal Pradesh State Action Plan on Climate Change (APSPCC) has projected that maximum temperature will increase by 2.2 °C to 2.8 °C during 2030s as compared to baseline i.e. 1961-1990 and towards 2080s the increase is projected by 3.4 °C to 5 °C. Minimum temperature is projected to increase by 1 °C to 2.6 °C during 2030s and by 2.8 °C

to 5^0C during 2080s. Biodiversity and forest are projected to be adversely impacted by climate change by 2030s in Arunachal Pradesh. As per APSPCC assessment, a change in forest types is projected in various districts of the state such as the northern region of upper Siang district, western region of Dibang Valley, southern region of west Siang and western region of Kurung Kumey district. Therefore, the biodiversity rich districts of Arunachal Pradesh are projected to be adversely impacted by climate change by 2030s. State action plan has concluded that the future climate is not optimal or suitable to the existing forest type and biodiversity (Anonymous, 2011). The endangered, rare, threatened and endemic plants species with very small populations and special habitats requirement are likely to be less resilient and more vulnerable to climate change risk in the state (Table 3).

Table 3: Rare, endangered and threatened (RET) plant species of Arunachal Pradesh likely to face severe threat due to climate change

Family	Species name	RDB Status	IUCN Status	CITES Status	Distribution range
Aceraceae	*Acer oblongum* Wall. Ex DC. var. *microcarpum* Hiern	Endangered	-	-	Mishmee Hills, Lohit
	Acer sikkimense Miq. var. *serrulatum* Pax	Endangered	-	-	Mishmee Hills, Lohit
Apiaceae	*Chaerophyllum orientalis* (Clarke) Mukh.	Indeterminate	-	-	Naga Hills; 2300 m
	Pternopetalum senii Deb et Dutta	Rare	-	-	Tirap
Arecaceae	*Livistona jenkinsiana* Griff.	Endangered	-	-	Mountain Valleys of Lohit, Siang and Tirap
	Phoenix rupicola T. Anders.	Rare	NT	-	Mishmi Hills; 450 m
	Wallichia triandra (Joseph) S.K. Basu	Rare	Lower Risk	-	Hayuliang, Wakro (near Glow Village) in Lohit; 900-1000 m
Balanoph-oraceae	*Rhopalo cnemis phalloides* Jungh.	Rare	-	-	Tirap
Begonia-ceae	*Begonia aborensis* Dunn	Rare	-	-	Abor Hills
	Begonia burkillii Dunn	Rare	-	-	Abor Hills; 300-1000 m
	Begonia scintillans Dunn	Indeterminate	-	-	Abor Hills; 1200-2000 m
Commeli-naceae	*Aneilema glanduliferum* Joseph et Rolla Rao	Vulnerable	-	-	Possibly endemic to Arunachal Pradesh; 1800 m
Fabaceae	*Gleditsia assamica* Bor	Indeterminate	VU	-	Endemic to Hills of North-East India
	Pueraria bella Prain	Rare	-	-	Abor Hills, Mishmi Hills and Tirap district; 200-1000 m
Gesneria-	*Rhynchoglossum*	Rare	-	-	Kameng & Subansiri

ceae	*lazulinum* Rao & Joseph				districts; Endemic; 1250-1500 m
Liliaceae	*Nomocharis synaptica* Sealy	Rare	-	-	Thachu Valley & Delei Valley in Arunachal Pradesh; 3048-3695 m
Orchida-ceae	*Bulleyia yunnanensis* Schltr.	Rare	EN	Appendix II	-
	Calanthe mannii Hook. f.	Rare	-	Appendix II	Khasi Hills
	Cymbidium eburneum Lindl.	Vulnerable	-	Appendix II	Endemic to Eastern Himalaya and NE India; 1000-1500 m
	Cymbidium hookerianum Rchb.f.	Vulnerable	-	Appendix II	1700-2500 m
	Diplomeris pulchella D. Don	Vulnerable	-	Appendix II	Tirap district
	Diplomeris hirsuta (Lindl.) Lindl.	Vulnerable	-	Appendix II	Kameng; 1500-2000 m
	Paphiopedilum fairrieanum (Lindl.) Stein	Endangered	-	Appendix II	Endemic to the Eastern Himalayas
	Paphiopedilum wardii Summerh.	Endangered	-	Appendix I	Lohit
	Pholidota wattii King et Pantl.	Rare	-	Appendix II	Endemic to NE India
	Vanda coerulea Griff. ex Lindl.	Rare	-	Appendix II	NE India; 1300-2000 m
Rafflesia-ceae	*Sapria himalayana* Griff.	Rare	-	-	Namdapha Wildlife Sanctuary
Ranuncu-laceae	*Coptis teeta* Wall.	Vulnerable	-	-	Lohit, Dibang Valley, Siang district and upper reaches of Upper Subansiri district; 2500-3000 m
Rubiaceae	*Hedyotis scabra* Wall. ex Kurz	Rare	-	-	
	Psychotria aborensis Dunn	Endangered	-	-	Abor Hills; 300-1220 m
Solana-ceae	*Pauia belladonna* Deb et Dutta	Rare	-	-	Tirap district; 2000 m
Styraca-ceae	*Alniphyllum fortunei* (Hemsl.) Makino	Rare	-	-	Subansiri district; 1600 m
	Huodendron biaristatum (W.W. Sm.) Rehder	Rare	-	-	Subansiri district; 1700 m

(Source: Nayar and Shastry 1987, IUCN red list, CITES)

Higher altitude plant species are most sensitive to climate change due to pristine ecological conditions and narrow distribution pattern (Photo plate 1). The rising temperature

of water bodies renders them more suitable habitat for invasive species that outcompete native species and synergistically interact with climate change to threaten native organisms. The prevailing rise in temperature and changes in precipitation patterns leading to increased incidence of extreme weather that could lead to diminishing crop and livestock diversity and have direct implications on agrobiodiversity and food security of the area. The species like *Rhododendron*, which occur in transition zone between alpine and subalpine ecosystem may face more threat due to limited scope of upward movement (Paul et al., 2005). Presently, people of the state are also experiencing the climate change impacts in form of change in snowfall and perception period and pattern, increase in atmospheric temperature, change in phenological behaviour of plants species viz. flowering and fruiting pattern, increase in the number of invasive alien species, vegetation shifting in higher altitudes areas (Bharali and Khan, 2011; Kanwal et al., 2013). In addition to projected climate change vulnerabilities, floral biodiversity of the state is also facing several threats and biotic pressures mainly due to shortening of fallow period in shifting cultivation (*jhum*), uncontrolled grazing, forest fires, encroachment, construction of developmental projects, commercial plantations and illegal extraction of forest products (Arunachalam et al., 2004).

Rhododendron anthopogon

Meconopsis grandis

Saussurea obvallata

Aconitum fletcheranum

Photo plate 1: Some important high altitude plant species of Arunchal Pradesh

CONCLUSION

Comprehensive scientific information on climate change impacts on floral diversity is not available for the state so far. There is therefore, an urgent need to carry out interdisciplinary in-depth research such as documentation of terrestrial and aquatic floral diversity, assessment of medicinal and aromatic plants status, population dynamics study, phenological monitoring study, altitudinal shift and change in community assemblage studies to assess and monitor the Climate Change impacts on floral biodiversity particularly for rare, endangered, threatened and endemics species of the state. These studies will help to frame comprehensive Climate Change mitigation and adaptation strategies for conservation of rich floral diversity of this mountain state. There is also need of establishment of long-term ecological monitoring sites in plant biodiversity hotspot sites to assess the pattern of change, ecological niche modelling of important flora, conservation of scared and community conserved sites, identification of climate resilient species for afforestation/restoration, monitoring of climate linked alien and invasive weeds (eg. *Mikania, Eupatorium, Ageratum, Parthenium*, etc.), documentation of traditional ecological knowledge (TEK) of ethnic community and capacity building of stakeholders through education and awareness programs. Community particularly women and youth participation would play pivotal role to mitigate, adapt and cope with the Climate Change impacts on floral biodiversity of the state. Outcome of long-term collaborative research work will further help in formulation of integrative policy for floral biodiversity conservation of Arunachal Pradesh.

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