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Plants of Gnathang, Eastern Sikkim with Respect to Long Term Monitoring Programme of Indian Space Research Organization

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Abstract: **The alpine ecosystem is fragile; climate change can bring tough impact on alpine plant species. Which are very sensitive to the temperature change. Therefore HIMADRI have take up incentive to monitor the effect of climate change on alpine flora species at Gnathang, East Sikkim. The current information is regarding variety and abundance of plant species found at alpine mountains of Gnathang. This information will be important for long term monitoring of climate change programmes in alpine regions of the country.**

Keywords: **Alpine Flora Species at Gnathang, East Sikkim, Space Research Organization.**

1. INTRODUCTION

The alpine life zone is globally distributed, from polar to tropical latitudes and occurs across oceanic and continental climates. The alpine ecosystem usually having distinct biological communities having high level of endemism, respond very sensitively to temperature change. This area are among the remaining most pure environments, least influenced by anthropogenic activities provides an ideal 'natural laboratory' for climate impact research studies. (C. P. Singh et al.). However changes in climatic conditions are likely to change the distribution of sensitive plant species.(Dalip K. Upreti1 et al 2015) As Mountain ecosystems are likely sensitive to global warming owing to the reduction in area with increasing elevation (Guisan et al., 1995). To monitor climate change and its effect on the fragile alpine ecosystem, a world-wide research initiative "Global Observation Research Initiative in Alpine Environments (GLORIA)" has been established for comparative study of climate change impact on mountain biodiversity (Grabherr et al. 2000 Pauli et al. 2003). Indian Space Research Organization (ISRO) in India has developed monitoring network for Indian Himalaya known as "Himalayan Alpine Dynamics Research Initiative (HIMADRI)". The programme intends for long term monitoring of ecologically sensitive parameters at benchmark sites in selected areas of Himalaya. Aparwat region in Jammu & Kashmir, Roharu area in Shimla district of Himachal Pradesh , Chopta-Tungnath site in the state of Uttarakhand, Roharu area in Shimla district of Himachal Pradesh, Sela Pass in Arunachal Pradesh and Kupup (Gnathang) in Sikkim this areas are selected by ISRO for conducting long term monitoring of vegetation to estimate reaction of environmental changes on biodiversity.(Dalip K. Upreti1 et al 2015).

To monitor the climate change at Sikkim Himalaya; Gnathang, East Sikkim has been selected, where long term monitoring will be setup just above the Gnathang valley, where plant diversity will be study for long interval of time.

2. MATERIAL AND METHODS

Sikkim have a total geographic area of 7,096 km2, state has an altitudinal range varying from 300m to 8586m above sea level, representing tropical, sub-tropical, temperate and alpine regions and a small portion of cold desert. The state has about 80% of its geographical area under forest cover, with an estimated over 4500 species of flowering plants. Besides 39% area occupied by alpine pastures and snow. Sikkim is rich in biodiversity, State have 26% of flowering plants from total plants species found in the country i.e. approximately 4,500 species of which 500 orchid varieties, 450 species of

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trees of which 11 species are oak, and 36 species of Rhododendron. (Sikkim state action plan on climate change-2014-2015) Therefore climate change study is most o study the impact in this part of Himalayas.

Gnathang or Nathang Valley is Situated at the height of 13,000 ft. above the sea level Surrounded by snow capped hills and mountain landscape. To study the impact of climate change and global warming in alpine vegetation of Himalaya, Hills of Gnathang ,East Sikkim has been taken up, where long term monitoring sites has been selected; Highest Summit Point (HSP). Three HSP sites, viz. HSP-1 (altitude 4003 m, Lat. 27°17'51.3"N, Long. 88°50'09.0"E), HSP-2 (altitude 3957 m, Lat. 27°17'43.3"N, Long. 88°49'57.9"E) and HSP-3 (altitude 3707 m, 27°17'26.0"N, Long. 88°50'02.0"E), These three HSP sites are establish by using remote sensing technique the distribution of flora and response of species in alpine region due to change in climatic conditions will be studied.

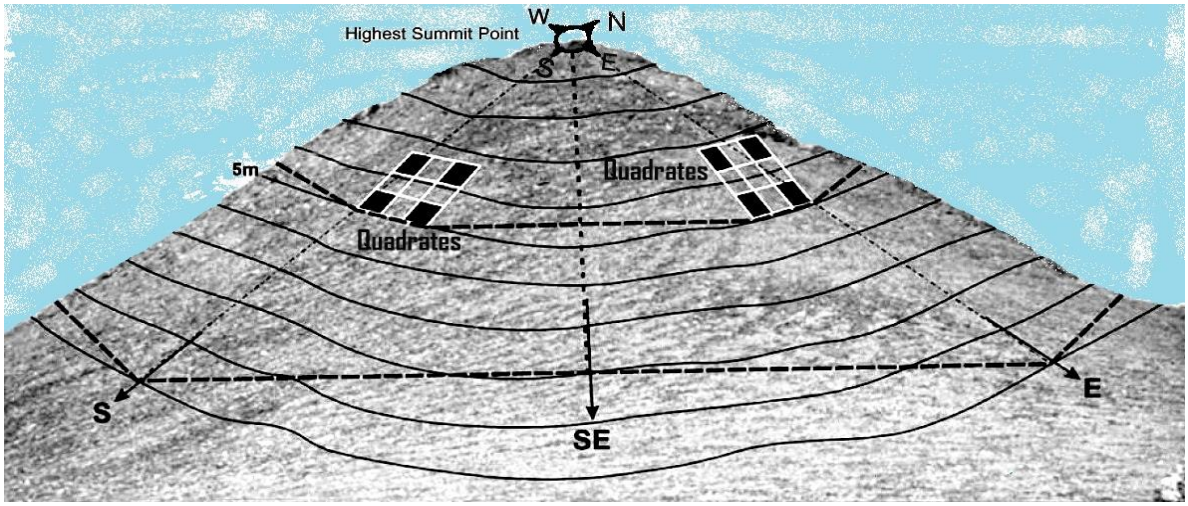

FIGURE 1: Outline of the actual plot settings in Gnathang.

Vegetation studied:

Gnathang, East Sikkim, was visited at the month of June 2015.diversity of plants was studied at HSP-1, HSP-2 and HSP-3, respectively in four compass direction was taken (East, West , North, South) , using clinometers on four directions elevation of HSPs at 5meters were taken out as shown in figure1 . At all four compass directions 3m × 3m quadrate clusters were laid (figure1) than 1m ×1m quadrate was formed inside 3m × 3m quadrates at four corners of the quadrates. In total of 16 quadrate areas were surveyed for flora study at, 5 and 10 meters distance summit area section, (SAS) down the slope of mountains in four directions as shown in figure 2.

Digital herbarium pictures 3 was collected for further studies from 3 summits, collected digital specimens were identified using herbarium from Botanical survey of India, Sikkim, Himalayan Regional Center, Gangtok. Furthermore published and unpublished literature has been also reviewed for accurate identification , the books like "Flora of British India and "Flora of Bhutan", and Flowers of Himalaya has been referred.

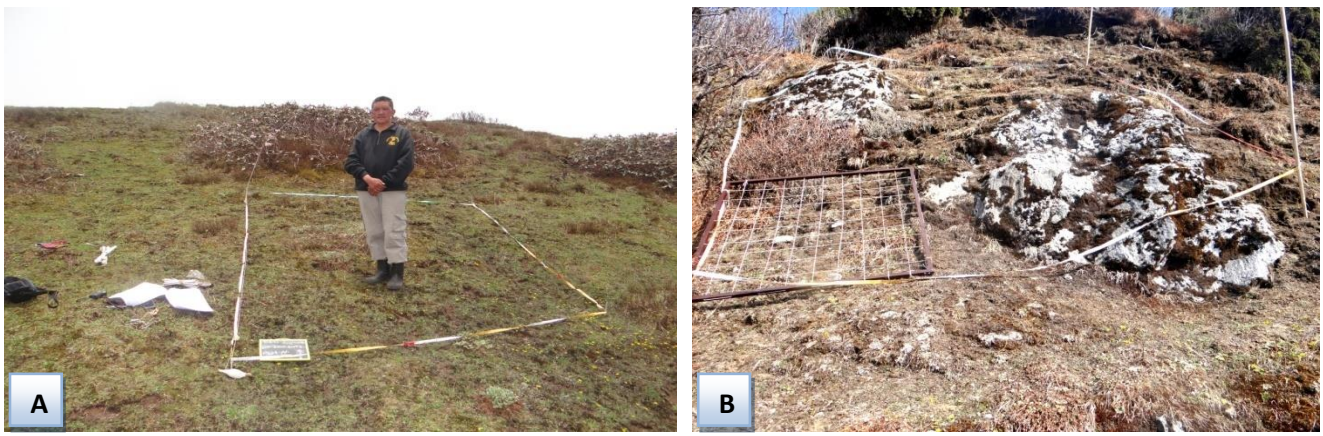

FIGURE 2: A. man standing inside 3m × 3m quadrate clusters, B.1m ×1m quadrate inside 3m × 3m quadrates.

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Table A: Plants found inside quadrate at all three summits. (+) indicates that the plant species was present in that hsp.

SL.NO.	BOTANICAL NAME	FAMILY	HSP 1	HSP2	HSP3
1	*Abies densa* Griff.	Pinaceae			+
2	*Arisaema costatum* (Wall.) Mart.	Araceae	+		+
3	*Berberis buxifolia* Lam.	Berberidaceae		+	+
4	*Bergenia purpurascens* (Hook.f. & Thomson) Engl.	Saxifragaceae	+	+	
5	*Fragaria nubicola* (Lindl. ex Hook.f.) Lacaita	Rosaceae		+	
6	*Geranium affine* Ledeb.	Geraniaceae		+	
7	*Gnaphalium coarctatum* Willd.	Compositae		+	
8	*Polygonum molle* D. Don	Polygonaceae			
9	*Potentilla saundersiana Royle**	Rosaceae		+	+
10	*Primula denticulata* Sm.	Primulaceae	+	+	+
11	*Primula sikkimensis* Hook.	Primulaceae	+	+	
12	*Primula tibetica* Watt	Primulaceae	+	+	
13	*Primula calderiana* Balf. f. & R.E. Cooper	Primulaceae		+	
14	*Primula elliptica* Royle	Primulaceae		+	
15	*Rheum acuminatum* Hook. f. & Thomson	Polygonaceae			+
16	*Rhododendron anthopogon* D. Don	Ericaceae	+		+
17	*Rhododendron campanulatum* D. Don	Ericaceae		+	
18	*Rhododendron ciliatum* Hook. f.	Ericaceae	+		
19	*Rhododendron lanatum* Hook. f.	Ericaceae		+	
20	*Rhododendron niveum* Hook. f.	Ericaceae		+	
21	*Rhododendron sikkimense* Pradhan & Lachungpa	Ericaceae			+
22	*Rhododendron wallichii* Hook. f.	Ericaceae		+	+
23	*Ribes laciniatum* Hook. f. & Thomson	Grossulariaceae			
24	*Rubus parvifolius* L.	Rosaceae			+
25	*Rumex* obtusifolius L.	Polygonaceae			+
26	*Saussurea fastuosa* (Decne.) Sch.Bip.	Compositae	+		
27	*Saussurea subulisquama* Hand.-Mazz.	Compositae		+	
28	*Saxifraga brunonis Wall. ex Ser.*	Saxifragaceae		+	+
29	*Saxifraga* stenophylla Royle	Saxifragaceae		+	
30	*Valeriana pyrolifolia* Decne	Caprifoliaceae		+	

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TABLE 2: Plants found in surrounding areas of Gnathang outside from quadrates

SL.NO.	BOTANICAL NAME	FAMILY
1	*Aconitum ferox* Wall. ex Ser.	Ranunculaceae
2	*Bupleurum candollei* Wall. ex DC.	Apiaceae
3	*Caltha palustris* L.	Ranunculaceae
4	*Corydalis flaccida* Hook.f. & Thomson	Papaveraceae
5	*Cousinia pterocaulos* (C.A.Mey.) Rech.f.	Compositae
6	*Cyananthus lobatus* Wall. ex Benth.	Campanulaceae
7	*Geranium lambertii* Sweet	Geraniaceae
8	*Houttuynia cordata* Thunb.	Saururaceae
9	*Hypericum uralum* Buch.-Ham. ex D.Don	Hypericaceae
10	*Juncus thomsonii* Buchenau	Juncaceae
11	*Mahonia napaulensis* DC	Berberidaceae
12	*Morina nepalensis* D. Don	Caprifoliaceae
13	*Myricaria rosea* W.W. Sm.	Tamaricaceae
14	*Podophyllum sikkimense* R.Chatterjee & Mukerjee	Berberidaceae
15	*Potentilla lineata* Trevir.	Rosaceae
16	*Potentilla microphylla* D.Don	Rosaceae
17	*Potentilla microphylla* D.Don	Rosaceae
18	*Primula florindae* Kingdon-Ward	Primulaceae
19	*Primula kingii* Watt	Primulaceae
20	*Prunus rufa* Wall. ex Hook.f.*	Rosaceae
21	*Ranunculus flaccidus* Hook.f. & Thomson	Ranunculaceae
22	*Rubus paniculatus* Sm.*	Rosaceae
23	*Saxifraga sibirica* L.	Saxifragaceae
24	*Senna occidentalis* (L.) Link	Leguminosae

3. RESULTS AND DISCUSSION

At three HSPs all together 12 (3m × 3m quadrate) was formed; inside which total of 48 (1m ×1m quadrates) was formed see in figure 2, within 48 (1m ×1m quadrates) total number 30 plant species was found belonging to 12 families and 19 genera . At HSP1 total of 10 species was found inside quadrate . Ericaceae was abundantly grown followed by Saxifragaceae, and cupressaceae.

At HSP2 total of 20 species were found, primulaceae is abundantly found followed by Ericaceae and compositae this HSP is more diverse and plants are growing abundantly as compared to HSP1 and HSP2.

HSP3 total of 15 plants species were found inside quadrate, Polygonaceae was found highly in number inside quadrate following by ericaceae and cupressaceae.

Juniperus communis was fund at all the three HSPs, it was observe that this plant was found from altitude of 3707m to 4003m of three HSPs.

Beside that *Rhododendron niveum, Bergenia purpurascens, Primula tibetica, Primula denticulata, Primula sikkimensis* were found in HSP1 and HSP2.

Potentilla saundersiana, *Primula elliptica*, *Berberis buxifolia*, *Saussurea subulisquam* this plant species were found in both the HSP2 and HSP 3 some of lichens species like *Coadonia coccifera*, *Heterodermia hypoleuca*, *and everniastrum cirrhatum* were found, this makes three HSPs of gnathang very diverse.

Furthermore 24 plant species has been identified from in and around Gnathang valley . Which has been shown in table 2. total of 12 families has been identified. Some of them were first reported by R.S Rao in 1955 from valleys of Gnathang (BSI Sikkim herbarium of Tag no. 498 *Prunus rufa* Wall. ex Hook.f. collected by R.S Rao ,9/9/1955. * Tag no .1057 *Rubus paniculatus* Sm. Collected by R.S Rao 1955)

Some of above mention plants in Tables are been use by local people of Gnathang village as a medicinal for human as well as for cattle's to treat various ailments. Some of them are mentioned below:

Leave of *Abies densa* is used for Stomach ache and fever for humans. (Pradhan & Badola 2008)

Leaves and fruits of *Fragaria nubicola* is mixed with lukewarm water and is given to cattle to treat diarrhea and it's also used to get relief from External parasite (Pande et al. 2007)

Flowers and Leaves of *Rhododendron arboreum* is mixed with water and given to cattle's to treat dysentery and diarrhea. Leaves are used to eliminate external parasites from cattle's body (Tiwari & Pande 2006; Pande et al. 2007)

Arisaema costatum roots of this plant is used to treat stomach problems manly gastric in humans.

Leaves and twigs of *Rhododendron campanulatum* is mashed with leaves of *Nicotiana tabacum* and mixed with warm water is given to cattle to treat chronic fever (Pande et al. 2007)

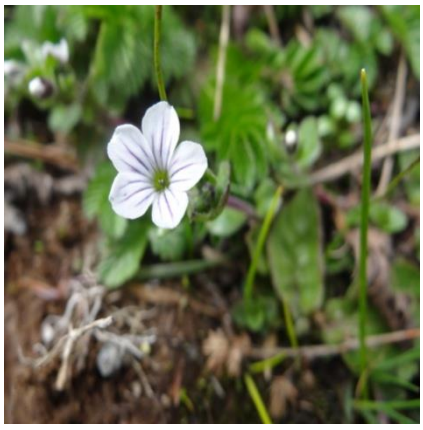
Aconitum ferox, is used for ailment such as skin diseases, Cough and fever (Ved et al. 2003)

Potentilla peduncularis

Primula calderiana

Rhododendron wallichii

Rhododendron fulgens



Geranium lambertii

Cousinia pterocaulos

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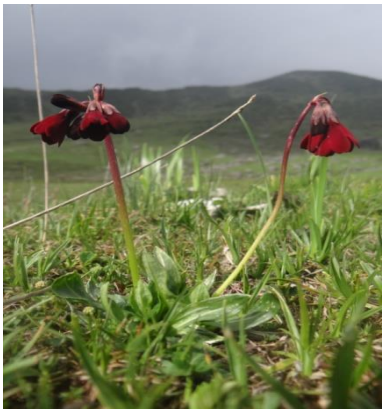
Euphorbia helioscopia

Ilovdia flavonutans



Primula kingii

Anemone rivularis

Anemone narcissiflora

Juncus thomsonii

Meconopsis bella and *Arisaema costatum*

Anaphalis triplinervis

Aconitum ferox

Picture: Plants found at mountains of Gnathang.

4. CONCLUSION

54 plants species has been documented in this paper From Gnathang, East Sikkim. This information will be father useful for the study of Climate change in this part of Himalaya; Climate change may lead to hostile environment, as plants growing in alpine areas are more sensitive to climate change. Which may result in extinction of some species. ,as well as lower elevation plant populations can moving to higher elevations, and may decreased version of endanger and endemic species Therefore the long term monitoring is must to see the effect and impact of climate change in alpine mountains. For this reason documentation is must to see the migration and to see deflection of plants for its natural habitat.

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