# A Study on the Traditional Knowledge and Population Status of Ethnomedicinal Plants in Uttarkashi District, Western Himalaya

**THESIS**
SUBMITTED TO THE
FOREST RESEARCH INSTITUTE (DEEMED) UNIVERSITY
DEHRA DUN, UTTARAKHAND

For
THE AWARD OF THE DEGREE OF
**DOCTOR OF PHILOSOPHY**
**IN FORESTRY**
**(FOREST BOTANY)**

By


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Chandrabani, Dehra Dun,
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**2014**

# DECLARATION

I hereby declare that the thesis entitled "**A Study on Traditional Knowledge and Population Status of Ethnomedicinal Plants in Uttarkashi District, Western Himalaya**" is original research conducted by me under the supervision of Dr. G. S. Rawat, Scientist 'G' of the Wildlife Institute of India. The thesis has been submitted to the Forest Research Institute (Deemed) University, Dehra Dun, for the award of the degree of **Doctor of Philosophy in Forestry (Forest Botany)**, and has not formed the basis for the award of any other degree. It embodies my own work and observations, and in that respect the investigation appears to advance knowledge on the subject.

Date: March 18, 2014

Place: WII, Dehra Dun

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Doctoral Candidate

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Supervisor

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**Scientist 'G'**
**Department of Habitat Ecology**

# CERTIFICATE

This is to certify that the thesis entitled "**A Study on Traditional Knowledge and Population Status of Ethnomedicinal Plants in Uttarkashi District, Western Himalaya**" submitted to Forest Research Institute (Deemed) University, Dehra Dun, for the award of the degree of **Doctor of Philosophy in Forestry (Forest Botany)**, is a record of bonafide research work carried out by **Shri Ninad B. Raut** under my guidance and supervision. No part of this thesis has been submitted for any other degree and it fulfills all the requirements laid down in the ordinance of Forest Research Institute (Deemed) University, Dehra Dun, for this purpose.

Date: March 18, 2014
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(Member outside the discipline)

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):- **Registration for Doctor of Philosophy Degree in Forestry.**

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In response to your application dated 22.08.2008 for enrolment as Research Scholar for the Degree of ctor of Philosophy in Forestry in this Institute, it is to inform you that the following decisions have been taken:-

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(As per clause 3.3 of the Ph.D. Ordinance)

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4. The Research Scholar may not later than eight months from the date of Registration, modify the scheme of the research work or nature or scope of the subject, on the recommendation of the Supervisor and RAC with the approval of Director.

5. **The research scholar should normally submit the thesis within 5 calendar years from the date of registration. Further extension of the term on yearly basis is possible only on specific recommendation of R.A.C., if approved by the R.D.C. However no extension is possible beyond 7 years of registration. The recommendation of Research Advisory Committee for extension of term of registration of the scholar should reach this office before expiry of term of registration.**

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Registrar
FRI University

**ncl:** 1. **Fee receipt No. 6497 dated 28.01.2009 for Rs. 16,000/-**
2. **Format of progress report**

**opy to:**

1. Dr. G.S. Rawat, Scientist-F, Department of Habitat Ecology, Wildlife Institute of India, P.O. Box-18, Chandrabani, Dehradun – 248 001 for information and necessary action.
2. Dr. V.B. Mathur, Dean & Head, Faculty of Wildlife Sciences, Wildlife Institute of India, P.O.Box-18, Chandrabani, Dehradun – 248 001 for information and necessary action.
3. Dr. K. Sankar, Professor & Nodal Officer, Wildlife Institute of India, P.O. Box-18, Chandrabani, Dehradun – 248 001 for information and necessary action.

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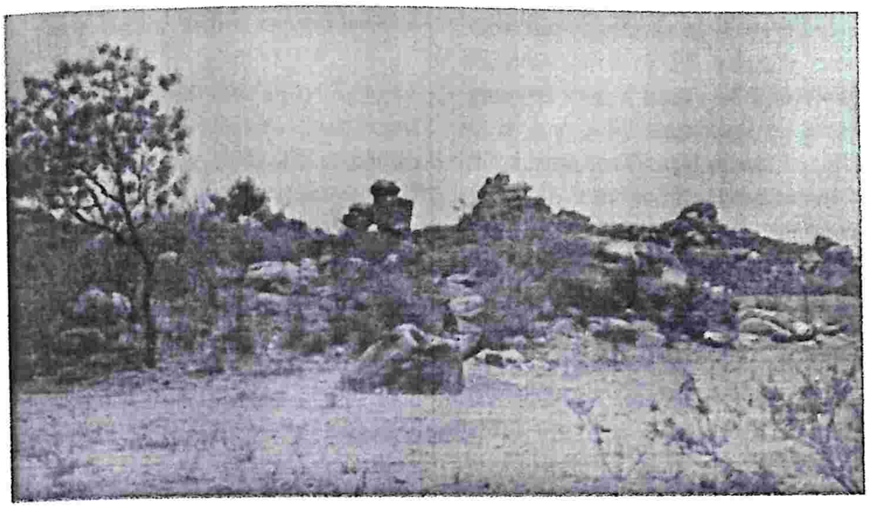

Figure 1. Reforestation site at Ramdurga village, Koppal district, North Karnataka.

of the forest will be monitored in terms of carbon stored in the forest using non-destructive methods, i.e. developing biomass tables with variables like diameter at breast height, basal area, tree height and wood density. The study is an attempt to quantify carbon pools (living biomass only, i.e. above ground and below ground biomass) from within the maturing forest over a period of 5 years as a role to play in our fight against global warming and climate change.

The study area comes under the North Dry Zone. The place experiences a semi-arid type of climate characterized by hot summers and low rainfall (about 52% of the annual rainfall is received during rabi season). It is cool and pleasant during major part of the year, except during the summer months of March to middle of June. The coldest period is December to January; minimum temperature reaches up to 16°C and maximum reaches 45°C during hot summer. The area is characterized by dryness for the major part of the year because of a less rainfall. The annual normal rainfall is 571.92 mm and normally rain commences from June and continues up to November. The area falls under the north median region of the state. The elevation is between 450 and 900 m. The area is characterized by a large stretch of barren plains covered with black soil, red soil in granites and grey granite areas. The total population of the district is 1,193,496, of which the rural population is 995,224, accounting for 83% of the total population. The district has 3,020 small and marginal industries, which (13%) are agriculture-allied units and are broadly agricultural based.

The reforestation programme aims to create a 'carbon sink' at the proposed site to improve the local biodiversity and also to offset/reduce carbon emission to achieve sustainability. The carbon quantification data will be useful to assess the trends of carbon balance in the region.

1. State of Forest Report, Forest Survey of India, 2011; www.fsi.nic.in

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# Depletion of traditional knowledge of medicinal plants

Traditional knowledge (TK) related to the use of natural resources including medicinal plants has been recognized as one of the important assets inherited through generations by the local communities[1]. Such knowledge is generally passed down to the next generation verbally, in the form of odes and poems. In the process of rapid modernization and advancement of medical sciences, partially documented or undocumented knowledge on ethnomedicine began to deplete drastically. Although several ethnobotanists and anthropologists have made attempts at documenting such knowledge in various parts of the world, several remote localities and indigenous communities have remained unnoticed. Traditional knowledge has now regained importance due to the discovery of new drugs and formulations from phytoresources[2,3]. It has been established that more than 80% of the people in the developing countries depend on traditional medicines for healthcare mainly due to their less side effects[3]. As a result, there has been a spurt in herbal industries. The pharmaceutical sector has to meet the ever-growing, excessive demand and this in turn has led to wild harvest of these resources, which may lead to rapid depletion of resource base. Contrary to the growing demand of medicinal plants all over the globe, TK on ethnomedicine is declining rapidly, especially in the developing countries[4].

The Himalayan region, well known for diversity and richness in medicinal plants, also harbours a large number of ethnic communities, each with distinct culture and TK system. Rapid pace of development and socio-economic transformations have led to erosion of natural resources and TK in the western Himalayan region. It is in this light that we undertook a study to assess the status of TK on medicinal plants by conducting a rapid survey on current knowledge on the use of medicinal plants among various ethnic groups in Uttarkashi district, Uttarakhand. Semi-structured interviews were used to know the extent of knowledge on medicinal plants passed from the older to the new generation. The survey was conducted in Bhagirathi, Upper Yamuna and Tons valleys, which represent agro-pastoral (Garhwalis), pastoral (Gujjars) and Jadhs (Bhotia) communities. A total of 861 persons living in 134 (of total 686) villages in the entire district were interviewed, covering different age groups.

The study revealed that only 31% of the population possesses traditional knowledge. However, 30% of them do not use medicinal plants for treatment of day-to-day ailments. Nearly 69% of the surveyed population was unacquainted about the use of these plants. Only 1% of the surveyed population practised TK to cure various diseases. The herbal practitioner charged a nominal fee or nothing for the treatment of diseases and this practice never formed part of their main income. Irrespective of gender, the age group of above 40 years was found to be the custodian of TK (84.93% male and 65.75% female) compared to the younger generation (15.04% male and 16.44% female). Out of 31% of TK-holder respondents, only 23% had taught the next generation about herbal remedies and only 8% of the new-generation (up to 20 years) respondents showed willingness to retain and use this knowledge.

This clearly proves that knowledge about medicinal plants in these regions is vanishing. Depletion of such an important source of knowledge is a big loss for a country like India. Documentation of the uses of haldi, neem and basmati in our classical traditional healthcare system (e.g. Ayurveda) and to a certain extent in traditional folklore has helped India retain patents of these plants. Thus, documentation of TK helps in protecting unconventional mode of knowledge and so it is equally important to conserve it along with medicinal plants. At the same time, the livelihood of traditional healers should be taken care of. As mentioned above, practising traditional healthcare was not a primary source of income; there was increasing ignorance about the whole healthcare system. Nearly 60% of the respondents mentioned that they do not have any interest in using herbal medicines, as it is painstaking to find, prepare and use such medicines, apart from restriction from government on wild harvest of some plants. About 15% of the respondents mentioned that availability of modern medical facilities plays a major role in depletion of TK, whereas 19% of the respondents pointed out the unavailability of medicinal plants in nearby forests.

Nowadays, rural life is changing into fast life of modern cities. This change is affecting the young generation and overall increasing willingness to use allopathic medicines over ethnomedicines for its faster effect. Though the respondents shared that the process of collection of medicinal plants is time consuming and tedious, it was observed that villagers were more interested in selling these medicinal plants instead of using them for self cure. But, this trade is more or less in the informal sector and so difficult to document.

Changes in agricultural practice were evident from the fact that locals preferred cash crops like soybean, rajma, potato and tomato over medicinal plants. Local needs and micro-socio-economic–environmental conditions of knowledge holders and of medicinal plants should be considered to formulate policies to conserve both traditional knowledge and the plants.


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# Religious taboo among the tribes of West Kameng – an excellent traditional system of conserving biodiversity

Conservation of natural resources by traditional societies across the globe seems to have arisen out of the age-old practice of animistic religious belief systems. Such belief systems are fundamental aspects of people's culture, which strongly conditions their use of natural resources[1]. Arunachal Pradesh, a biodiversity hotspot region in the eastern Himalayas, is a tribal-dominated state with 26 major tribes and 110 ethnically distinct sub-tribes[2], where more than 80% of the population is from the rural area and is directly or indirectly dependent on the surrounding forest resources for its livelihood[3]. Besides these, the forest is also an integral part of the local people, which fulfils their cultural and social needs. This reliance has created an indivisible bond between the ethnic communities of the state and the natural resources.

Monpa and Sherdukpen, two ethnic groups of the West Kameng District, have managed and conserved the biodiversity of their surrounding since time immemorial. Subsequently, they have developed their own folk culture, customs, beliefs, faith, tradition, taboos, etc. For them, conservation of biodiversity is not an isolated, compartmentalized concept, but an integrated part of their lives. These two tribal groups are not only familiar with the economically important plant species in their surrounding forest, but have also good knowledge of religious and cultural values of plant diversity. Many plants like *Gymnocladus assamicus*, *Rhododendron* spp, *Quarcus* spp, *Daphne papyracea*, *Thuja occidentalis*, *Manihot esculentum* and *Illicium griffithii* have been conserved in their natural habitats through their deep knowledge of beliefs, faith and taboos. They worship nature and consider many of the forest patches as sacred groves. Almost adjacent to all the villages of the Monpa and Sherdukpen tribes there is a sacred grove (Figure 1 *a*). These sacred groves vary in size from a few trees to dense forests covering vast tracts of land and have been protected by the tribes through generations. Each sacred grove is dedicated to local deities and nobody is permitted to cut plants or kill animals or any form of life. To protect these forests the ancestors of the two tribes have made specific sets of rules and regulations enshrined in religious or cultural beliefs and superstitions, and all

*Dedicated to my family*

## CONTENTS

# Acknowledgments

Some people say the acknowledgments might be the most read pages of a thesis. I am glad that in this way, I have the opportunity to express my gratitude to all people who have supported me in many ways not only while writing this thesis but also to reach this stage.

"If we knew what it was we were doing, it would not be called research" - Albert Einstein

Hence, I would like to acknowledge my supervisor, Dr. GS Rawat, who held my hand and helped in exploring the field of research when I joined Wildlife Institute of India (WII). His kind nature, soft spoken personality and immense knowledge were some aspects of his magnificent persona. Just a brief discussion with him on Himalaya and Ecology of Plants would open an encyclopedia for student like me. His nature of considering students have had help me in various time.

I am grateful to Ex-Director, Mr. PR Sinha and Dean, VB Mathur, of WII for encouragements and support. Without help and support provided by Research Coordinator & Nodal officer of FRI DU it was more than difficult to pursue research therefore Dr. K. Sankar is deeply acknowledged.
The Ph.D. was carried out while working in the collaborative project between Uttarakhand Forest Department (UKFD) and WII. Therefore, I would like to thank UKFD for funding this project. I express gratitude to both the Co-PIs, Dr. BS Adhikari (WII) and Dr. S Chandola (Director, Uttarakhand Forest Development Corporation (UFDC) for their valuable inputs during the project duration. Dr. Adhikari, had help by all possible ways even after project ended. His valuable comments and experience in working in Himalaya was of immense help. I am very grateful to him.

A vast geographic area of Uttarkashi district which comprises of three Forest divisions and 16 ranges is administered by UKFD. It might have been difficult to traverse this mountainous area without support and permission from UKFD. DFOs Sushanta Patnaik, I.P.Singh, G. Sonar, and all SDOs as well as RFOs are acknowledged for permitting me to enter their territory to carry out work. Without support of ground staff (Forester to Beat Guards and even Lathets), in many ways, it would have been difficult to reach out tops of mountains peak and by that covering larger area of the district. Their knowledge about local area and their willingness to work with us (in some occasions even on holidays) needs a big applause. Few people, indeed, need a special mention, Mr. Tamta (RFO, Taknaur), Mr. Negi (RFO, Gangotri Range), Mr. Buddhi Prasad Bahuguna (Forester, Badahat Range), Mr. Balbir Singh Panwar (Forestor, Dharasu Range), Mr. Narayan Singh and Mr. Bharat Sing (Lathets, Taknaur Range) who went out of box to make my work easy. I thank them all from bottom of my heart. People of Uttarkashi were very hospitable and not only fed me with food but with the knowledge they have about the medicinal plants, which is soul of the study.

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A very good friend and mentor at-times, Dr. Pankaj Kumar's guidance was monumental from the beginning of my WII career. Right from synopsis till the end of thesis his comments and suggestions has laid easier track to accomplish the task. Kausik da, like an elder brother, has encouraged, protected and took nice care during the most required phase of my life. His critical yet important comments and suggestions on the thesis draft have brought the required shape and soul to it. I owe big thanks to them. I am extremely thankful to Amit Kumar, Madhura, Moni and Daya for help provided in data entry and preparing herbarium whereas Kaustubh Bhagat for going through draft.

Importance of Statistics and GIS in research is very significant but was my weaknesses. So, even smallest help was of great use. I thanked Suthirtha, Ninad, Shivam, Tapojit, Swati, Parabita, Abhishek, Mousumi, Merwyn, Rupesh, Sabuj, Upamanyu da, Ambika and Nilanjana ma'am, Pragatish, for their help. Discussions with Drs. Gajendra, Amit Kotiya, Jeewan, Ishwari, Vinay, Umesh, Ms. Kunzes and Ms. Priyanka were valuable and need a special mention.

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"Sometimes the little things in life mean the most." — Ellen Hopkins

I thank organizers of the SCCS – Cambridge for selecting me to present my work at international dais and also for an additional workshop on designing social surveys. It helped me in streamlining the main objective of the study as well as interpreting data in very unique way. I oblige to mentor (of this workshop) Dr. Julia Jones (Bangor University, UK) who carefully listened to my study and gave important feedback.

PhD is not just the degree (for me) but a journey that changed my life (almost) completely. And this journey would not have been possible without help, support and encouragement received in pre-PhD phase. Behnaz Ma'am (who told us that if someone discourages you for being into Botany tell them that you study Plant Sciences and also supported me for many extracurricular activities which built the base of my research mind), Bhavana Ma'am (who taught TAXONOMY so well that I decided to complete master's in it), Sarangdhar Ma'am (A mother for many of her M.Sc. students, including me. She even helped me narrowing down my PhD topic), Almeida Sir, Suchandra Maám, Latoo Sir and Sushil Sir (for teaching taxonomy on field), Goldin Sir (The mentor & Colleague anyone would want to get associated with; he played a key role in my WII entry by preparing me for interview, by managing my leaves and also by scheduling my journey till Dehradun), Mr. Anand Pendharkar (WII alumni – who instilled WII-style research into my Mumbai University-style mind), Mr. Amar Deshpande and Mr. Amit Chavhan (for many suggestions during initial phase of my career). Drs. Punyashlok Bhaduri (IISER-Kolkata), Dharmendra

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*"We must find time to stop and thank the people who make a difference in our lives."*
*— John F. Kennedy*

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## List of tables, figures and plates

**LIST OF FIGURES**

**LIST OF PLATES**

**List of Abbreviations commonly used in the thesis**

| Abbreviation | Meaning / Full form |
|---|---|
| AD | Anno Domini |
| API | Active Pharmaceutical Ingredient |
| asl | Above sea level |
| BC | Before Christ |
| CBD | Convention on Biological Diversity |
| EH | Eastern Himalaya |
| EMPs | Ethnomedicinal Plants |
| EPO | European Patent Office |
| FD | Forest Division |
| FRLHT | Foundation for Revitalisation of Local Health Traditions |
| GLM | general linear model |
| IHR | Indian Himalayan Region |
| IISD | International Institute for Sustainable Development |
| IUCN | International Union for Conservation of Nature |
| LCHP | Locally Common and High Pressure |
| LCLP | Locally Common and Low Pressure |
| MAPs | Medicinal and Aromatic Plants |
| medfac | Medical Facilities at Village level |
| MNCs | Multi-National Companies |
| MPs | Medicinal Plants |
| MT | Metric Tonnes |
| RCI | Relative Cultural |

| Abbreviation | Meaning / Full form |
|---|---|
| | Importance or Indices |
| RDHP | Restricted Distribution with Heavy Pressure |
| RDLP | Restricted Distribution with Low Pressure |
| RME | Rapid Mapping Exercise |
| TK | Traditional Knowledge |
| TKDL | Traditional Knowledge Digital Library |
| TKH | Traditional Knowledge on Healthcare |
| TKS | Traditional Knowledge System |
| TMAPS | Threatened Medicinal and Aromatic Plant Species |
| UCLP | Under Cultivation with Low Pressure |
| UKFD | Uttarakhand State Forest Department |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| USPO | United States Patent Office |
| UVI | Use Value Indices |
| WDHP | Wide Distribution and High Pressure |
| WDLP | Wide Distribution and Low Pressure |
| WH | Western Himalaya |
| WIPO | World Intellectual Property Organization |

## List of technical / medical terms and their meaning

| Technical term | Meaning |
|---|---|
| Abortifacient | An agent that causes abortion |
| Alopecia | The partial or complete absence of hair from areas of the body where it normally grows |
| Alopecia areata | It is a condition in which hair is lost from some or all areas of the body, usually from the scalp |
| Anthelmintic | An agent that expels parasitic worms (helminthes) from the body |
| Antihemorrhagic agent | substance that promotes hemostasis (stops bleeding) |
| Astringent | An agent that tends to shrink or constrict body tissues in order to arrest secretion |
| Blunt trauma | a usually serious injury caused by a blunt object or collision with a blunt surface (as in a vehicle accident or fall from a building) locally *Ghum Chot* |
| Calcificant | An agent that induces mineralization of a soft tissues |
| Carminative | An agent used against cramps of the digestive tract |
| Cataract | An opacity which develops on the crystalline lens of the eye |
| colic | Severe, often fluctuating pain in the abdomen caused by intestinal gas or obstruction in the intestines and suffered esp. by babies |
| Conjunctivitis | Inflammation of the conjunctiva (the outermost layer of the eye or the inner surface of the eyelids |
| Contusion (or Bruise) | skin injury that results in a discoloration of the skin or blood to seep into the surrounding interstitial tissues |
| Coolant | use allows human body to cool down by way of metabolic adjustments |
| Diarrhoea | Frequent lose or liquid bowel movements |
| Dysentery | Inflammation of the mucus membrane and glands of the large intestine with mucous and bloody evacuation |
| Dysmenorrhoea | Painful menstruation |
| Dyspepsia | Disturbed digestion or indigestion |
| Dysuria | Painful urination |
| Eczema | Range of persistent skin conditions |
| Emmenogogue | An agent that promotes menstrual flow |
| Emulsifier | An agent which stabilizes an emulsion |
| Expectorant | An agent which increases the expulsion of tracheal or bronchial mucus through expectoration or coughing |
| Febrifuge | Herbal remedy with fever reducing effects or anti – pyretic |
| filarial | related to or infested with or transmitting parasitic worms especially filarial |
| Furuncle = boil | a painful circumscribed inflammation of the skin with a pus-filled inner core |

| | |
|---|---|
| Germicidal | An agent capable of destroying germs |
| Gonorrhoea | A common sexually transmitted disease caused by bacterial infection |
| Hemostasis / haemostasis | process which causes bleeding to stop |
| Hyperthermia | Elevation of core body temperature above the normal diurnal range of 36°C to 37.5°C due to failure of thermoregulation [Hyperthermia can be caused through sun exposure, exercise, and infection]. Hyperthermia is not synonymous with fever |
| Lactation | Lactation is the *medical term* for yielding of *milk* by the mammary glands which leads to breastfeeding |
| Lactogenic | Inducing lactation |
| Leucoderma | A chronic skin condition of the lower back |
| Leucorrhoea | White discharge from the female genitals |
| Nocturnal emission | Ejaculation of semen experienced by male during sleep |
| Opthalmia | Sever inflammation of the eyes |
| Otalgia | Ear pain |
| Pneumonia | An inflammatory disease of the lungs |
| Purgative | An agent taken to induce bowel movements (Syn. Laxative) |
| Rheumatic arthritis | A chronic inflammatory autoimmune disorder that attack the joints |
| Scabies | A transmissible ectoparasitic skin infection |
| Sciatica | An inflammation of the sciatic nerve on the posterior of the thigh |
| Spermicidal | An agent that kills sperms |
| Sprain | An injury of the ligaments caused by sudden overstretching |
| Stomatitis | An inflammation of the mucous lining of the mouth |
| Urogenital | Pertaining to the sex organs and the urinary tract |
| Vermifuge | A type of anthelmintic, an agent that expels parasitic worms from body stunning |
| Wart | A small, rough tumor or a solid blister of the skin caused by virus |

# EXECUTIVE SUMMARY

Traditional Knowledge (TK) is considered as one of the important components of the healthcare system. *Ayurveda*, an age old healthcare system in India, largely depends upon TK, especially when it comes to application part. Much of this practice has been verbally passed on from one generation to the next but a considerable knowledge remains undocumented and thus becomes vulnerable. In 2003, UNESCO recognized such traditional practices as inextricable components of culture, and therefore worthy of being protected and sustained. This was the primary reason to study TK in Uttarkashi District. To address this, a study was conducted from September 2008 to September 2013. Field work was done from September 2008 to December 2011, data entry and analysis was carried out till December 2012. There are in total six chapters in addition to Executive summary, References and annexures explaining the details of the work carried out during the study period. Chapter wise summaries are given below:

**Chapter 1** deals with the general introduction of the topic, history of the Traditional Knowledge (TK) on healthcare, review of literature and objectives of the study.

Traditional knowledge is valuable and helpful to the locals who depend on it in their day to day life. It is also to the modern pharmaceutical industries. It has gained recognition around the world due to rapidly growing demand for alternative and basic therapeutic uses of plants. EXIM Bank, in 1997, estimated the global market for herbal medicines (including aromatic plants) for *ca.* $60-62 billion per year which has been growing steadily at the rate between 5 and 15% per annum. India, especially Himalayan region serves as store house of ethnomedicinal plants (EMPs) with unique eco-climatic and geographic variation. Despite being the custodian of EMPs and rich cultures that inherited TK related to healthcare, it is feared that such knowledge is eroding rapidly. Habitat loss, unsustainable wild harvest, rapid urbanization and infrastructure development are some of the reasons that have led to depletion of EMPs and TK related to it. This is a major concern in case of Himalayan region. For example, in Garhwal Himalaya, there is rapid change in culture and healthcare system.

Keeping this in view, a study was initiated to assess the current status of TK on the use of EMPs for the curative purpose. Furthermore, it was important to know the population status of these EMPs in order to prioritize them for conservation. The study aims to suggest strategies for conservation and management of high value EMPs as well as a mechanism for formalizing protection of TK. Uttarkashi, one of the largest and culturally diverse districts of Uttarakhand, was therefore selected for this study. The Major objectives of the study are as follows.

1. To document the current state of traditional knowledge on ethnomedicinal plants among locals, along with their usage pattern in Uttarkashi district,
2. To investigate the population status of the high value ethnomedicinal plants in the district,
3. To study the habitat specificity and distribution of selected ethnomedicinal plants in the district,
4. To evolve strategies for conservation and management of high value ethnomedicinal plants

**Chapter 2** deals with the detailed description of study area i.e., Uttarkashi district that lies between 30° 27' 18" N and 31° 27' 42" N and 77° 48' 26" E and 79° 24' 00" E. The climate varies from sub-tropical (mild winter, hot summer) to temperate and alpine types. The altitude ranges from 800m above sea level (asl) to 7000m asl. The area above 5500m asl generally remain under snow for most part of the year. There are total 686 villages in the district. Most of the villages are located along river valleys *viz.,* Bhagirathi, Yamuna and Tons. Majority of the human population is Indo-Aryans (commonly called *Garhwalis*), whereas sparse population belongs to *Jadhs* (an ethnic Indo-Mongoloid) and *Gujjars* (transhumant pastoral community). The district harbours a wide range of vegetation types ranging from sub-tropical Euphorbia scrub to high alpine dry scrub and desert steppe. Nearly 39% of the geographical area falls under forest vegetation. Population status and habitat specificity of EMPs were studied in the reserved forest present in Uttarkashi district. There are three Forest Division (FD) *viz.*, Upper Yamuna FD, Uttarkashi FD and Tons FD, covering an area of 361000ha.

**Chapter 3** deals with the status of Traditional Knowledge related healthcare and the uses of ethnomedicinal plants (first objective).

The study area was stratified as **low altitudinal zone (LAZ;** 900m-1500m asl), **middle altitudinal zone (MAZ;** 1501m – 2000m asl) and **high altitudinal zone (HAZ;** 2001m – 2500m asl). These zones coincide with sub-tropical (upto 1500m asl), warm temperate (upto 2000m asl), and cool temperate zones (upto 2400m asl). Total 134 (20%) villages, *en route* to the forests, were surveyed for documenting the TK on EMPs covering 861 respondents. In addition to random survey, key informants (village head) and Snowball sampling (traditional healers) techniques were used to reach out to TK practitioners. 'Semi-structured interviews' were conducted to document status of TK.

The analysis revealed that only about 31% respondent possessed TK on therapeutic uses of EMPs and < 1% practice it (n=861). More respondents from age group 40-60 years (in case of male) and from age group 60-80 years (in case of female) had healthcare related TK ($\chi^2 = 40.9$; df = 3, $p < 0.01$). It was found that 64% *Jadhs* were TK holders who were aware of 15 EMPs to cure 19 ailments. On the other hand, only 30% among Garhwalis were found possessing TK who were aware of 99 EMPs to cure total 57 ailments. Villagers, who possessed TK, were more at higher altitudes (> 1800m) than at lower altitude.

The study reveals that only about 23% respondents (n=266) were found sharing TK with younger generations. Furthermore, only *ca.* 8% (n=60) of new generation, who received TK, were keen to use this knowledge. According to respondents, major cause for depletion of TK were: loss of interest (82%), TK has not been passed by older generation (29%), availability of modern medical facility (28%), depletion of EMPs (39%) and myth that revealing the TK leads to the loss of effectiveness of medicine (6%). When TK prevalence in a village was modeled as a binomial response against different covariates in general linear model (GLM), the results showed that TK was prevalent in high elevation and farther away from district head-quarter (**$r^2$ = 0.59)**.

The respondents revealed the uses of about 101 EMPs for curing 57 ailments. These EMPs belonged to 62 species of herbaceous plants, 25 species of trees and 14 species of shrubs. Root, rhizome and leaves were most useful parts, used in treatment. At present only 46 species of EMPs were found in use. Ethnomedicinal uses of EMPs are given in Annexure II along with information on their geographical distribution, habit and useful parts. A formula was generated from modifications of various literatures for calculating use value (UV) of species.

$$\mathbf{UV = RV + DV + PU + PV}, \text{ where,}$$

*RV = Response value; DV = Disease value; PU = no. of Parts used; PV = Part value*

Five EMPs, in each altitude zone, were selected based on the highest UV in that zone. Due to repeated occurrence of two EMPs, total 12 species were finalized as high use value EMPs in the district. Apart from being an important fuel-wood and fodder species in the hills, *Quercus leucotrichophora*, has also come out as one of the 12 high value EMPs. In some parts of Uttarkashi though it is used as medicinal plants the another reason of it occurring as high value EMP could be that there were no more important EMPs was referred by respondent. An important dilemma in ethno-medico-botanical studies is validation of the treatment. The repeated report of use of a plant against particular disease would be one indicator. But particular plant could be a part of secret formulation known only to a healer. Such a dilemma was encountered in Tons valley, where *Solanum anguivi* was found to be used as abortificient. But further study is required to confirm its use as abortificient.

**Chapter 4** deals with distribution, abundance and population status of 12 high valued EMPs. These are: *Aconitum heterophyllum, Dactylorhiza hatagirea, Geranium wallichianum, Picrorhiza kurrooa, Rheum australe, Senecio nudicaulis, Verbascum thapsus, Viola pilosa, Berberis aristata, Zanthoxylum armatum, Juglans regia, Quercus leucotrichophora.* A total of 135 transects (each 1km) were laid following Rapid Mapping Exercise (RME). Twenty sample plots were laid along each transect, at an interval of 50m. For sampling medicinal trees 10m circular plots ($314m^2$) were laid. A concentric 5m circular plot ($78.5m^2$), within the larger plot, for medicinal shrubs and on the outer boundary of smaller circle, four 1m X 1m quadrats were laid in cardinal direction to enumerate medicinal herbs. All together 2624 plots for trees and shrubs and 10496 for herbs were laid. Data on the availability of EMPs and their population status in an area was shown in terms of density ($Dm^{-2}$ for herbs and $Dha^{-1}$ for shrubs and trees) % frequency (F) and abundance across transects laid. Coefficient of

Variation (CV) was calculated for each transect location of every species and used as an index of dispersion of EMPs.

Block wise density and frequency of these species have been given (Tables 4.1 to 4.12). Abundance ranking (high and low) has been used for preparing distribution maps (Figures 4.2 to 4.13). Distribution of *Aconitum heterophyllum* was very sporadic and patchy in all eight transect locations (F = 4 to 25%). It was found maximum ($Dm^{-2}$ = 2.95 ± 7.18 SD; F = 20%) in Ganganani block (Taknaur Range, Uttarkashi FD). *Dactylorhiza hatagirea* was found in 11 transect locations and its maximum population ($Dm^{-2}$ = 3.15 ± 3.33 SD; F = 60%) was found in Suki block (Gangotri Range, Uttarkashi FD) where it was most frequent. *Geranium wallichianum* was contiguously distributed and frequent (F = 5 to 75%) at three transect locations out of 52 transect locations. The population was abundant ($Dm^{-2}$ = 23.15 ± 19.49 SD; F = 70%) at Harsil block (Gangotri Range). *Picrorhiza kurrooa* was found sporadically distributed at seven places but at all transect locations it was frequent near rocky surfaces. Maximum population ($Dm^{-2}$ = 6.65 ± 13.77 SD; F = 20%) was observed at Suki block (Gangotri Range, Uttarkashi FD). *Rheum australe* was found at only two sites, Harsil block ($Dm^{-2}$ = 0.60 ± 2.09 SD; F = 10%) and Suki block ($Dm^{-2}$ = 0.30 ± 0.98 SD; F = 10%) of Gangotri Range, where the distribution of the species was very patchy (F = 10%). Population of *Senecio nudicaulis* was sporadic at almost all transect locations out of 19 transect locations (F = 5 to 40%). Maximum population was found in Dilasur block ($Dm^{-2}$ = 3.60 ± 6.04 SD; F = 40%) Mukhem Range (Uttarkashi FD). *Verbascum thapsus* was sporadically distributed at all 16 locations of which Kukreda block (Devta Range, Tons FD) holds maximum population ($Dm^{-2}$ = 6.45±10.36 SD; F = 35%). *Viola pilosa* was found abundant and contiguously distributed in as many as 10 transect locations (F = 55 to 95%) out of 67 transect locations where it occurred. Maximum population ($Dm^{-2}$ = 25.85 ± 13.93 SD; F = 90%) was found at Dichli block (Dharasu Range, Uttarkashi FD). *Berberis aristata*, occurred in 17 transect locations but was found sporadically distributed at almost all locations. Maximum population ($Dha^{-1}$ = 311.82 ± 6.39 SD; F = 25%) was found in Ranukigad block (Dunda Range, Uttarkashi FD). *Zanthoxylum armatum* was seen sporadically growing on forest-village fringes with Molda block (Mugarsanti Range, Upper Yamuna FD) having maximum population ($Dha^{-1}$ = 127.28 ± 2.88 SD; F = 15%). *Juglans regia* was found maximum ($Dha^{-1}$ = 28.66 ± 1.37 SD; F = 35%) in Bhuki block (Taknaur

Range, Uttarkashi FD). At other 13 locations the distribution was patchy (F = 5 to 30%). *Quercus leucotrichophora* was found at 58 transect locations, with good population and contiguous distribution at almost 30 locations (F = 60 to 100%). It was found maximum ($Dha^{-1}$ = 366.24 ± 6.03 SD; F = 95%) in Godar block of Naugaon Range (Upper Yamuna FD).

This chapter summarized that global demand for EMPs like *A. heterophyllum*, *D. hatagirea*, *P. kurrooa* and *R. australe* have led to over exploitation of these species. But other EMPs (*Q. leucotrichophora, Z. armatum* and *B. aristata*) also faced the heavy pressure of demand due to their use in day to day life and cultural significance. Many attempts of the cultivation of these EMPs have been unsuccessful. Based on the findings from previous studies (by few authors) and present study highest and lowest density range of four alpine EMPs was also given in this chapter. It is realized that, *in situ* conservation is the most reliable and cost effective method. Thus, the information on occurrences of EMPs generated from this chapter could be utilized for further conservation planning for high value EMPs.

**Chapter 5** deals with habitat specificity of selected high value EMPs. The impact of various covariates, such as vegetation type, slope, aspect, elevation, ruggedness, human pressure (adjusted z score of original percent value), temperature and precipitation, on the presence and absence of EMPs in Uttarkashi district was studied.

The Hierarchical cluster analysis was conducted using PC-ORD (ver.4.34), to indicate how many different vegetation types existed within the survey area. Further, Indicator Species Analysis (ISA) was used to determine the optimal number of final groups. This data was used to understand the computing preferences of habitats by a species using Ivlev's index of electivity. Transects (plots) laid in alpine meadows were not included in this analysis due to absence of tree species in this area. The aspect classes were also analysed using Ivlev's Electivity Index. The index is defined as,

$$\text{Ivlev's Electivity Index } (E) = \frac{U_i - A_i}{U_i + A_i}$$

Where, ***E*** is the measure of electivity, ***Ui*** the percent (or proportion) of occurrence (no. of plots) of species ***i*** to all occurrences of that species in all habitats in sampled area (it's percent value) and ***Ai*** the percent (or proportion) of all sampled plots within a particular habitat to all sampled plots in sampled area (it's percent value).

Each EMP species was considered as a sample for this analysis. A standard statistical method (Chi-square test) was performed to determine the strength of the selection of habitat and aspect. The Hierarchical Cluster analysis segregated five clusters of vegetation types. Including alpine meadows and lower sub-tropical miscellaneous forested area, total vegetation types in the study area becomes seven.
Descriptive analysis was conducted using SPSS (ver.19.0) to study the range of habitat characters (elevation, ruggedness, human pressure, mean annual temperature and annual precipitation) favoured by species within its distribution area.

Plants respond to the harsh alpine environment with a high degree of specialization. Therefore, study on micro-habitat preference by four alpine EMPs, which are commercially important also, was carried out. Various vegetation types present within study area were considered for the analysis [e.g., Tall Forbs (TF), mixed herbaceous formations (MHF), matted shrubs (MS), *Danthonia* grasslands (DG), *Kobresia* sedge meadow (KSM), Cushionoid vegetation (CNV) and treeline gaps (TLG)]. A chi-square test was performed to test the significance of the difference between micro-habitats where these EMPs occurred. Mann-Whitney U test was also performed using R (ver. 3.0.0) to see the selection of slope and aspect by alpine EMPs.

The results of the study indicated that distribution of *Q. leucotrichophora, G. wallichianum, V. pilosa* and *B. aristata* were less likely to restrict by any covariate used in the study and these were found widely distributed in the study area. *J. regia* is distributed in temperate forests dominated by broadleaf as well as coniferous species. *A. heterophyllum, D. hatagirea, P. kurrooa* and *R. australe* was found in sub-alpine to alpine areas around 3500m asl. *G. wallichianum* showed wide preference for habitat types. *A. heterophyllum* was restricted between southeast to southwest aspect. *D. hatagirea* was restricted to east to southwest aspects. *G. wallichianum* was restricted to southeast and northwest aspects. *P. kurrooa* was restricted on south to west aspects, but was more frequent on southwest aspect. *R. australe* was restricted to southeast to south aspects. *V. thapsus* was restricted between southeast to west aspects. *B. aristata* was restricted to northeast to east aspect whereas *Z. armatum* was restricted to east, southwest and west aspects. *V. pilosa, Q. leucotrichophora* and *J. regia* were not restricted to any particular aspect. *P. kurrooa* was restricted to undulating terrain as evident from high degree of ruggedness through the descriptive analysis. According to analysis, *P. kurrooa* was found most vulnerable to human activities, followed by *D. hatagirea, R. australe, Z. armatum* and *A. heterophyllum.*

Analysis of micro-habitat preference by alpine EMPs (*viz., A. heterophyllum, D. hatagirea, P. kurrooa* and *R. australe*) revealed that *A. heterophyllum* and *P. kurrooa* show positive and significant response to slope. Only *P. kurrooa* (presence and absence locations) showed significant difference with aspect. *A. heterophyllum* and *D. hatagirea* occurred in six types of habitats whereas *P. kurrooa* occurred in five habitats. *R. australe* occurred in only two types of habitat. This occurrence was found significant ($\chi^2 = 175.29$/ Df = 6; $p < 0.000$).

**Chapter 6** gives general synthesis and conclusions based on the current status of traditional knowledge on the use of EMPs for curative purpose among local communities (Chapter 3), area specific population status and distribution of EMPs (Chapter 4), and habitat specificity (Chapter 5). This chapter, along with strategies for conservation and management of high value EMPs, also aims to suggest a mechanism for formalizing protection of TK.

The major strategies include:

1. **Identification of local traditional healers and *Vaidyas*** within various ethnic communities, who can play a major roie in conservation, management and awareness generation about depletion of EMPs and TK related to it. The idea follows one of the Aichi targets (target#18). The healers and *vaidyas* should be given an opportunity to register themselves with the authority and Forest Department can issue identity cards to them in conjunction with the health department. Involvement of local community through access and benefit sharing (ABS) would help in conservation efforts. *Vaidyas*' knowledge and help could be taken in cultivation of EMPs as well as developing mechanism for sustainable harvesting practices.

2. For the purpose of effective management and sustainable use of MAPs, through ABS, **the existing *Van Panchayats* can be given additional responsibilities and re-**

**designated as Biodiversity Management Committees (BMCs)** for which provision exists in Biodiversity Act (2002). In this, stake holders (*Vaidyas*, Local traditional healers and villagers) would become committee member by forming a user groups. Major portion of the revenue collected would go to user groups whereas a small portion of it should go to Forest Department, for the conservation purposes.

3. Strategic goal (C, target 11) of Aichi Biodiversity Targets emphasizes on conserving habitat that are important in terms of biodiversity and ecosystem services. On this line, a total of **twelve blocks have been identified as rich in terms of availability of high value EMPs as well as other EMPs.** Of these, six blocks are identified as potential medicinal plants conservation area (MPCA) based on the diversity and population status of high value EMPs. The remaining six blocks can be considered for establishing Medicinal plant development area (MPDA). The detailed descriptions of the sites along with strategies of managements have been given in the thesis.

4. **Specific *in situ* conservation of highly threatened MAPs** which are specific to one or two habitat types (*viz., D. hatagirea*) should be carried out on priority basis. Habitat specificity (chapter 5) along with population status (chapter 4) of these EMPs has been given and can be utilized for their *in situ* conservation.

In general, the information generated from the present study about current status of traditional knowledge, prioritization of EMPs, the area specific population status and habitat preferences of EMPs and strategies for protection of EMPs as well as TK would be helpful in developing long term plan for conservation and management of EMPs in the hilly district of Uttarakhand, Western Himalaya.

# Chapter 1: General Introduction

# 1.0 GENERAL INTRODUCTION

## 1.1 Background

The Himalayan region represents one of the most complex and diverse ecosystems due to tremendous variation in eco-climatic conditions, topography and habitat types (Singh 2006). This region is recognized as one of the global biodiversity hotspots that provides numerous ecosystem goods and services to mankind both within and outside the region (Samal *et al.* 2003; Diaz and Duffy 2010). The wide range of ecosystems services provided includes provisioning (e.g. food, fibre, freshwater, timber, fuel and medicines), regulating (e.g. climate change and floods), cultural (e.g. recreational and aesthetic) and supporting (e.g. soil formation), which are critical to human well-being including human health, livelihoods, nutritious food, security and social cohesion (de Groot *et al.* 2002; SCBD 2009). A large number of ethnic groups which are dependent on these goods and services have been evolved with its unique socio-cultural traditions (Kollmair *et al.* 2005). People living in different agro-climatic zones have, by trial and error, or by experimentations and empirical reasoning, selected and made use of plants and animals around them to meet their day to day requirements of life (Robinson 2007). Apart from the natural resources, bio–geo–cultural diversity has fostered the creation of vast ethnomedicinal knowledge systems especially highly developed in relation to human health (Unnikrishnan and Suneetha 2012).

Traditional Knowledge (TK) related to human healthcare has been strewn and reached us mainly by two ways: i. Classical healthcare system (which is documented and literature is available), and ii. Traditional knowledge which is (undocumented as it is) orally transmitted from one generation to other (Pushpangadan 2002; Robinson 2007).

## 1.2 Historical Perspective

The oldest available record on use of plants goes back to Paleolithic era. The archaeological evidences indicate that humans were using plants during the Paleolithic era (approximately 60,000 years ago). In Shanidar (Northern Iraq), existence of flower fossils were found near one of the burial of Neanderthal man (Leroi-Gourhan 1975). Interestingly, seven out of the eight flower species which were identified from the fossils are still found in Iraq and locals use them for their herbal and medicinal properties (Al-Rawi and Chakravarty 1964; Solecki 1975). Evidences of considerable disturbance of the grave by rodents were found later on, which is attributed to the presence of the pollen near the burial in Shanidar (Solecki 1977). Therefore, it is difficult to say that Neanderthal man was using those plants for their medicinal properties. Yet this place is considered to be the oldest archaeological site were walnuts were unearthed (Malhotra 2008). But around 6000 years ago, in Indian subcontinent, a medical system existed which is known to everyone till date, as Ayurveda, which means 'Science of life' (*Ayush* = life; *Vedas* = Science) (Fritts *et al.* 2008). Based on Ayurveda three major treaties *viz.* Charak Samhita (900 BC.), Sushrut Samhita (600 BC.) and Ashtang Hriday (500 AD) came into existence. It was believed that the knowledge of Ayurveda was given by god (Trawick 1992). Ayurveda had nurtured almost all the medical systems of the world. It was respected in neighboring countries so much that it was translated into Greek (300 BC), Tibetan and Chinese (300 AD), Persian and Arabic (700 AD) and several other Asian languages, even though these culture had their own *Materia Medica* (Mukherjee 2001; Begde 2008). The oldest and most comprehensive Chinese work about herbal drugs the *'Yellow Emperor's Internal Classic'* was dated 300 BC (Samuel 2010). Ancient Egyptian texts known as Egyptian medical papyri or *'Papyri'* had a glimpse of medical procedures and practices in ancient Egypt. For example, Kahun Gynecological Papyrus, Edwin Smith Papyrus and the Ebers Papyrus, of which Kahun Gynecological Papyrus was written in *ca.* 1800 BC and is the oldest known medical text founded by Flinders Petrie in 1889 whereas Edwin Smith Papyrus dates back to 1600 BC (ESI 2002; Dollinger 2002; Samuel 2010). In European countries, ethnobotany started from the Roman and Greek cultures, and the herbal medicine of ancient Greece laid the foundations of Western medicine (Colombo *et al.* 2011). Theophrastus (*ca.* 370 – 285 BC), described uses of plants and established generic names of economically important species such as *Crataegus, Daucus,* and *Asparagus* that are still in use (Stearn 1958; Balint *et al.* 2006). The botanical documentation in general made during the middle ages (AD 1000-1500) was meager (Samuel 2010). But around 1500 AD, in medieval Europe, Paracelsus von Hohenheim (1493–1541) expanded an older Christian European idea as the Doctrine of Signatures which stated that God provided clues about the medicinal value of a plant in their general form i.e. God's signature (Keightley 1925; Pearce 2008). Thus, walnuts were thought to be good 'brain food' and bloodroot good for circulatory problems. The mottled leaves of lungwort (*Pulmonaria officinalis*) were thought to resemble lung tissue and the plants are still used to treat ailments of respiratory tract (CNR 2008). Plants with potent odors and strong tastes are employed in medicine and ritual (Lai and Roy 2004; Tapsell *et al.* 2006). These sensory cures are correlated with the presence of bioactive compounds. It is no coincidence that herbs and spices possess antimicrobial activity (Billing and Sherman 1998; Sherman and Billing 1999). The use of herbs and spices in cuisine developed in part, as a response to the threat of food-borne pathogens (Billing and Sherman 1998). Thus, the practical interests in ethnobotany go back to the beginning of civilization when people relied on plants for survival (Colombo *et al.* 2012).

Many scientists disregard the idea of 'Doctrine of Signature' because most signatures were post hoc appellations rather than a *priori clues*, though many traditional healers still accept it (Bennett 2007). Due to several reasons such as invasion, trade relations etc. many communities modified available information on healthcare practices (Begde 2008). Such modification were constantly being revised as per communities' requirement but remained undocumented though passed on to next generation through stories, odes etc. Gradually the necessity was visualized to document the knowledge that many cultures inherited. In India, Garcia da Orta (1563) published a book '*Coloquios dos simples e drogas e cusas medicinas da India'* which gives an account of 50 Medicinal Plants (MPs) and their utilities gathered around Goa and Malabar (Schutz 2009). It is written in the form a dialogue between the author and Spanish fictitious Doctor Rauno (Patil 2012). Powers (1874) coined the term 'aboriginal botany' for the study of plant use among traditional societies, which elucidated the total aboriginal dependence on plants for food and medicine. Later on, the term 'ethnobotany' was first used by a botanist - John W. Harshberger in 1895. He studied 'plants used by primitive and aboriginal people' (Harshberger 1896). Ethnobotanical study was escalated during 1980's and the subject became multidisciplinary (Cotton 1996). The concept of Ethnobotany has widen from time to time evolving in the process into a truly interdisciplinary science amalgamating anthropology, archaeology, botany, ecology, economics, medicine, linguistics and other disciplines (Cotton 1996; Maheshwari 1996). The discipline, therefore, gained serious attention and its focus shifted from 'man' to 'human' to people and from 'aboriginal' to 'primitive' to 'traditional' (Balick and Cox 1996; Cotton 1996; Abbasi *et al.* 2012)

## 1.3 Classical Healthcare Systems in India

The knowledge on the curative value of plants is as old as the human race itself. However, an organized beginning may be attributed to Ayurveda, with over 5000 years' old history (Samuel 2010). The earliest mention of medicinal use of plants in Hindu scriptures is recorded in Rigveda, an oldest repository of human knowledge, written between 4500 and 1600 BC (Chopra and Handa 1961; Jaggy 1973). The references to herbal plants in Rigveda are very brief, but more details are given in the Atharvaveda. Ayurveda is said to be a part of (*Upaveda*) of Atharvaveda. After the Vedas there is no other documented information on the development of herbal curative science till 1,000 BC. Subsequently, the classic works of Charaka and Sushruta described the drug treatment system prevailing at that time (Jaggy 1973). Approximately around 1500 BC, Ayurveda was delineated into two distinct schools: Atreya - The School of Physicians and Dhanvantari - The School of Surgeons (Begde 2008). Roughly 500 years later, by revising and supplementing the text written by Atreya, the great sage - physician Charaka authored Charaka Samhita in 900 BC which describes 341 plants and plant products for use in medicine (Sharma 1981; Mukherjee 2001). Sushruta who was follower of the Dhanvantari School of thought authored Sushruta Samhita in 600 BC which describes 395 formulations comprising the knowledge about prosthetic surgery to replace limbs, cosmetic surgery, caesarian operations and even brain surgery (Mukherjee 2001; Begde 2008). Of these 395 formulations, 57 drugs are of animal origin, 64 minerals and rest are of plant origin (Majumdar 1971, Krishnamurthy 1991). In *ca.* 500 AD, Vagbhatt compiled knowledge from both the schools of Ayurveda in his Astanga Hridaya which was considered to be third major treatise on Ayurveda (Begde 2008). In South Asia, in addition to Ayurveda there are several other healthcare systems such as Unani, Siddha, Chinese, Amchi and Homeopathy are practiced, which make use of about 9000 plant species (WHO 2002). In India alone, about 2000 plant species are used in the classical healthcare system: Ayurveda (900 species), Siddha (800), Unani (700) and Amchi (300) (Pushpangadan 2002).

### 1.4 Traditional Knowledge on use of Bioresources

Convention on Biological Diversity (CBD), in its Article 8(j) describes traditional knowledge (TK) as:

*'The knowledge, innovations and practices of indigenous and local communities around the world, developed from experience gained over the centuries and adapted to the local culture and environment'.*

It is transmitted orally from one generation to other. It tends to be collectively owned and takes the form various verbal and nonverbal forms of communications like stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds. It is mainly of a practical nature, particularly in fields such as agriculture, fisheries, health, horticulture, and forestry (WIPO 2008; IISD 2011). In other words, TK encompass the sophisticated array of information, understandings and interpretations that guide human societies around the globe in their innumerable interactions with the natural environment (Nakashima *et al.* 2000).

### 1.5 Traditional Knowledge on Healthcare

'Ethnomedicine' is a branch of ethnobotany that deals with the study of traditional medicines, not only of those that have relevant written sources but also of those, whose knowledge and practices have been verbally transmitted over the centuries (WHO 2002). Hughes (1968) coined the term **'ethnomedicine'** to denote the medical beliefs and practices found in primitive and folk societies. He refers ethnomedicine as *"those beliefs and practices relating to disease which are the products of indigenous cultural development and are not explicitly derived from the conceptual framework of modern medicine"*.

Whereas according to Foster and Anderson (1978), "ethnomedicine denotes the totality of health knowledge, values, beliefs, skills and practices of indigenous people, including all the clinical and non-clinical activities that relate to their health needs".

It is a fact that TK holders are incredibly diverse and the knowledge is not a static wisdom, so it may not be possible to have a single definition of the term also due to its dynamic nature (Berks 1993; Dutfield 2001; Schuh 2005; Jain 2005). TK has been referred as 'traditional ecological knowledge' or 'indigenous or local knowledge' by many (Nakashima *et al.* 2000). Each of this term carries different implications, and there is an ensuing discussion about which one is the most appropriate. For example, the word 'traditional' emphasizes on the transmission of knowledge along a cultural continuity, but might ignore the ability of traditional societies to adapt to changing circumstances whereas, 'indigenous' is meant to highlight the autochthonous nature of this knowledge but it might overlook knowledge from populations who are not officially recognized as indigenous. The word 'local' can be applied to different geographic contexts, but it lacks specificity (Mazzocchi 2006). However, use of the word 'traditional' is viewed by some (e.g., Stevenson 1996, 1999) as not empowering to people because it may be perceived as referring to a distant past, without illustrating the dynamic aspect of that knowledge and its current relevance (Houde 2007). Whereas, the term 'traditional knowledge' is deemed more appropriate because it shows the ancient roots to 'much of this knowledge' and this knowledge is transmitted from one generation to the next without proper documentation (Hobson 1992; Nickels 1999; Castellano 2000). Mugabe (1999) states that indigenous people, communities and nations may be holders of traditional knowledge, but not all traditional knowledge holders are necessarily indigenous, which sounds legitimate. Therefore, depending upon the study requirements, researchers use the word 'indigenous' specifically to denote if it is 'unique to a particular community or ethnic group' (Warren and Pinkston 1998) or 'traditional' to describe the knowledge associated with the locals of the study region (Gervais 2005) whereas, term 'ethno-medicinal plants (EMPs)' is used to notify the plants used by communities for traditional healthcare practices (Jain 2004).

## 1.6 Review of Literature

### 1.6.1 Significance of Traditional Knowledge as a discipline

The significance of TK on the use of bio-resources for conservation of biodiversity and sustainable development was recognized internationally during 1980's (Gadgil *et al.* 1993; Nakashima *et al.* 2000; Mazzocchi 2006). During the same period TK started gaining the acknowledgement as science (Hobson 1992). Article 8 (j) of CBD gave additional and required support to the conservation of TK (www.cbd.int). Later, in 2003, in the Convention, for Safeguarding Intangible Cultural Heritage by UNESCO, it was stated that knowledge and practices concerning nature and the universe are part of our cultural heritage. This means that ethnobotany, ethnobiology, traditional environmental knowledge, ethnoveterinary, folk medical and pharmaceutical knowledge are now recognized as inextricable components of culture, and therefore worthy of being protected and sustained. The Convention's statement also represents an important shift in the political approach to scientific research concerning ethnobiology and traditional knowledge, which in ethnobotany represent the focus or the starting point of a lot of research and analysis (Colombo *et al.* 2012). Even before getting recognition as science, TK was considered important as western science profited from the appropriation of traditional taxonomic and ecological understandings, with little acknowledgment of their intellectual origins (Nakashima *et al.* 2000). This knowledge is valuable and helpful, even today, not only to those who depend on it in their daily lives, but to the modern industries and agriculture as well. It has also gained recognition around the world due to rapidly growing demand for alternative and basic therapeutic uses of plants (Labadie 1986; Lee 1999). The reasons for such a rapid growth are potential discovery of new drugs, new formulations and wider socio-economic implications (Alves and Rosa 2007). The history of medicine reveals that most of the early discoveries resulted from serendipity or folklore approaches, often involving poisonous sources and not really from traditional medicines (Patwardhan and Mashelkar 2009). It is estimated that over 100 new natural product-based leads are in clinical development (Harvey 2008). About 60% of anticancer and 75% of anti-infective drugs approved from 1981 to 2002 could be traced to natural origins (Rao *et al.* 2004; Gupta *et al.* 2005). Even today, more than 80% of the people in the developing countries depend on the traditional medicines for primary healthcare (IUCN 1993). India ranks second in the world in terms of use of traditional MPs after Chile. Nearly 65% of India's population in the rural areas uses Ayurveda and folk medicines to meet their primary healthcare need (WHO 2003; Pattanaik and Reddy 2008). The percentage of population which uses traditional medicines in other countries ranges from 40% in China to 71% in Chile whereas in the developed countries, such as Canada (70%), France (49%), Australia (48%), United States of America (42%) and Belgium (31%), a significant proportion of population uses traditional, complementary and alternative medicines (WHO 2002). Such an enormous utilization had increase the demand of medicinal and aromatic plants (MAPs). This quantum jump in volume of plant material traded within and across the countries has set new records. Therefore, study and implementation of TK on the cultivation and trade of MPs is also essential to improve the economy of local people (Jain 1991; Rao and Prasad 1995; Tripathi 1995).

### 1.6.2 Economics of the herbal medicines

The global market for herbal medicines (including aromatic plants), as per estimation by EXIM Bank in 1997 was to the tune of $60-62 billion per year which has been growing steadily at the rate between 5 and 15% per annum (Planning Commission 2000; Nagpal and Karki 2004; Subrat 2005). This market is expected to grow to $5 trillion by year 2050 (Joshi *et al.* 2004). But Joy *et al.* (1998) estimated that world market for plant derived drugs might have accounted for about $36.9 billion (Rs.2,00,000 crores) at the same time, India's contribution was less than $0.369 billion (Rs.2,000 crores), which was just a 1%. The Indian medicinal plants-based industry is growing at the rate of 7-15% annually. Currently, the value of MAPs-related trade in India is estimated at $0.92 billion (Rs. 5,000 crores) per annum whereas the pharmaceutical industry's turnover of $2.68 billion (Rs. 14,500 crores) with a growth rate of 15 percent (Sharma *et al.* 2008). In India, classical healthcare system, e.g. Ayurveda, contributes $0.813 billion (Rs. 3,500 crores) annually to the internal market (Joshi *et al.* 2004). The domestic pharmaceutical market in India is worth approximately $4.3 billion (Grace 2004), 75% of which is supplied by Indian firms and the remainder by MNCs (Goldman Sachs 2004). India is way behind as compared to China as, in 2002, China's domestic market was worth approximately $6.1 billion, and was expected to reach $10 billion by 2005 with growth rate of 18% per annum (Grace 2004). This makes China the world's tenth largest market, ranking just after Canada and Mexico (Morgan 2004). The annual demand, in 2001, for raw materials of MAPs in India, was around 24 million metric tons (MT), which was increasing at the rate of 20% per annum (Karki 2001). With overall production of $7.3 billion (finished product's domestic consumption, plus exports), Indian firms produce approximately 1.5% of the global pharmaceutical market of $480 billion. However, this small share, in value terms, belies the importance of the Indian industry in volume terms, estimated at more than 20% of global consumption (Goldman Sachs 2004). The large difference between value and volume comes about due to the segment Indian companies serve – the high-volume, low-priced segment. The fact that Indian firms serve developing country markets is also evident from export statistics; in 2003, 40% of Indian finished products, by value, were exported and 60% of Active Pharmaceutical Ingredient (API), by value, was exported; Of total, 44% of the combined API and finished product exports, by value, went to highly regulated markets (e.g. USA, Europe, Japan and Australia) leaving the other 56% to 'less regulated' markets, a category which applies to all developing countries (Grace 2004). **Table 1.1** show similar results where India ranked 2nd in export countries but net value of that export material is not that high when compared with many other countries.

Therefore, such voluminous demand generates concern over the wild resource that India have. However, if India manages to streamline the conservation (and thereby production) of MAPs, the profit will increase. It is also important to consider that the export of raw material should be converted in to the fine product export so as to increase the net value of income. At a same time, conservation of locally important EMPs, which may not have very high market value, was visualize as urgent need by few, for example, Dalal (1996).

**Table 1.1: The 12 leading countries which export of medicinal and aromatic plant and value of the exported volumes**

| Country | Volume (Export) [in Tonnes] | Value [in 1,000 $] |
|---|---|---|
| China | 1,39,750 | 2,98,650 |
| **India** | **36,750** | **57,400** |
| Germany | 15,050 | 72,400 |
| USA | 11,950 | 1,14,450 |
| Chile | 11,850 | 29,100 |
| Egypt | 11,350 | 13,700 |
| Singapore | 11,250 | 59,850 |
| Mexico | 10,600 | 10,050 |
| Bulgaria | 10,150 | 14,850 |
| Pakistan | 8,100 | 5,300 |
| Albania | 7,350 | 14,050 |
| Morocco | 7,250 | 13,200 |
| **Total** | **2,81,550** | **6,43,200** |

Original Source: UNCTAD COMTRADE database, United Nations Statistics Division, New York (Lange 2002); adapted from Schippmann *et al.* 2002.

### 1.6.3 Global estimation of medicinal plants

Medicinal plants (MPs) are plants containing inherent active ingredients used to cure disease or relieve pain (Okigbo *et al.* 2008). There is no reliable figure for the total number of MPs on Earth and numbers as well as percentages for countries and regions vary greatly

(Schippmann *et al.* 2002). Different estimates about number of MPs used in traditional and modern medicinal systems are globally 35,000 to 70,000 MPs (Farnsworth and Soejarto 1991, Bhattarai and Karki 2004) or 53,000 (Schippmann *et al.* 2002, 2006). Of which about 3,000 are traded internationally (Lange and Schippmann 1997). In China 10,000 – 11,250 MPs are used (He and Gu 1997, Xiao and Yong 1998, Pei 2002). It is estimated that India has about 17,560 species of vascular plants, of which around 7,000 to 8,000 species are used as MPs (Pushpangadan 1995, 2002; Shiva 1996; Samant *et al.* 1998).

In India, only around 2,000 MPs are researched well to say that they are frequently used and traded as MPs and only about 500 plants are used in various herbal drugs by pharmaceutical companies (Jain 1994; Pushpangadan 2002). Two-third, of the total estimated MPs, are still harvested either from the wild. It is estimated that the wild collection ranges from 80 % in countries like China where focus has been shifted on cultivation, to near total wild collection in countries like South Africa (Hamilton 2004). Due to which globally, *ca.* 15,000 species may have been put under IUCN's endangered criteria (Vorhies 2000; Schippmann *et al.* 2002, 2006; Hamilton 2004). In India also over 90% of the traded MPs are harvested from wild, most of them in an unsustainable manner (Uniyal *et al.* 2000; Rawat 2005).
Habitat fragmentation occurs when previously connected habitat splits due to human developments such as urban areas, agricultural fields, logging and roads (Glennon and Kestor 2005; Thapa 2010). Owing to increasing demand for MPs, loss and fragmentation of natural habitats, it is feared that 15-20% of the total vascular flora of India (around 3000 species) may fall under one of the threatened, rare, or endangered categories of IUCN (Holley and Cherla 1998).

### 1.6.4 Studies on ethnomedicinal plants in India

An organized study of ethnobotany in India was started by Atkinson (1882). He published 12 volumes of Gazetteer of Northwest provinces of India. Research in ethnomedicine gained momentum in the years that followed and many monumental works came out as a result. Indian Materia Medica (Nadkarni 1954), System of medicine practiced by *Santals* (Bodding 1925, 1927), Indian Medicinal Plants (Kirtikar and Basu 1933), Glossary of Indian Medicinal Plants (Chopra *et al.* 1956), Dictionary of Indian Folk Medicine and Ethnobotany (Jain 1991), Notable Plants in Ethnomedicine of India (Jain *et al.* 1991) are to name a few. Growth and development, during the end of 20th century and during beginning of 21st century, of ethnobotany in India owes much to the works done by many eminent scientists on different aspects of ethnobotany such as, Borthakur (1981, 1992, 1993, 1996, 2003); Jain (1991, 1994, 2005); Jain *et al.* 1991; Jain and Saklani 1991; Pushpangadan and Atal (1984, 1986) and Pushpangadan (1984, 1994, 1995). Research was also carried out on ethnopharmacology in India and its future perspective based on Indian knowledge systems. The approach and quantity of the ethnobotanical work has been changed and increased dramatically in the last two decades mainly due to threats to biodiversity, recognition as science, consideration of folklore as part of national heritage and patenting of formulations in recent times (Hoffman and Gallaher 2007; Patil 2012). But a primary challenge in this quantitative trend is how to produce values that are reliable and comparable measures of less tangible qualitative data (Hoffman and Gallaher 2007). Generally, use of relative cultural importance (RCI) indices and Use Values (UV), which started in late 1980s, produces numerical scale or values per taxon (Prance *et al.* 1987; Phillips and Gentry 1993a, b; Phillips *et al.* 1994; Lykke *et al.* 2004; Martin 2004; Reyes-García *et al.* 2006). Relative Cultural Importance (RCI) indices or Use value Indices (UVI) are quantitative measures designed to transform the complex, multidimensional concept of 'importance' into standardized and comparable numerical scales or values. Per-taxon plant use citation data from ethnographic plant interviews is applied to RCI formulas to derive values (Hoffman and Gallaher 2007). With some exception (e.g. Dhar *et al.* 2000; Kala *et al.* 2004; Cruz-Garcia 2006), such studies are rare in India where RCI / UVI were used to determine the numeric values for any taxon to prioritize them for further analysis as well as to transfer TK into comparable form.

### 1.6.5 Studies on ethnomedicinal plants of Uttarakhand

The change in approach towards the ethnobotany, globally, has increased the amount of work done locally. Uttarakhand state, a rich repository of wild MPs was not an exception and did follow the trend with many studies being undertaken by various notable researchers. After the monumental work of Atkinson (1882), the Himalayan region, especially Uttarakhand, witnessed growth in scientific studies in the field of ethnobotany only after Independence more specifically, from 1960s (Jain and Saklani 1991). Uniyal (1968) studied MPs of Bhagirathi valley; Shah and Joshi (1971) documented ethnobotany of Kumaun; Chandra and Pande (1983) collected plants from nearby areas of Dodital which were claimed to be medicinal and used in folklore; Gaur and Semwal (1983) and Gaur and Tiwari (1987) documented little known wild edible and medicinal plants of Garhwal region; Gaur *et al.* (1984) surveyed high altitude areas of Garhwal to document MPs; Maheshwari and Singh (1984) documented plants used by Bhoxa tribe of Bijnor and Pauri Garhwal districts; Pande and Pangtey (1987) carried out ethnobotanical study on ferns of Kumaun region; Rawat and Pangtey (1987) studied alpine ethnobotany of Kumaun; Pangtey *et al.* (1989) documented ethnobotany of Bhotia tribe of Kumaun; Badoni (1986, 1990) studied ethnobotany of hill tribes and Pinswari community of the region Uttarkashi and Pinswad; Bisht and Badoni (1990) documented how *Araceae* members were used by tribal in Garhwal; Bhatt and Gaur (1992) documented Raji's knowledge on usage of plant in Pithoragarh; Jain and Saklani (1991) noted observations on ethnobotany from Tons valley; Maikhuri *et al.* (1997) studied cultivation and management of MPs at Nanda Devi Biosphere reserve; Maikhuri *et al.* (1998) studied role of MPs in traditional healthcare system of Nanda Devi Biosphere reserve area; Gaur (1999) wrote flora of Pauri district with ethnobotanical notes; Samant *et al.* (1996) studied how natives use natural resource in Nanda Devi Biosphere reserve, and in (1998) documented information on diversity, distribution and potential values of MAPs of Indian Himalayas. Kala and Rawat (2001) looked into human use pattern and conservation of MPs in Bhuyander valley, Badoni and Badoni (2001) studied ethnobotanical heritage of Garhwal. These monumental works formed the baseline data in ethnobotany field. In addition to these, more recent and relevant studies were as follows.

Ethnomedicinal value of 57 plants used by the tribals of Garhwal Himalayas was reported by Negi *et al.* (1993). Farooquee and Saxena (1996) studied the conservation and utilization of medicinal plants in the high hills of Central Himalaya by stratifying the study area based on geographical and physical parameters, using questionnaires along with formal and informal discussions, and suggested a ban on unscrupulous collection of MAPs for commercial purpose from the forests. Kumar and Rohatgi (1996) estimated that about 70% of plant species are used for medicinal purpose in the Garhwal region by various communities and gave an account of 35 important medicinal plant species in terms of uses and parts used. A study in the buffer zone of Valley of Flowers National Park, Garhwal Himalaya by Kala (1998) revealed that villagers use 112 MPs of which 23 are rare and endangered including 5 species listed in Red Data Book of Indian Plants. Bhatt (1999) discussed the different factors such as illiteracy, unsustainable environmental education and extremely poor economic condition which led to ecologically damaging activities in Himalaya in his study in Chamoli district. According to him the traditional mode of subsistence also has suffered a major setback due to many anthropogenic pressures such as increasing demographic expansion resulting in rural sprawl, growing commercialization and an alarming reduction in the availability of natural resources as a result of over collection in the past. He also suggested the involvement of government and non government agencies as well as the tribes and ethnic communities for the conservation of the biodiversity. Dhar *et al.* (2000) listed 175 plant species (belonging to 79 families) from Indian Himalaya, which are commercially used by pharmaceutical industries. Adhikari *et al.* (2003, 2005 and 2007) documented habit wise medicinal plants from Uttarakhand based on secondary literature and reported 88 species of medicinal climbers, 197 medicinal tree, and 222 shrubs from the state. Kala *et al.* (2004) grouped 114 ailments into 12 broad classes of diseases and reported a total of 300 MPs used in curing these diseases by various ethnic communities of Uttarakhand. He also found that herbs contributed the highest percentage (65%), followed by shrubs (19%) and trees (16%). He noted that the maximum species were used to cure general body-ache followed by gastrointestinal and dermatological problems. Status of MPs used by Traditional Healers or *Vaidyas* was studied by Kala (2005a) to reveal that *Vaidyas* use 156 (cultivated and wild) MPs in 243 herbal formulations to cure 73 ailments. Rawat (2005) conducted a rapid survey of the medicinal and aromatic plants in alpine meadows of Uttarakhand and reported 144 species (including 1 species each of terrestrial fern and fungi each) of medicinal plants used both locally and by various herbal industries. Pande *et al.* (2006) compiled many previous studies on folk medicines in Uttarakhand and enlisted around 1338 species of MAPs, with highest species from family Asteraceae, followed by Fabaceae. The same study also compiled a list of 364 plants for ethnoveterinary plants along with their uses. Kala (2007) surveyed 3 districts in the state of Uttarakhand and reported 32 medicinal, 16 horticultural, 22 fodder and 20 timber yielding plants as most preferred species by the local people in the Indian Himalaya. He conducted a structured questionnaire survey in ten villages in each study districts. Information was grouped under four topics viz., medicinal, horticultural, fodder and timber yielding. He categorised 12 species as threatened and one species as near threatened. He has shown his concern on the survival of these threatened species due to their low population size, over exploitation from the wild and preferences of the local people. He also states that the local communities and their traditional knowledge are being ignored in designing the policies for environmental management. Georgiadis (2008) worked on the ethnobotany of Garhwal Himalaya, enlisting 251 medicinal plants along with their medicinal use and distribution. The study also pointed out that the area falls under distinct phytogeographic region which faces many challenges due to its rough terrain and existing facilities are limited. Therefore, in order to uplift the economy of the people, ecological and social aspects should be considered.

Many studies were documenting ethnobotany of Kumaun region and in Garhwal region, district Pauri and Chamoli were most fascinating district. Nevertheless, Uttarkashi district did get attention by many scholars and it witnessed some of the monumental work that were done by Ahluwalia (1965) who documented MPs of Har-ki-dun region of Tons Forest Division, Bisht *et al.* (1988) who documented folk medicines of Arakot valley and Paliwal and Badoni (1990) who studied ethnobotany of Hill tribe of district, Some of the recent studies are explained here. Jain and Saklani (1991), through the informal interactions with villagers, reported 32 species of medicinal plants used by locals in Tons valley in Uttarkashi. But this study was restricted to Har-ki-dun area, whereas, Rana *et al.* (2003) reported 761 species of vascular plants in Tons valley, of which, local people extensively used 115 species for the medicinal purpose. Uniyal *et al.* (2002b) studied traditional and ethnobotanical uses of plants in Bhagirathi valley, Uttarkashi. Study revealed that out of total 211 plant species listed, 85 species are used for human and animal diseases. Study also pointed out that people preferred to treat animals with wild MPs due to unavailability of veterinary hospitals in the study area whereas situation is reveres incase of humans. In Uttarkashi, change in lifestyle and implications of modernization in the agricultural practices and resources utilization, due to inclination towards short term monitory benefits, has put tremendous pressure on forests but at the same time usage of wild plants for healthcare has been dwindled (Uniyal *et al.* 2003). In case of Himalayan region, altitudinal gradient and the varied vegetation composition associated with it attributes different dependency of human beings on nature. Such factors intensified the urge to shift inventory oriented focus, of ethnobotanical research, to ecological and more multidisciplinary studies. Most of the previous studies were inventory based, or carried out in single altitude zone. Also in most the cases TK documented through studies was not compared across altitudinal gradient.

### 1.6.6 Studies on Population status

Most of the ethnobotanical studies conducted so far, have focused on the preparation of general inventory. However, quantitative studies on the population status and availability of MAPs in Uttarakhand are rather limited, except work done by Uniyal *et al.* (2002a), Rawat (2005) and Semwal *et al.* (2007). Previous workers have also emphasized on the need to quantify the populations of threatened medicinal plants along different zones. Rawat (2005) studied the population status of MAPs in alpine meadows of Uttarakhand, but such a study has not been carried out at lower elevations.

Uniyal *et al.* (2002a) estimated population status, distribution of plant species across wide elevational range and biomass availability of threatened medicinal and aromatic plant species (TMAPS) which have high trade and conservation value from higher altitudes of Kumaon Himalaya. Based on various parameters such as altitude, topography, soil moisture and physiognomy of vegetation different habitats were selected and belt transects of 20m X 2m were laid to estimate the population status of species. To estimate the biomass three 1m X 1m quadrats were laid. This study reveals that along with altitude, microtopographic features such as presence and absence of water, canopy cover and slope plays significant role in distribution of TMAPS. The small population size has been considered as one of the major reason for the depletion of a species. They have also provided suggestions for sustainable use, propagation, disposal and conservation of medicinal plants by the local communities as well as for development of conservation policies. Rawat (2005) evolved Rapid Mapping Exercise (RME) for the survey of MAPs in alpine region of Uttarakhand to estimate the population status of medicinal plants in Uttarakhand. He has categorized the medicinal plants found in the alpine meadows, in seven different groups. Eighteen species have been categorized as restricted distribution with heavy pressure (RDHP), Restricted distribution with low pressure (RDLP) - 33 spp., locally common and high pressure (LCHP) - 17 spp., locally common and low pressure (LCLP) - 8 spp., wide distribution and high pressure (WDHP) - 3 spp., wide distribution and low pressure (WDLP) - 19 spp., under cultivation with low pressure (UCLP) - 2 spp. Semwal *et al.* (2007) worked on the assessment of population structure, status and distribution in Kedarnath Wildlife Sanctuary. They identified the populations of selected species with the help of belt transects of 60m x 30m. For herbs they laid 10, random plots of 1m x 1m. They found that most of the species were restricted to the 2-3 habitats out of total 10 identified habitats. The study also revealed that few species may represent all habitats, but their population was high only in particular habitats and not in all. In addition, each species showed patchy distribution even in their favored habitats. Unlike animals, flagship species in plant kingdom are either absent or very rare. Usually, the habitat of one species is shared by some or the other significant species. Due to which species specific studies are rare even though such studies undoubtedly help in better conservation and management. One of such rare study, on *Picrorhiza kurrooa,* was carried out by Uniyal *et al.* (2009) in Uttarakhand and Himachal Pradesh. Population status and extraction pattern in three different localities were studied and compared. Study also revealed concerned about shrinking population of *P. kurrooa* and many other MPs which are harvested legally or illegally, for commercial purpose or for local use.

### 1.7 Present Study

India ranks tenth among the plant rich countries of the world and fourth among the Asian countries after Indonesia, China and Philippines (Williams 2001). Subsequent to ratification of Convention on Biological Diversity (CBD) in 1992, and in accordance with this, India has come up with its own Biological Diversity Act (2002), which focuses on the conservation of biodiversity and associated knowledge as well as facilitating access to them in a sustainable manner, including sustainable use of MAPs. The positive outcomes of these provisions are depending on how we formalized institutional mechanism at grass roots level. Globally, MAPs are in high demand while TK related to it, which has always contributed towards advancement of healthcare system, is feared to be depleting rapidly due to various factors. Attempts of patenting *Haldi, Basmati* and *Neem* by foreign consultancy firms with United States Patent Office (USPO) and European Patent Office (EPO) had shown the urgency of documentation of traditional wisdom present in the country. India has developed Traditional Knowledge Digital Library (TKDL), where > 2,30,000 indigenous formulations have been documented and are available for many patent offices throughout the world, in many languages (Jayaraman 2009). However, TK is dynamic and rapid globalization as well as change in lifestyle of many communities has led to its depletion (Uniyal *et al.* 2003; Nautiyal *et al.* 2008; Raut *et al.* 2012). Hence protection and documentation of TK becomes important

(Jayaraman 2009; WIPO 2012). One of the Aichi targets also (strategic goal E, target#18) stress upon conserving TK (www.cbd.int). Thus, a TK compilation has improvised by incorporating suitable quantitative methods of research in ethnobotany. For example, such as calculation of cultural importance (or RCI / UVI) based on various parameters, which are of great scientific interest and importance so as to prioritize species (Hoffman and Gallaher 2007).

Conservation of MAPs is also essential as over 70% of India's MAPs are collected mostly from wild. Major concentration of high value MAPs are known to be in the Western and Eastern Ghats, the Vindhyas, Chotta Nagpur plateau, Aravalis and Himalayan region. The Indian Himalayan Region (IHR), which constitutes around 16% geographical area of India, contributes over 1750 species of MAPs i.e. nearly 32% of MAPs found in India (Samant *et al.* 1998; Dhar *et al.* 2002; Singh 2006). Uttarakhand, one of the Himalayan states, assumes special status in terms of diversity of MAPs and their use by local communities due to unique geography and diverse climatic conditions. The state harbours over 700 MAPs which is the highest number of MAPs harboured by any Himalayan states (Nautiyal *et al.* 1997; Kala 2004). Hence, it has been projected as 'Herbal State' of India (Jalal *et al.* 2008). The state views the MAPs as a major source of revenue. Production and development of MAPs in the state are closely linked with the rural livelihood and traditional healthcare systems, growth of pharmaceutical industries and conservation. One of the major stakeholders in the conservation and development of MAPs, in the state, is the Uttarakhand state Forest Department (UKFD) which also controls much of the wilderness. The UKFD is responsible for conservation, Development and sustainable harvesting (CDH) of MAPs (Rawat 2005; Kala *et al.* 2006).

In Uttarakhand, several previous studies prioritized MAPs on the basis of their geographical distribution, population status and rarity (e.g. Uniyal *et al.* 2002a; Rawat 2005). Furthermore, rarely species were prioritized for conservation based on their cultural importance; for example, studies conducted by Dhar *et al.* (2000) and Kala *et al.* (2004). Additionally, data on distribution and availability of Himalayan MAPs appear to be inadequate. Hence, it was felt that there is a need to document the traditional knowledge as well as traditionally used MAPs and also to have recent data on usage, population status and abundance of MAPs. Nagoya Protocol on Access and Benefit Sharing (ABS) also emphasizes on the involvement of local communities in conservation efforts through ABS mechanism (Albuquerque *et al.* 2006; www.cbd.int/abs/).

A study was, therefore, initiated to assess the current status of TK on the use of ethnomedicinal plants (EMPs) for the curative purpose. Furthermore, it was important to know the population status of these EMPs in order to prioritize them for conservation. To address these, a study was conducted from September 2008 to September 2013. Field work was done from September 2008 to December 2011, data entry and analysis was carried out till December 2012.

### 1.7.1 Scope of the study

This study aims to document the TK on the usage of EMPs among the local communities and quantify availability (population status) of high value EMPs in the forests of the Uttarkashi district, Uttarakhand. The study has relevance in the field of ethno-medicobotany which will incorporate modern methods to document and analyzed the TK along with population status of EMPs in the wild. Use of combination of methods for calculating UVI at different altitudinal gradient will also help in prioritizing species at different landscapes and altitudes. The major research questions include: How do local communities across different valleys and altitude differ in terms of TK on the use of wild medicinal plants and why? What is the population status and habitat specificity of important ethnomedicinal plants in the wild? Which are the important localities and micro-habitats where known populations of such high value EMPs exist? Based on the information generated through the study, a spatial database on the occurrence of various species was prepared to help the Forest Department, one of the important stakeholders of MAPs in the state, by prioritizing the areas for conservation and management of EMPs. The study, along with strategies for conservation and management of high value EMPs, also aims to suggest a mechanism for formalizing protection of TK.

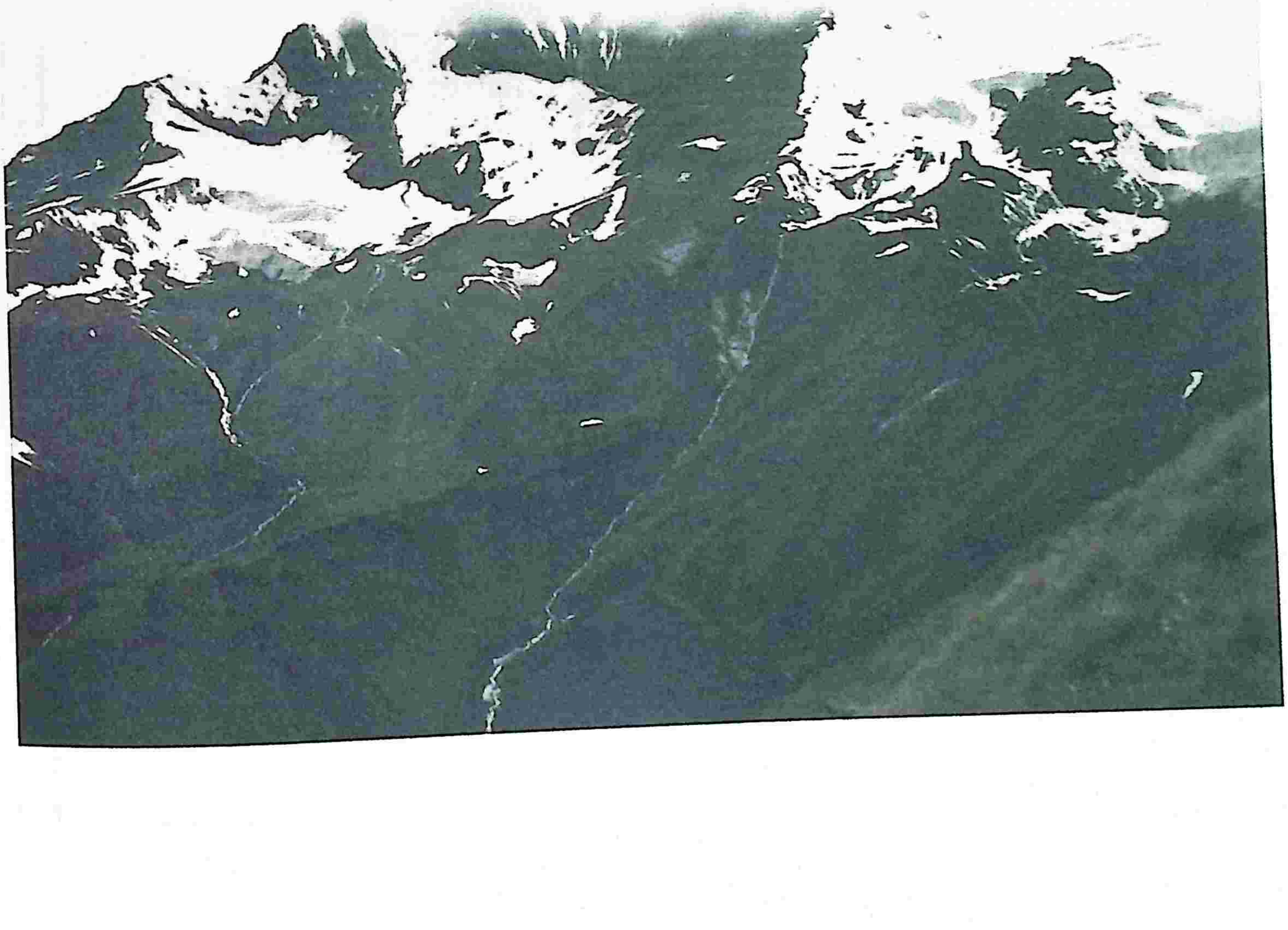
Major objectives of the study were:

### 1.7.2 Objectives

1. To document the current state of traditional knowledge on Ethnomedicinal plants among locals, along with their usage pattern in Uttarkashi district,

2. To investigate the population status of the high value ethnomedicinal plants in the district,
3. To study the habitat specificity and distribution of selected ethnomedicinal plants in the district,
4. To evolve strategies for conservation and management of high value ethnomedicinal plants.

# Chapter 2: Study Area

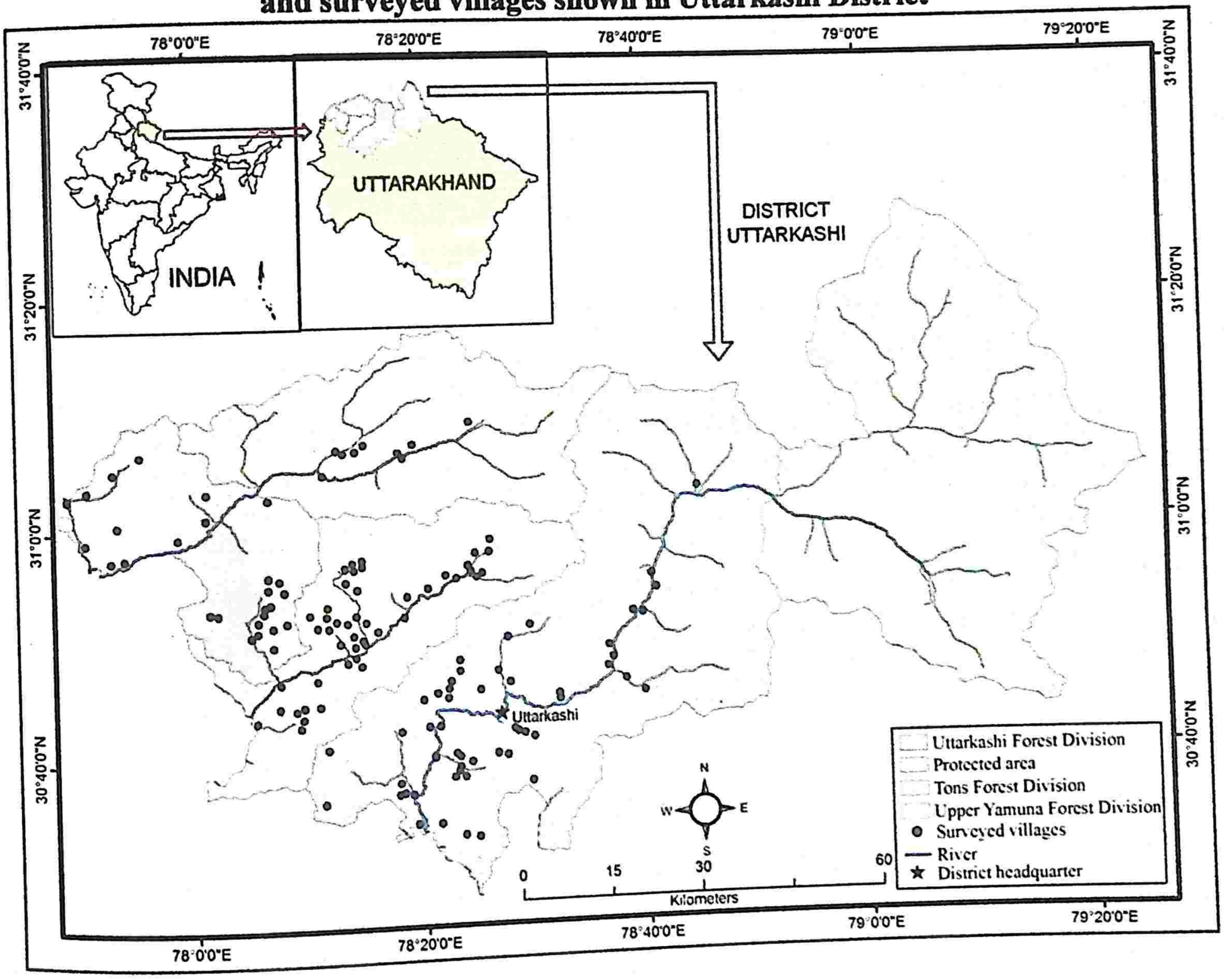


# 2.0 STUDY AREA

## 2.1 Intensive Study area: Uttarkashi District

**2.1.1 Location, area and History:** The intensive study was carried out in Uttarkashi District of Uttarakhand state in western Himalaya (**Figure 2.1**). It lies between north Latitude 30° 27' 18" and 31° 27' 42" and east Longitude 77° 48' 26" and 79° 24' 00".

**Figure 2.1: Location map of Intensive study area (District Uttarkashi) in India; Rivers and surveyed villages shown in Uttarkashi District**




It is spanned over an area of 8016 km$^2$. The district is bordered by Kinnaur district (of Himachal Pradesh) in the north, Tibet in the northeast and districts Chamoli, Rudra Prayag, Tehri and Dehradun (of Uttarakhand) in the east, southeast, south and west respectively. It was carved out of erstwhile Tehri Garhwal district in 1960. In ancient time, it was commercial market of the nearby area and trade was conducted between Tibet and Barahat (the old name of Uttarkashi). The district is named after its headquarters town Uttarkashi, and this name Uttarkashi to Barahat was probably given by sage Adi Sankaracharya. During his visit to Barahat, he found resemblance between Kashi (i.e., Varanasi) and Uttarkashi (then Barahat; Uttar = North) in terms of design-decoration and infrastructure and the location in between two rivers that has similar names - Varuna and Assi. Presence of Vishawanath Temple, Annapurna Temple, Kalbhairav Temple, Manikarnika Ghat are another similarities between the two cities (NIAR 2009).

**2.1.2 Geology and Soil**: The elevation of the district ranges from 800m to 7000m asl (**Figure 2.2**). Few high peaks present are Bandarpunch (6720m), Gangotri (6613m), Bhagirathi (6607m) and Swargrohini (6562m). There are very sharp undulations owing to high mountains; narrow valleys and deep gorges (**Figure 2.3 and 2.4**).

The northern and eastern parts are covered with snow throughout the year (CGWB 2009). The higher ranges and snow covered peaks consists entirely high grade metamorphic rocks such as quartzites, marble and various types of micaceous schists and gneisses and slightly lower altitudinal areas with sedimentary and low grade metamorphic rocks such as limestone and sericite biotite schists (Wadia 1975). The quality of soil is determined by the kind of rocks in the sub-soil. The surface soil is richer in organic matter and darker in colour. The soil in steep slopes (>30°) are shallow due to erosion and mass wasting processes. Soil in general is acidic except those developed from limestone which is natural to slightly alkaline (Awasthi 2001). Valley soils are developed from the colluviums and alluvium brought down from the slopes and deposited in valleys. Therefore the soils are coarse textured except the surrounding hills are of shale rocks (Ghildiyal 1981). Immature soils are generally present in the terraces and along channels on the colluviums and alluvial materials. Less developed soils are common on the surface of the slopes whereas brown forest soils are medium to heavy textured, deep, moderately well drained, rich in organic matter and acidic in nature (CGWB 2009). In the alpine areas either meadow soil or soil rich in moronic contents are found (Awasthi 2001).

Figure 2.2: Elevation map of District Uttarkashi

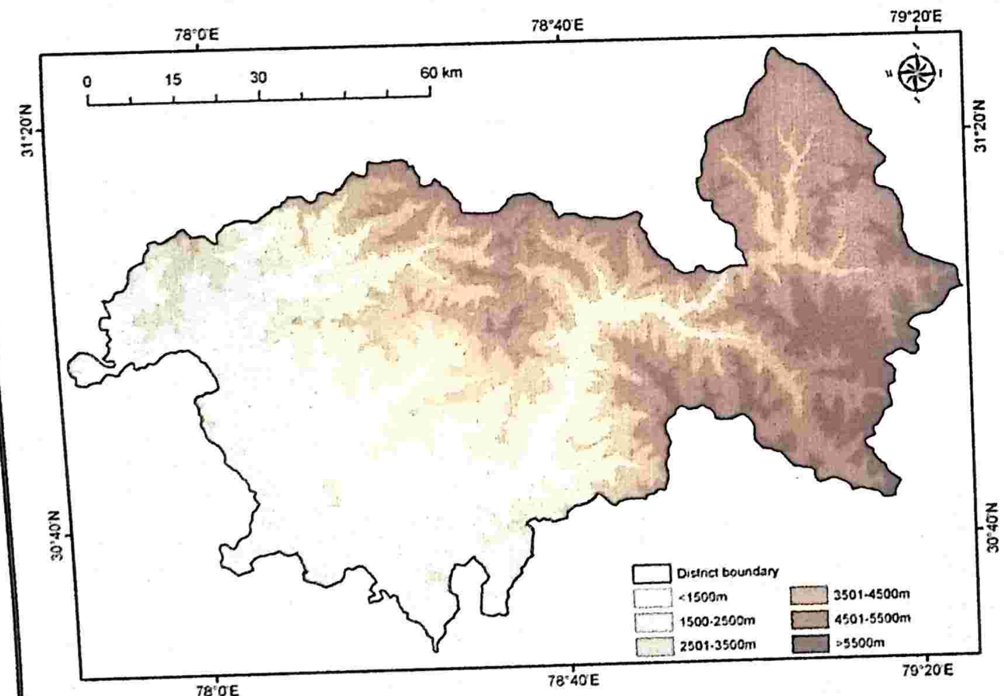



Figure 2.3: Aspect map of District Uttarkashi

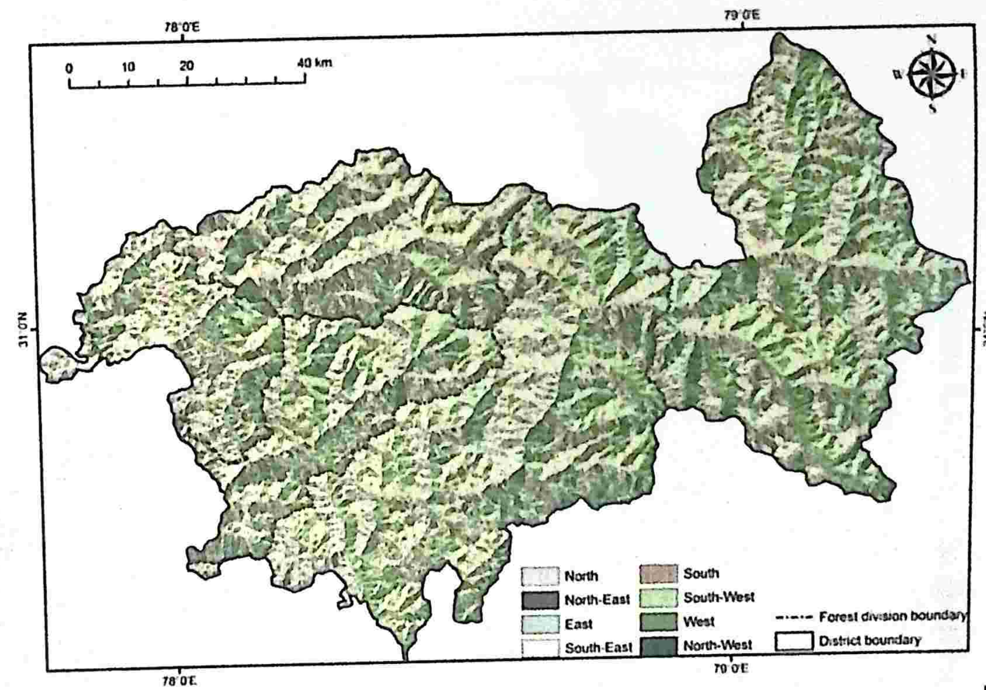
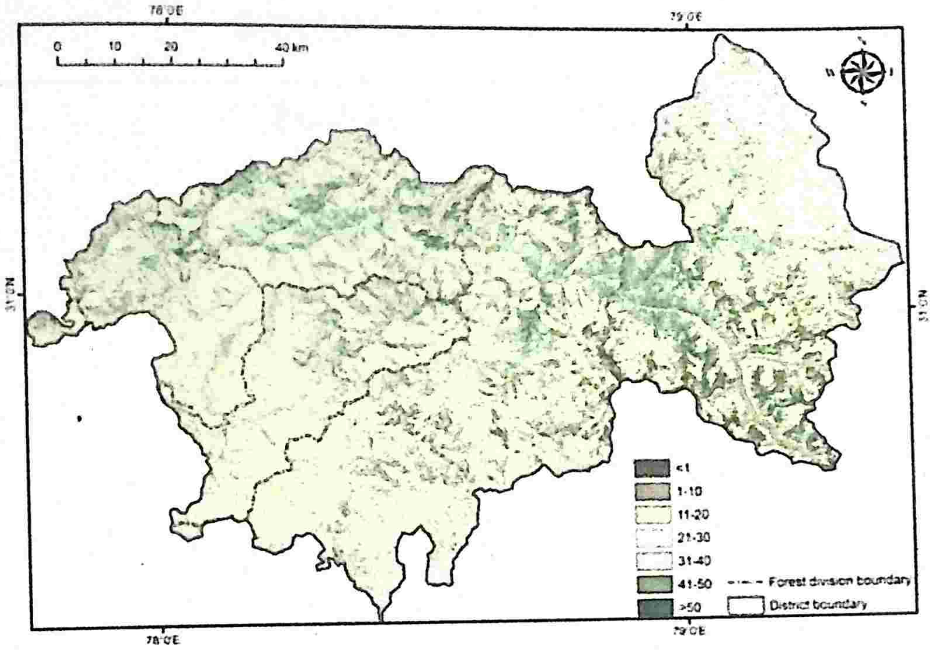
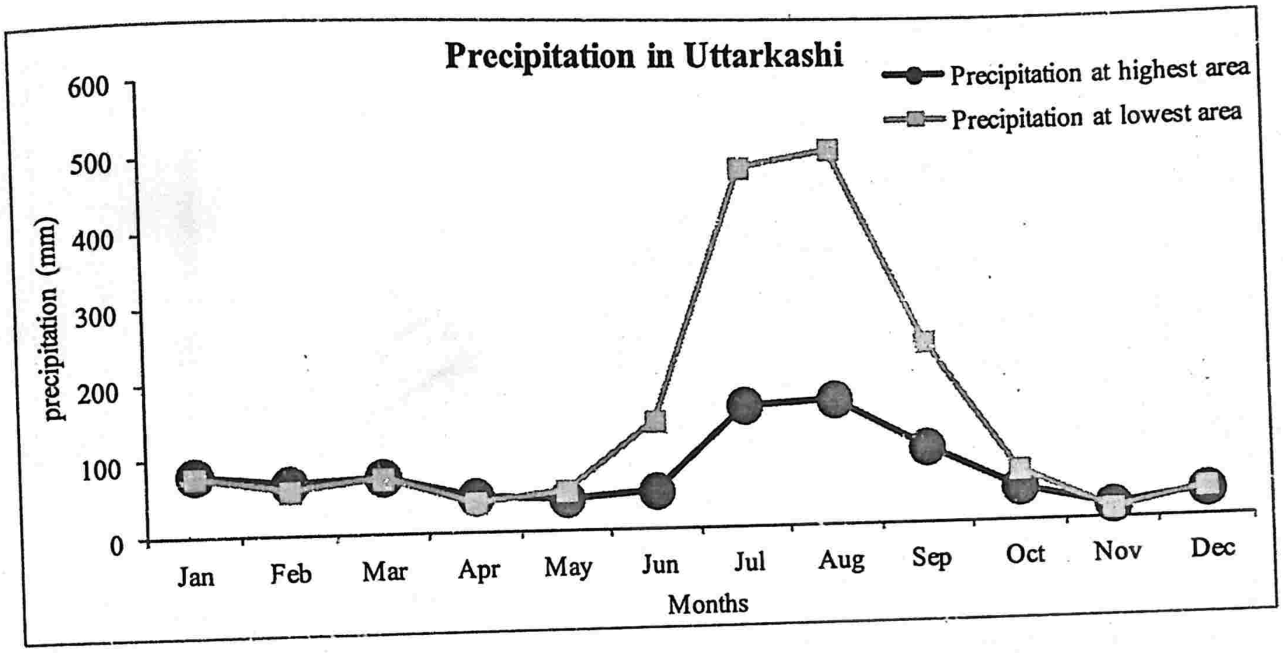


**Figure 2.4: Slope in District Uttarkashi**




**2.1.3 Climate**: The climate from sub-tropical (mild winter, hot summer) to temperate and alpine types. The northern part of the district remains perennially under snow cover representing alpine type of climate. According to Awasthi (2001), the district is represented by three distinct seasons *viz.*, winter (October to March), summer (April to June) and rainy (July to September). Winters are severe with frosts and snowfall common during December to February in the middle and upper elevations. Rainfall is highly variable and depending upon the altitude. Monsoon bearing winds penetrate through the valleys usually in June and the rainfall is at the maximum (about 75%) during July-September, where August is the wettest month. Rainfall rapidly decreases after September and it is lowest in November. About 17% of the annual precipitation occurs in four winter months. The winter precipitation is in association with the passage of the western disturbances and is mostly in the form of snowfall, particularly at higher elevations. The precipitation during the pre-monsoon month, which is about 7% of the annual total and the post-monsoon months, is frequently associated with thunderstorms. The annual average rainfall of district is 1684 mm. The average annual rainfall at the rain-gauge stations located at Dharasu, Uttarkashi, Rajgarhi, Jamuna Chatti, Rana and Kharsali is 1095.0, 1552.8, 1631.2, 1917.5, 1948.5, 2092.9 mm respectively (CGWB 2009). Month wise precipitation at two locations in the intensive study area *viz.*, Ranadi (1062 m) and Kyarkoti (4552 m) are shown in **Figure 2.5**.

**Figure 2.5: Precipitation at highest and lowest points in study area** (data source - BIOCLIM; Hijmans *et al.* 2005)




**2.1.4 Temperature:** Temperature is an important factor in determining vegetation types. The average mean temperature of the district varies from -10°C to 35°C. The temperatures recorded at extreme altitudes within the sampling area *viz.*, Ranadi (1062 m) and Kyarkoti (4552 m) are shown in **Figure 2.6** and **Figure 2.7**. The climate data was derived from Worldclim website (Hijmans *et al.* 2005) which is freely available for download.

**Figure 2.6: Temperature at Ranadi (1062 m) - lowest point in the sampled area** (data source - BIOCLIM; Hijmans *et al.* 2005)

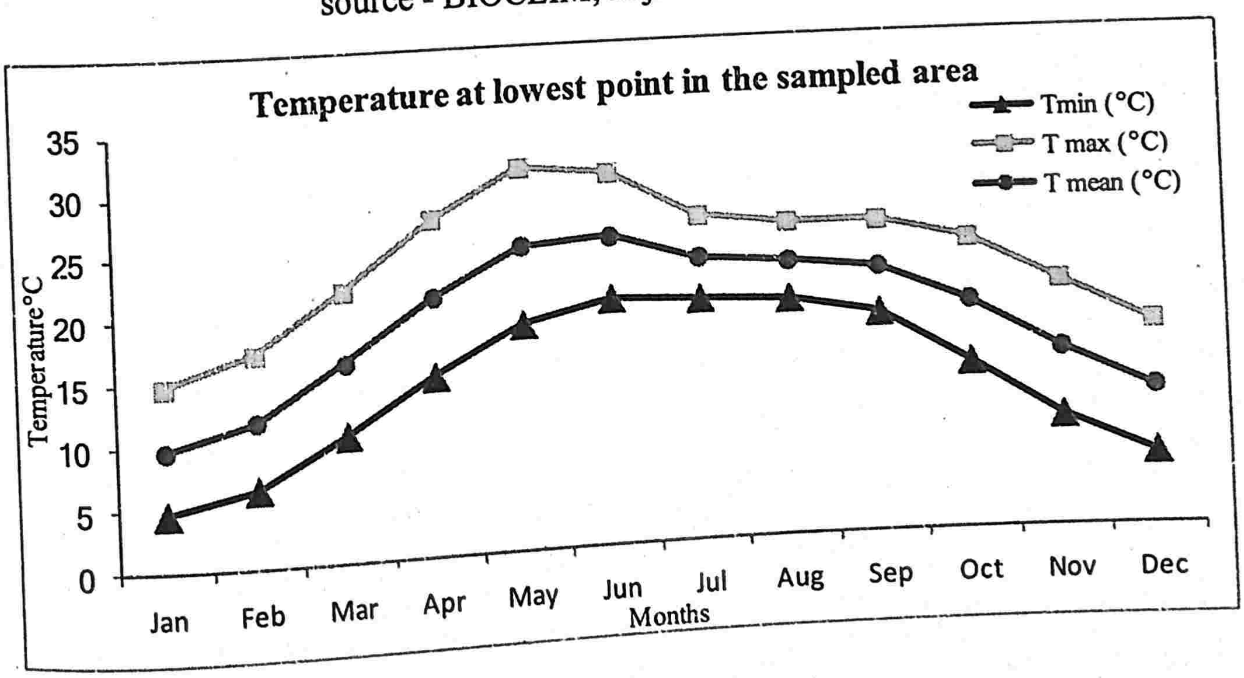
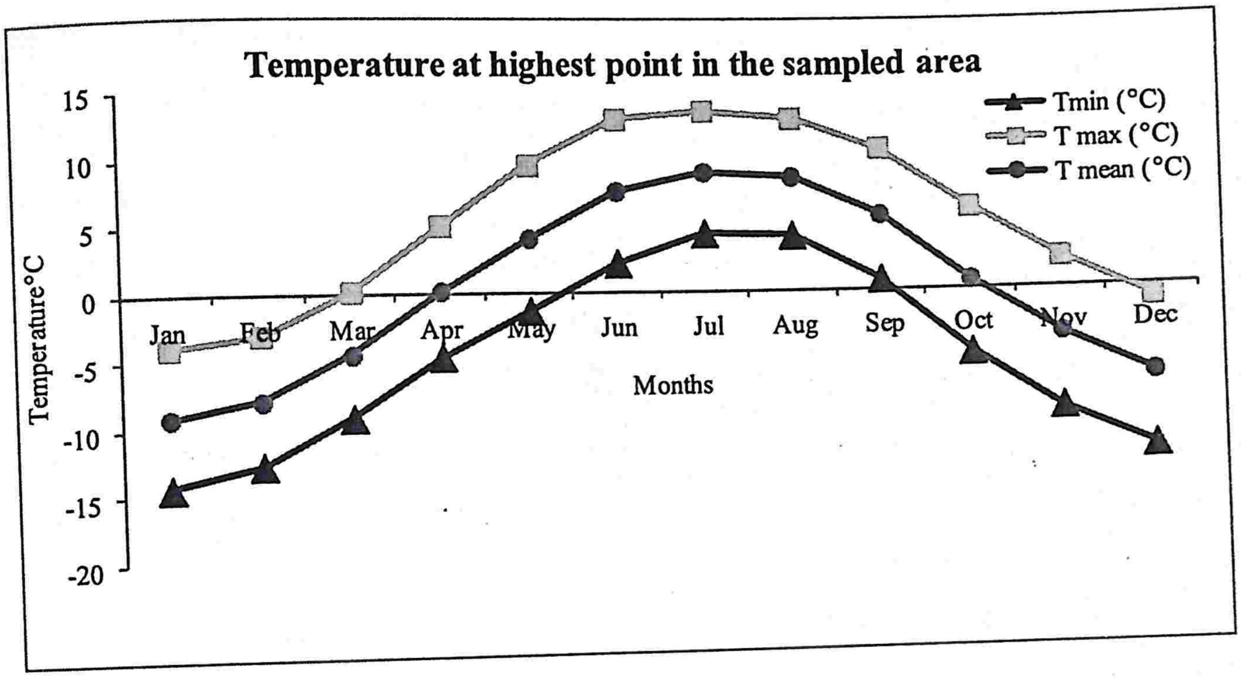


**Figure 2.7: Temperature at Kyarkoti (4552 m) - highest point in the sampled area** (data source - BIOCLIM; Hijmans *et al.* 2005)



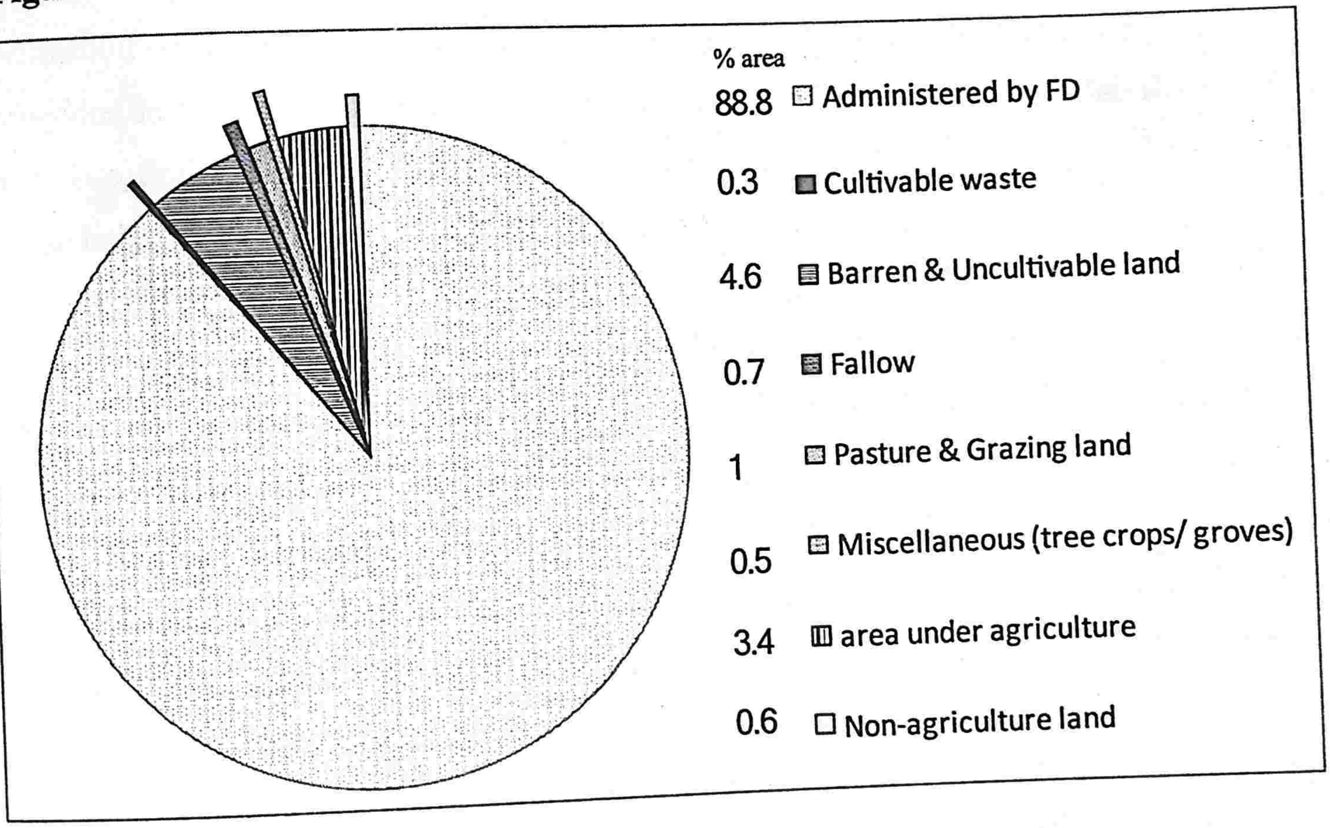

**2.1.5 Administrative divisions and villages:** There are total 686 villages and 3 towns present in the district. These villages are distributed in four tehsils (namely, Bhatwari, Dunda, Badkot, Purola) and six developmental blocks, *viz.*, Bhatwari (94 villages), Chinyalisaur (101 villages), Dunda (120 villages), Mori (92 villages), Naugaon (184 villages) and Purola (78 villages) and 5 villages are abandoned (DAU 2010; DES 2010). Area-wise Bhatwari is biggest tehsil but comprises fewer villages. Purola, which is farthest tehsil from district head quarter, is also considered to be exclusively rural. It constitutes the North-Western part of the district. Mori Block of it is the most remote part of the tehsil and considered one of the most marginalized parts of Uttaranchal (Mattias *et al.* 2006). Most of these villages are situated along the catchments area of the rivers (Awasthi 2001). Human habitation generally extend up to 4000m but optimum belt where majority of population lives extends only up to 2500m (Bose 1972). Few villages are located at 2600m but beyond that altitude only temporary hutment, locally known as *Chani*, were found almost up to 3600m. Shepherds from villages migrate to *Chanis* during summer and may reach up to 5000m. There are two national highways (NH 94 and NH 108), both starts and ends in the Uttarakhand state only but are amongst the heaviest trafficked roads in the state in terms of the number of pilgrims and tourists travelling from south and east to Gangotri, Yamunotri and nearby places in the region (UNWTO-UTDB 2008). This road network is amongst the old road networks of the district. In recent past, new road network woven by government and Border Road Organization (BRO) has intersected district which has joined valleys reducing remoteness of many villages.

**2.1.6 People, occupation and culture**: The total population of the district is 2,95,013, of which the male and female population is 1,52,016 and 1,42,997 respectively (Census of India 2001). The population density is 37persons/km$^2$ and the sex ratio is 941. Total literates are 1.61,161 which is 65.71% of the entire population. More males are literate (83.60%) than females (49.69%) (Census of India 2001). Population belongs to two (broad) ethnic groups, *viz.*, Indo-Aryan and Indo-Mongoloid (*Bhotiya*). Most of the population represents former group whereas *Jadhs*, which represents later ethnic group, is the tribal community lives near Baghori (Harsil) and Dunda in Bhagirathi valley. Other transhumant community is *Gujjar,* who are semi-nomadic people moves between Bhabhar belt of Dehra Dun district and high altitude meadows (of Uttarkashi, Tehri and Chamoli districts). The extreme conditions of the high altitude and scantily available resource base has forced these pastoral people to evolve strategies to cope with the situation. The favorable summer conditions at high altitude and inverse in winter controls the migration of these people twice a year between their summer settlement on the high altitudes and winter settlement in the valleys (Farooquee 1999). During the travel between *chani* and uppermost extend till shepherds go (generally, up to 5000m), they follow fixed path. Camping locations are near the water bodies which they changed almost every week to move forward till mid-September. By onset of winter in October they start moving downwards to reach plains. Similar pattern is followed by *Gujjar*, but they (usually) get settled at 3600m asl. In Tons valley, lesser *Gujjar* groups were observed going to alpine meadows than in other two valleys of the district. However, in some areas (like near Thadiyar and few locations near Mori) *Gujjar* groups were found permanently settled, leaving their traditional pastoralist occupation. Now, they are engaged into agriculture for their sustenance.

Majority of the population, except *Jadhs*, have agriculture as their main occupation though they do have livestock and do follow complementary pastoralism. Generally, wool based trade and rearing of sheep and goat has been traditional and main occupation of *Jadhs*. In entire district, the net sown area is only 3.3% and land holdings are fragmented (**Figure 2.8**). Area under agriculture is very low, of which major area is under cultivation of Wheat

(33.07%), Rice (28.14%), Manduwa (15.37%). Other food crops sown are maize, Sava (coarse millet), Rajma, Urad, Gahat, Soybean, Mustard and Til (*Sesamum* sp.). The vegetables grown are Potatoes, Tomatoes, Radish, Cabbage, Cauliflower, Brinjals, French Beans and Cucumbers. The fruits are Apples, Peaches, Walnuts, Apricots, *Citrus* fruits, Pears and Plums (Awasthi 2001; CGWB 2009; Singh 2009).

**Figure 2.8: Area under different land-use in Uttarkashi (adapted from Awasthi 2001)**




Other than agriculture and pastoralism, tourism supports economy of the district. Impact of tourism, to many sacred and scenic places in the district, can be seen not only on their economy but also on culture. Gangotri and Yamunotri are the famous Hindu pilgrimages which are visited by lakhs of people, not only from India but from entire world. In addition to these holy places district has several unique and significant mythological places, such as Gaumukh, Kapil Muni's Ashram, Duryodhan's Temple, Karna's Temple, Pokhu Devta's Temple, Shani Temple, Bhairav Temple and Vishwanath Temple. Besides these holy places people come here to visit and enjoy the beauty of high altitude meadows, locally known as *Bugyal* (Rawat 2005). Dodital, Dayara, Har-ki-dun in addition to many high altitude passes are tourists' attraction.

Culture of Uttarkashi district is similar throughout except places where *Jadhs* have settled and in some parts of the Tons valley. Culture of the area (of Tons valley) adjacent to Jaunsar area (of Dehra Dun district) up to villages Jakhol, Lewari is somewhat similar to that of Jaunsari culture. Fraternal Polyandry was once common in this belt but with change in lifestyle this tradition is depleting (Majumdar 1962).

**2.1.7 Drainage**: Water is probably the only natural resource to touch all aspects of human civilization – from agricultural and industrial development to the cultural and religious values embedded in society (Matsuura 2002 cited in Castelein and Otte 2002; Singh and Rana 2012). Therefore, drainage is very important for any area. The district is well drained with presence of two holy rivers of India, namely, Bhagirathi and Yamuna.

Bhagirathi (become Ganga at Deoprayag, after meeting river Alaknanda), the most saintly river in India, forms main drainage system of the district. It originates at Gaumukh in Gangotri glacier at 4000m asl. Its main tributaries, within the district limits, are Janhavi and many other rivulets, locally known as *Gads,* like Jadhganga, Jalandhari, Pilangana and Assi Ganga. Bhagirathi river originates from Gangotri Glacier at Gaumukh on the western slope of Chaukhumba. Another important drainage system is form by river Yamuna. River Yamuna is the largest tributary of the river Ganga. The main stream of the river Yamuna originates from the Yamunotri (or Bunderpoonch) glacier near Bandar Punch at an elevation of about 6320m asl and remains in the district boundary till Nainbag, then it enters into Dehra Dun district. Third important river of the district is Tons river which also originates from Bunderpoonch glacier. It is largest tributary of river Yamuna and marks the boundary of district as well as of state with neighboring Himachal Pradesh. Other major tributaries of Yamuna include Hanuman Ganga, Kamal Ganga and Badiyargad (Kedar Ganga). In case of river Tons, Rupin and Supin rivers merged together at Naitwar to form Tons. Pabar river, which runs forming the boundary between Himachal Pradesh and Uttarakhand, meets into Tons at place called Tyuni. From this point onwards, Tons forms boundary of Uttarakhand and Himachal Pradesh. Khunigad, Miyangad are among other tributaries of Tons. Prehistorically rivers have been a central feature of the economic environment. It additionally developed unique culture for its residents and because of the essential role that water plays in human life and economic endeavor, human settlement has almost always been close to water (Sadoff and Grey 2002; Gupta 2011b).

**2.1.8 Forest and Vegetation:** Almost 88 % of the total area of the district is administered by the Forest Department but only 39.23% of total geographic area is covered with vegetation and remaining is snow-covered or bare rock (**Plate 2.1 A;** Rao and Nandy 2001; FSI 2009).

**2.1.8.1 Administration:** In Uttarkashi, there are three protected areas (PAs), *viz.*, Govind Wildlife Sanctuary (WLS), Govind National Park (NP) and Gangotri NP and three territorial Forest Divisions (FD) *viz.*, Uttarkashi Forest division (UFD), Upper Yamuna Forest division (UYFD) and Tons Forest division (TFD). These three FDs together covers about 3,61,000ha area. **(Figure 2.1)**

UFD is divided into six forest ranges, Badahat (313.62 $km^2$), Dharasu (341.54 $km^2$), Dunda (247.26 $km^2$), Gangotri 669.85 $km^2$), Mukhem (283.32 $km^2$), Taknaur (706.60 $km^2$). The UYFD is divided into five forest ranges namely, Yamunotri (266.91$km^2$), Kuthnor (253.16 $km^2$), Rawain (190.68 $km^2$), Mugarsanti (139.49 $km^2$) and Naugaon (153.74 $km^2$). TFD is divided into five ranges, Kotigad (171.06 $km^2$), Devta (119.35 $km^2$), Sandra (119.91 $km^2$), Singtur (120.10 $km^2$) and Purola (211.71 $km^2$). UFD is spread around Bhagirathi watershed, UYFD is around Yamuna drainage and TFD is around the drainage of Tons. Only one range of TFD *i.e.* Purola is situated around small river - Kamal Ganga, which serves as the tributary of Yamuna.

**2.1.8.2 Vegetation**: The widely varying climate, altitude and topography produce a wide range of vegetation and serve as habitats to diverse species of wildlife. Forest formation ranging from *Euphorbia* scrub to dry alpine scrub makes district unique habitat for different forest types. According to Champion and Seth's (1968) forest categories *viz*., Subtropical Pine Forest, Himalayan Moist Temperate Forest, Himalayan Dry Temperate Forest, Sub-Alpine Forest, Moist and Dry Alpine Scrub and Alpine Meadows (*Bugyals*), are found in the study area. The forest vegetation is dominated by Chir Pine forest 9/$C_{1a}$ **(Plate 2.1 C)**, Banj Oak forest 12/$C_{1b}$ **(Plate 2.2 A)**, Moru Oak forest 12/$C_{1b}$, Kharsu Oak forest 12/$C_2$a **(Plate 2.2 C)**, West Himalayan Fir and Birch forest 12/$C_{2b}$ and 14/$C_{1d}$ **(Plate 2.2 D and E)**, Moist Deodar forest 12/$C_{1c}$ **(Plate 2.2 B)**, Moist temperate forest 12/$C_{1e}$, sub-alpine Fir and Birch forest 14/$C_{1b}$ and 14/$C_{1d}$. A brief description of some major forest types and their characteristics are described below:

**2.1.8.2.1 Subtropical Forest (<1500m)**

Various types of forests occurred in subtropical zone but in Uttarkashi mainly one type occurs i.e., miscellaneous deciduous forest of lower hills (**Plate 2.1 B**). These types of forests occur throughout the central and outer hill ranges up to 1200 m, where they usually give way to Chirpine (*Pinus roxburghii*). The trees are mostly deciduous being leafless or nearly so during summer. These deteriorate rapidly into a scrub composed of shrubs like *Carissa opaca, Rhus parviflora* and *Woodfordia fruticosa*. The other species of trees include *Dryopteris roxburghii, Ougenia oojeinnesis, Lannea coromandelica, Bauhinia variegata, Mallotus philippensis, Sapium insigne, Sterculia villosa, Engelhardtia spicata* and *Glochidion velutinum*. Some common shrubs forming the undergrowth of these forests includes *Indigofera cassioides, Rhus parviflora, Woodfordia fruticosa, Murraya koenigii, Adhatoda zeylanica, Colebrookea oppositifolia, Carissa opaca and Nyctanthes arbor-tristis*.

**2.1.8.2.2 Temperate Forests (1500 – 2500m)**

Following major categories of forests can be seen within warm temperate belt:

(i) **Chirpine Forests:** A Chirpine (*Pinus roxburghii*) forests is generally occurring between the altitudes 1000m and 2000m, though this species extends occasionally below and above these altitudes (**Plate 2.1 C**). The growth of Chirpine on steep rocky slopes is poor and in extreme conditions it can be replaces by low level scrub and other broadleaved species. Chirpine can establish easily on themselves on dry southern aspects where xerophytic conditions fire is prevalent. The ground vegetation in Chirpine forest is usually covered with few grasses and shrubs, which are fire resistant. Some of the commonest species associated with Chirpine are: *Lyonia ovalifolia, Pyracantha crenulata, Glochidion velutinum, Euphorbia royleana* is very often abundant in dry rocky grounds. *Rhus parviflora* and *Woodfordia fruticosa* often form an undergrowth of varying extent. *Indigofera cassioides, Lespedeza stenocarpa, Rubus ellipticus, R. niveus, Berberis lycium, Leptodermis lanceolata, Aechymanthera gossypina, Myrsine Africana* and *Inula cappa* and others often abundant shrub species.

(ii) **Banj oak Forests:** Banj Oak (*Quercus leucotrichophora)* forests are generally found between 1500m and 2400m and occupy the moist ravines running down as low as 1000m (**Plate 2.2 A**). The common associates of Banj Oak are: *Rhododendron arboreum, Lyonia ovalifolia, Neolitsea umbrosa, Ilex dipyrena, Carpinus viminea, Quercus lanata, Q.*

*glauca, Euonymus pendulus, Betula alnoides, Pyrus pashia, Myrica esculenta, Populus ciliata* and *Alnus nepalensis.* Some of the common associates among shrubs are: *Berberis chitria, B. asiatica, Desmodium elegans, Indigofera heterantha, Rubus niveus, Boenninghausenia albiflora, Myrsine Africana, Deutzia staminea, Plectranthus japonicus, Pterocanthus alatus, Golfussia dalhousiana, Pseudaechymanthera glutinosa* and *Sinarundinaria falcata.*

**2.1.8.2.3 Cool Temperate Forest (2500 – 3000m)**

(i) **Tilonj Oak Forests:** Tilonj (or Moru) Oak (*Quercus floribunda)* forests usually occur between Banj Oak and Kharshu Oak forests between the altitudes from 2100m – 2700m. It attains its maximum development on deep moist soils and especially where subsoil is limestone. Tilonj Oak is definitely more mesophytic than Banj Oak forests. Tilonj Oak forests are usually found in areas away from habitation and have least biotic damage. Tilonj Oak is less fire resistant than Banj Oak. These forests have luxuriant growth and have a greater mixture of secondary species in the top storey mainly of deciduous trees with a well marked evergreen second storey. Some of the common tree species associated with Tilonj Oak are: *Quercus leucotrichophora, Q. semecarpifolia, Betula alnoides, Carpinus viminea, Acer caesium, Ilex dipyrena, Euonymus pendulus, Persea duthiei, Aesculus indica, Abies pindrow, Ulmus wallichiana, Rhododendron arboreum* etc., while common shrubs found in such forests are: *Rhamnus purpurea, Lindera pulcherrima, Lyonia ovalifolia, Myrsine semiserrata, Boenninghausenia albiflora, Sarcococca saligna, Lonicera quinquelocularis, Viburnum cotinifolium* and *Eurya acuminata* etc.

(ii) **Temperate Deciduous Forests:** These forests usually found from 2000m – 2750m in moist soil especially in depressions on northern aspects along hill streams. This type of forest is composed of deciduous tree species having large girths, though usually poor due to close canopy but wherever canopy is broken, small trees, shrubs, and Himalayan bamboos come up. The predominant tree species forming moist temperate deciduous forests include *Aesculus indica, Ulmus wallichiana, Betula alnoides, Acer caesium, A. cappadocicum, Carpinus viminea, Juglans regia, Fraxinus micrantha, Corylus jacquemontii, Cornus macrophylla, Taxus wallichiana, Prunus undulata, Prunus nepalensis, Euonymus fimbriatus* etc., while understory is represented by *Viburnum foetens, Rubus nepalensis, Berberis* spp., *Spiraea* spp., *Strobilanthus wallichii,* *Thamnocalamus spathiflorus, T. falconeri, Cardiocrinum giganteum.* Among the climbers *Parthenocissus semicordata and Clematis connata are most frequent.*

(iii) **Kharshu Oak Forests:** Kharshu Oak (*Quercus semecarpifolia)* is a dominant species of this forest and occurs between the altitudes 2500m – 3300m (**Plate 2.2 C**). This Oak forms a dense crop with some admixture of other species but at some places it forms pure crop of its own. Its second storey, it is often absent but dense patches of Himalayan bamboos represent a marked features in many places, though sometimes absent in other aspects. There is generally a ground of mostly deciduous shrubs with a varying amount of grasses, ferns, and herbaceous flora. Scattered tree of Silver Fir and Spruce are found in these forests. At higher elevations, it merges with sub-Alpine forests of Silver Fir, Rhododendron, Birch, but often it directly merges into Alpine meadows. Some common tree associates of Kharshu Oak are: *Betula utilis, Quercus floribunda, Acer caesium, Abies pindrow, Meliosma simplicifolia, Rhododendron arboreum and Sorbus foliolosa,* while *Rosa sericea, R. macrophylla, Viburnum foetens, Cotoneaster acuminatus, Strobilanthus wallichii, Ribes glaciale* and *Salix denticulata* are among the dominant shrubs.

(iv) **Temperate Grassy Slopes:** These types of habitat are found in between 2200m -3000m. At higher elevations, it merges into the sub Alpine forests of Kharshu mixed forest. Some common associated species of Temperate Grassy slopes are *Rhododendron arboreum, Cotoneaster acuminatus, Strobilanthus wallichii, Berberis chitria, Berberis lycium* and *Plectranthus japonicus* etc.

**2.1.8.2.4 Sub-alpine Forest (3000 – 3500 m)**

Dominant associations in the sub-alpine forests are described below:

(i) **Kharshu Oak and Fir Mixed Forests:** the distributional range of this forest lies between 2600m – 3400 m particularly on the northern aspects and sheltered localities (**Plate 2.2 D**). The drier parts in these forests tend to be occupied by pure Kharshu Oak forests characterized by early melting of snow. Typically, two story forests with the Fir standing singly or in stripes and groups over Kharshu Oak forests and other deciduous and evergreen trees.

Himalayan Bamboos are found throughout within these forests. Climbers are relatively less but there is a vigorous and gregarious growth of mosses. Some common tree associates are: *Quercus floribunda, Pyrus lanata, Rhododendron arboreum, R. barbatum, Sorbus foliolosa* etc., while *Rosa macrophylla, Viburnum foetens, Berberis* spp., *Strobilanthus wallichii, Smilax vaginata* are among the shrub species. *Parthenocissus semicordata* and *Hedera nepalensis among the climbers found in such forests.*

(ii) **Birch/Fir Forests:** This type contains an irregular forest with Fir (*Abies spectabilis*), Birch (*Betula utilis*) *and Rhododendron* (*Rhododendron arboreum* and *Rhododendron campanulatum*) in varying percentages as main constituents of the forests and occurs between 3000m – 3300m (**Plate 2.2 E**). Kharshu Oak also extends upto this forest along with Himalayan Bamboos. The common tree species often associated with this forest are: *Quercus semecarpifolia, R. barbatum, Pyrus* spp, *Prunus padus, Acer caesium, Juglans regia, Taxus wallichiana* etc., while *Cotoneaster acuminatus, Rosa sericea, Ribes glaciale, R. himalense, Lonicera* spp., *Rhododendron campanulatum, R. lepidotum, Gaultheria trichophylla* are common shrubs. Climbers (*Smilax vaginata*) are very sparse.

**2.1.8.2.5 Alpine Vegetation (>3500m)**

(i) **Alpine Scrubs:** There is a gradual transition from sub-Alpine forest to scrub above the Birch and Fir forests. The bushy growth of plants is prevalent throughout the area and patches are discontinuous because of broken terrain. The terrain is often steep and strewn with boulders and is frequently intersected by rocky slopes. Lower limit begins from 3200m and upper limit can be extended beyond 4000m asl. Except *Rhododendron campanulatum* and *Sorbus foliolosa most* of the species in alpine scrub are dwarf, hardly attaining 1m in height. Some common shrub species are: *Rhododendron lepidotum, Gaultheria trichophylla, Juniperus communis, J. wallichiana, Berberis jaeschkeana, Lonicera spp.,* and *Salix spp. etc.* Besides, some woody species such as species of *Berberis, Caragana, Cotoneaster, Juniperus, Lonicera, Myricaria, Rhododendron, Rosa,* and *Salix* in isolated patches.

(ii) **Alpine Meadows (Plate 2.2 F)**: Of all alpine landscapes, in the Himalaya, the herbaceous meadows, locally termed as '*Bugyals*' are rich in plant diversity and also regarded as repositories of MAPs (Rawat 2005). Several graceful, cushioned and hairy grow in great profusion, which are well known for their beautiful and attractive flowers. All the plants growing above alpine scrubland and are collectively known as '*Bug*' from which the word *Bugyal* has been derived. Some of the common genera grow frequently in alpine meadows are: *Aconitum, Allium, Aster, Astragalus, Corydalis, Delphinium, Draba, Epilobium, Euphorbia, Gentiana, Geranium, Impatiens, Nepeta, Pedicularis, Polygonum, Potentilla, Primula, Ranunculus, Saussurea, Saxifragra, Sedum, Senecio, Stellaria, Swertia, Tanacetum,* along with a large number of grasses and sedges. These *Bugyals*, based on the altitude, aspect which in turn, influence the duration of growing season and moisture availability, can be categorized in different types. According to Rawat (2005) these types can be described as follows:

**Tall Forbs (TF):** The treeline gaps and shady moist slopes with deep soil exhibits profuse growth of fast growing herbaceous species (upto *ca.* 1m). Characteristic species are *Polygonum polystachyum, Selinum wallichianum, Pleurospermum angelicoides, Angelica glauca, Phlomis bracteosa* etc.

**Mixed herbaceous formations (MHF):** Gentle and moist slopes higher than the TF, have large number of herbaceous species e.g., *Bistorta affinis, B. macrophylla, Potentilla atrosanguinea, P. argyrophylla, Ranunculus hirtellus, Anemone rivularis* etc. A large number of loose association and combination with grasses and sedges could be seen along with these species.

**Matted shrubs (MS):** Shady moist slopes especially in areas of late snow mainly between 3500 – 4000m asl show presence of dwarf willows (*Salix lindleyana*), *Cassiope fastigata* and *Rhododendron anthopogon.*

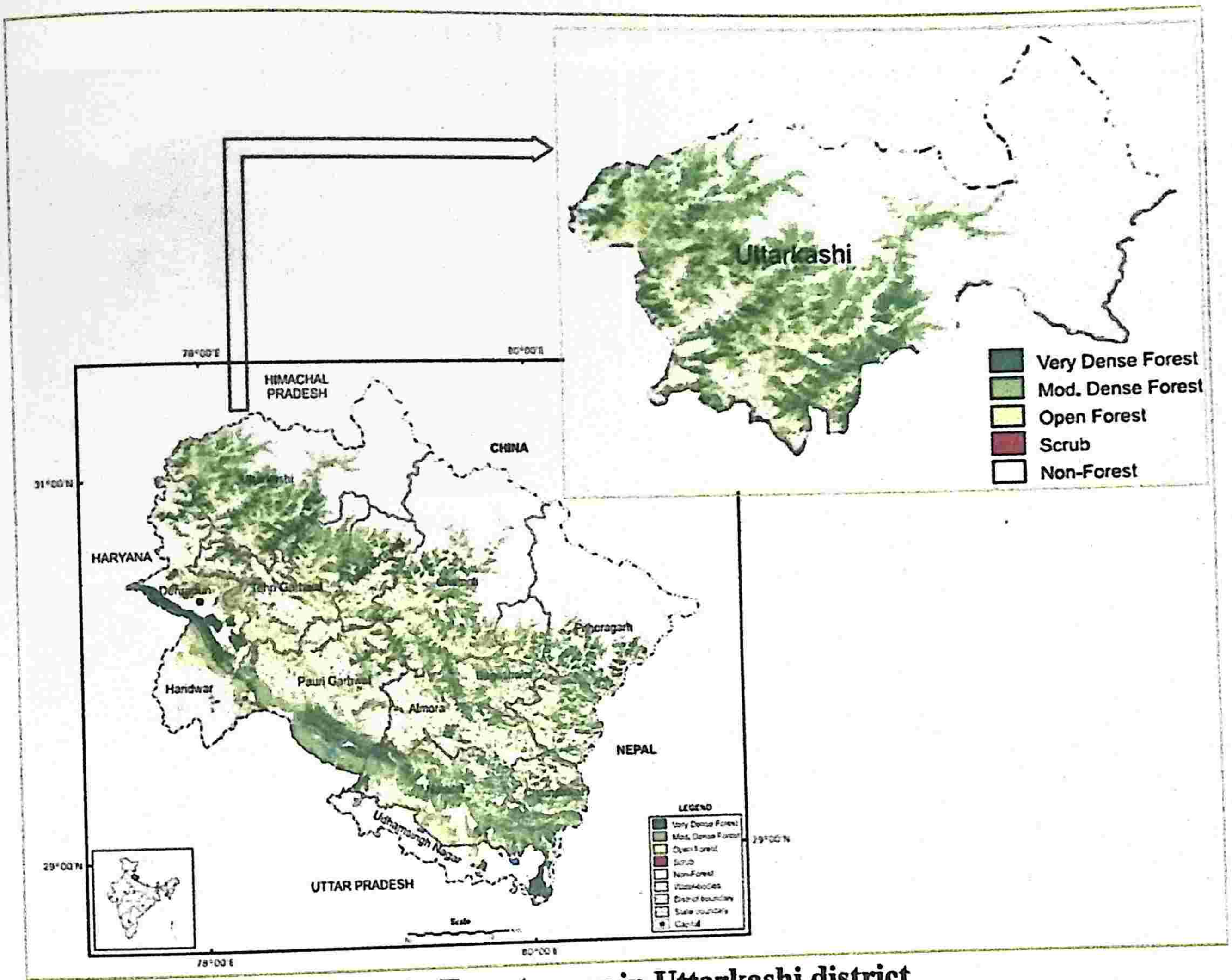
***Danthonia* grasslands (DG):** *Danthonia cachemyriana* is one of the dominant tussock forming grasses in lower and mid alpine region. Associated species are *Trachydium roylei, Jurinea dolomiaea, Iris kamaonensis, Anemone rivularis.*

***Kobresia* sedge meadow (KSM):** The south facing slopes, usually above 4000m asl support *Kobresia nepalensis* and *K. capillata.* Other species associated are *Festuca valesiaca, Aconitum violaceum, Anaphalis nubigena, Saxifraga* species.

**Cushionoid vegetation (CNV):** The higher altitudes (>4000m asl), especially snow blizzards sites are characterized by dwarf cushionoid species clinging to ground e.g., *Androsace globifera, Saxifraga* species, *Arenaria bryophylla. Saussurea obvallata* and *S. graminifolia* may appear in moist aspects which are protected from winds.

According Rawat (2005), there are about 16 *Bugyals* in the study area. The study area is known to host many high value medicinal plants *viz., Aconitum ferox, Aconitum* *heterophyllum, Aconitum lethale, Allium carolinianum, Allium humile, Allium stracheyei, Anemone rivularis, Angelica archangelica, Angelica glauca, Aquilegia pubiflora, Arnebia benthamii, Berberis aristata, Berberis asiatica, Bergenia ciliata, Bergenia stracheyi, Caltha palustris, Cinamomum tamala, Cissampelos pariera, Curcuma* sp., *Dactylorhiza hatagirea, Dioscorea deltoidea, Emblica officinalis, Geranium wallichianum, Hedychium spicatum, Jurinea dolomiea, Lilium polyphyllum, Malaxis acuminata, Meconopsis aculeata, Nardostachys grandiflora, Phyllanthus emblica, Picrorhiza kurrooa, Podophyllum hexandrum, Polygonatum cirrhifolium, Polygonatum multiflorum, Polygonatum verticillatum, Rheum australe, Rhododendron arboreum, Rubia manjith, Selinum tenuifolium, Skimmia anquetilia, Swertia chirayita, Tagetus minuta, Taxus wallichiana, Thalictrum foliolosum, Tinospora cordifolia, Trillidium govanianum, Valeriana jatamansii, Zanthoxylum armatum* (Rawat *et al.* 2004, Rawat 2005, Raut *et al.* 2010, Rawat *et al.* 2012).

**Plate 2.1**




**A: Forest cover in Uttarkashi district**

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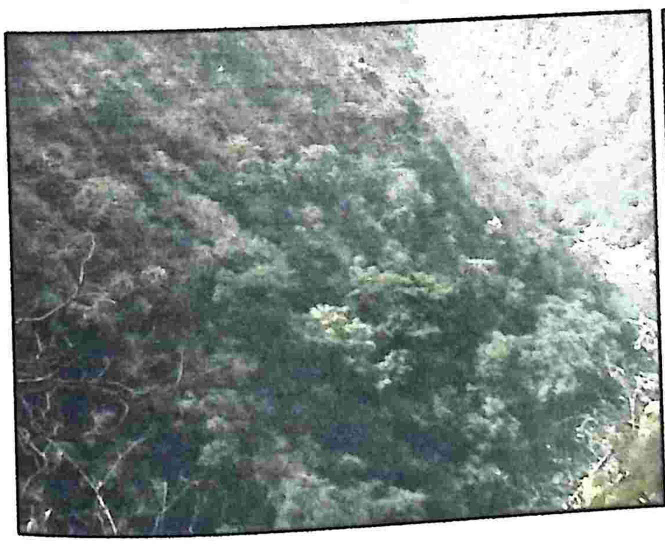
**Major vegetation types in Uttarkashi district**



**B: Miscellaneous Forest of lower elevation / Sub-tropical forest**

**C: Pine Forest / Temperate Chir Pine Forest**

**Plate 2.2**

**Major vegetation types in Uttarkashi district**

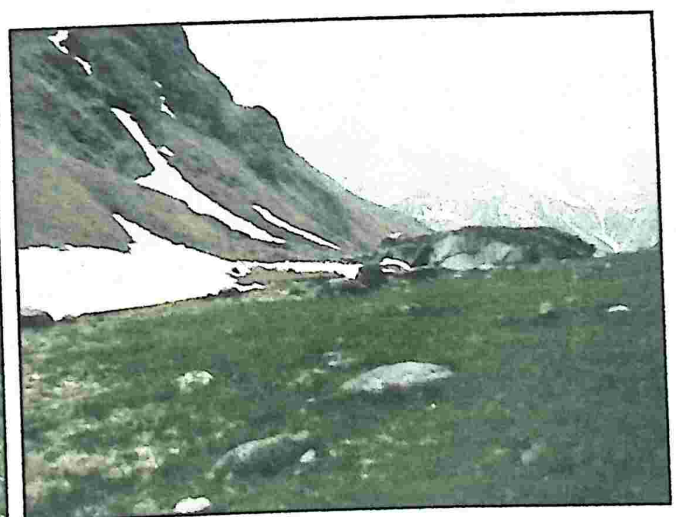
**A: Banj Oak forest**

**B: Deodar forest**

**C: Kharsu forest**

**D: Fir mixed forest**

**E: Fir forest**



**F: Alpine meadow**

# Chapter 3:
# Traditional Knowledge on Ethnomedicinal Plants

# 3.0 TRADITIONAL KNOWLEDGE ON ETHNOMEDICINAL PLANTS

## 3.1 Introduction

Traditional knowledge (TK) on plant based healthcare system assumes special significance in conserving the medicinal plants. Recognition as science and potential role in drug discovery has augmented the importance of TK. At the same time, there have been attempts to improve the TK compilation by incorporating suitable quantitative methods of research in ethnobotanical data collection, processing and interpretation instead of qualitative ethnobotanical studies that focuses on inventory of plants and their uses with little emphasis on quantitative studies (Prance 1991; Colombo *et al.* 2012). Information on folk uses is considered more reliable when it satisfies one or more of the following criteria:

1. Same or similar use of a species reported by more than one informant
2. Same use reported from different locations
3. Same use reported among different communities / ethnic groups

Whereas, for MAPs elaborate data on symptoms of disease, plant part used, plant-part-disease relationship is required (Saklani and Jain 1991; Idu 2009), documentation is further more necessary as there is a feeling that due to rapid globalization and change in lifestyle, this wisdom may erode rapidly. The Himalaya is rich in MAPs diversity due to variability in environmental and geographical conditions (Samant *et al.* 1998). This coupled with fact that it is home to many economically marginalized communities, depending heavily on the bio-resources including MAPs for their livelihood, make it extremely rich in terms of TK (Dhar *et al.* 2002). As a hilly district in the Himalayan state of Uttarakhand, Uttarkashi is no exception to this. An attempt to document the TK of Uttarkashi district is also important to understand the current status on usage of TK related to MPs.

**Objective: To document the current state of traditional knowledge on Ethnomedicinal plants among locals, along with their usage pattern in Uttarkashi district**

Based on above objective following key questions were formulated.

1. How does TK on use of herbal medicines vary across major socio-economic groups, age and gender?

2. What is the current status of TK on healthcare system among younger generation?
3. What could be the factors which govern prevalence of TK on use of MPs in the study area?
4. What is the diversity and richness of ethnomedicinal plants in the study area? How many diseases can be cured using the said plants?
5. How to prioritize ethnomedicinal plants for conservation?

## 3.2 Methodology

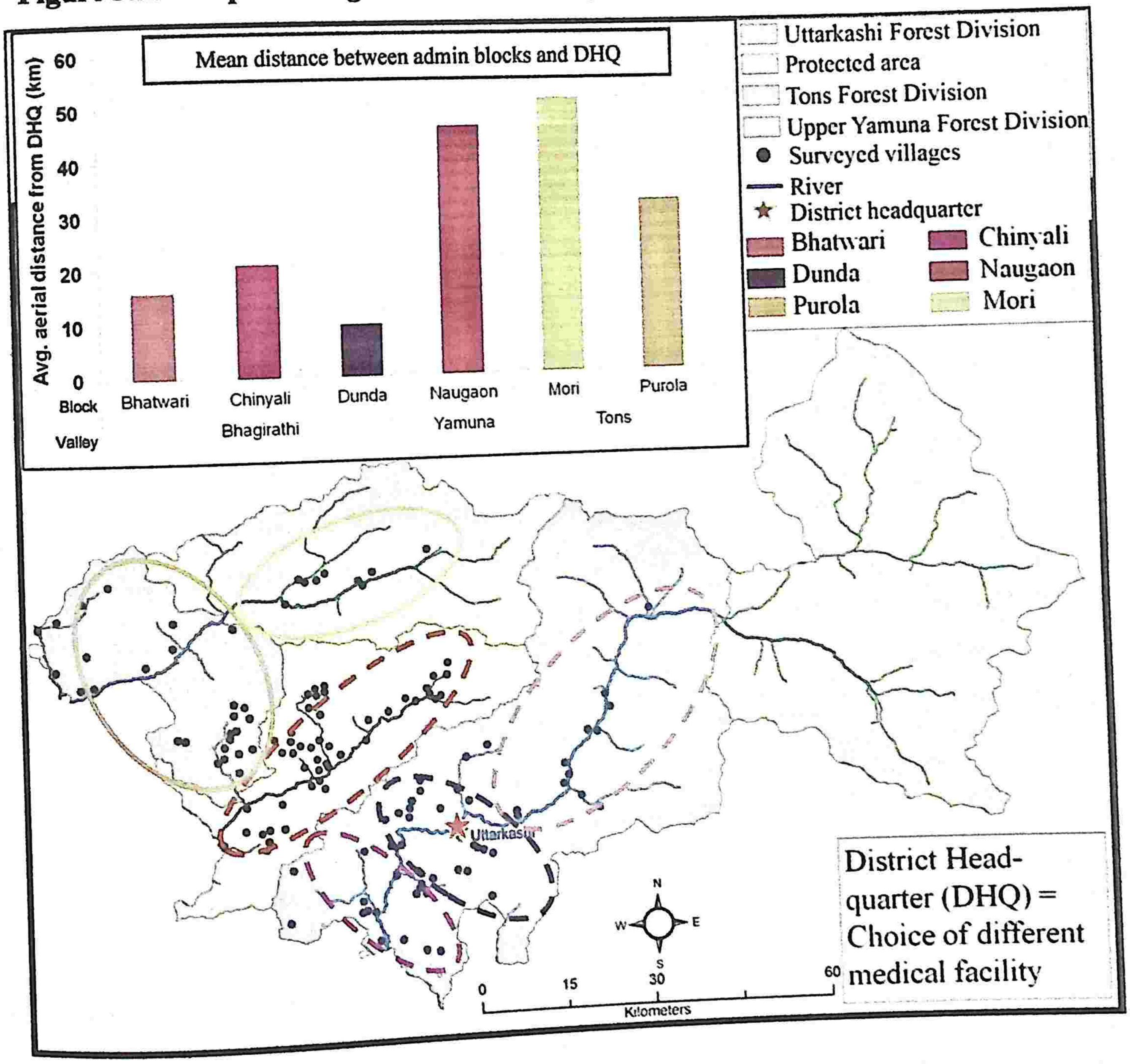
### 3.2.1 Data collection

**3.2.1.1 Stratification based on river valleys and altitudinal gradient:** The need and demand for water have been a driving force for health, society, economic prosperity, cultural significance and development throughout human history (Matsuura 2002 cited in Castelein and Otte 2002; Singh and Rana 2012). Most of the villages present in Uttarkashi are situated along river valleys (Awasthi 2001). Therefore, ethnomedicinal surveys were carried out in three major river valleys of Uttarkashi district *viz.* Bhagirathi, Tons and Yamuna. These river valleys were further stratified as per altitudinal gradient. Human habitation generally extends up to 4000m but optimum belt where majority of population lives extends only up to 2500m. On a similar note, the forest composition in Himalaya, stratifies as sub-tropical forest upto 1500m asl, warm temperate (dominant tree species Chirpine) upto 2000m asl, and cool temperate (dominant tree species Banj oak which is sparsely occur from 1500m asl) that extend till 2400m asl. In Uttarkashi villages are located from 900m asl to 2600m asl. Hence, elevation range from 900m-1500m asl was considered as **low altitudinal zone (LAZ)**, 1501m – 2000m asl as **middle altitudinal zone (MAZ)** and 2001m – 2500m asl and above as **high altitudinal zone (HAZ)**.

**3.2.1.2 Village selection:** Villages which were situated *en route* to the forests were surveyed for documenting the TK on ethnomedicinal plants (EMPs). Villages surveyed were not necessarily dependent on the nearby reserved forests. Neighbouring villages were avoided from interviewing. Overall 134 villages (20% of total) were surveyed in the entire district. In Bhagirathi valley 52 villages were surveyed whereas 41 villages were surveyed in each of Yamuna and Tons valleys (**Figure 3.1**).

**3.2.1.3 Documentation of TK on EMPs:** Total 861 respondents were interviewed during the study. Almost every fifth village *en route* to reserve forest was selected for conducting interviews (Martin 2004). Each randomly selected village was visited at least once in the entire study period. The village head, locally known as *Pradhan* (key informant), was most of the times consulted initially to gather information about presence of old medicine man or the local '*vaidyas*' in his village. Interviews of *vaidyas* were conducted, if present in the villages. Irrespective of presence and absence of *vaidyas,* in each of the surveyed village, villagers interviewed randomly while roughly maintaining a distance of 50m between respondents. An established method of 'semi-structured interviews' were carried to document TK following Martin (2004). It contains two parts – structured questionnaire and descriptive interview (**Annexure I; Plate 3.1**).

**Figure 3.1: Sampled villages and their average distance from district head quarter**




Snowball sampling, a method typically used with unknown or rare populations, was also used to locate *vaidyas* in different villages (Coleman 1958; Goodman 1961; Spreen 1992). Though this method was very useful, in most of the cases it was observed that *vaidya*, due to over-age (or death), had stopped using his/her TK on healthcare.

Interviews were recorded using digital recorder (Cenix VR-240). These recordings were later downloaded on to a computer and listened again during data entry, to complete missing information, if any.

TK holders and their knowledge (i.e. species known to them as well as number of diseases they can cure) were compared across three socio-economic groups (See Chapter 2.2.7 for more on socio-economic groups). In case of *Jadhs* and *Gujjars* small sample size is the result of small population of the communities living in the study area.

**3.2.2 Data Analysis:**

**3.2.2.1 Current Status of Traditional Knowledge**

The traditional knowledge gathered was transferred to an electronic template using MS Excel spreadsheets (MS Office 2007) and summarized using Excel's functions. The spreadsheet data filter facility was employed to determine frequencies of citation so as:

i. to conclude number and status of TK holders,
ii. to identify the most common ailments in the study area,
iii. popularly used EMPs,
iv. to determine proportions of different variables like plant families, habits (growth forms), plant part used.

**Comparison of TK across various parameters:** MS Excel (ver. 2007) was used to compare presence of TK across different valleys / altitudinal gradient, difference in TK holders across gender / age. To test the significance between the differences, $\chi^2$ test of significance was applied (Zar 2010). The respondents were classified into four age classes viz. Age 1(0-20 years), Age 2 (21- 40 years), Age 3 (41-60 years) and Age 4 (61years and above). Number of plant part-disease relationship known to each TK holder was treated as his/her TK for further quantification. For example, if respondent '$R_1$' knows that part '$P_1$' of species '$S_1$' is used to cure disease '$D_1$' then his/her TK is equal to 1. Similarly, value of TK will be 2 for the same $R_1$ if the relationship between species and diseases s/he knows is either one of these: $S_1D_2$ or $S_2D_1$; TK value 3 if $S_1D_3$ or $S_3D_1$.

**Factors governing presence of TK:** Prevalence of TK on covariates like elevation, distance from district headquarters (DfH) and medical facilities at village level (medfac) were modeled using Binomial regression (logit link and binomial errors; Fisher and Yates 1938; Long 1997). A global model was fitted by incorporating medical facilities and interactive effect of elevation and DfH. Thereafter, five candidate models were fitted indicating various plausible hypotheses regarding these predicted effects on TK. The best hypothesis was selected by information theoretic approach (AICc value; Akaike 1974). Analysis was performed, using software R (version 3.0.0; R core team 2013). Elevation and distance from district head-quarter (DfH) was considered as indicators of availability of more medicinal plants, closeness to forest, remoteness and unavailability of medical facility. Number of respondents interviewed and TK holders of them, in the surveyed villages, were considered as the independent variables (i.e., presence of TK holders versus absence of TK holders). Elevations of villages were recorded during the field work with the help of GPS (Garmin 72). The data on DfH was extracted using ArcGIS software (version 9.3; ESRI 2011). Data from district Chief Medical Officer's (CMO) office and Census of India (2001) was used for availability of medical facilities at village level, it consisted mainly data on presence of any hospital, dispensary or even primary or community healthcare centers.

**3.2.2.2 Ethnomedicinal plants (EMPs) of Uttarkashi District**

**EMPs - observed v/s expected:** Species richness estimator - Chao 1 - was used to predict (i) the number of EMPs are used by locals of Uttarkashi to cure diseases and (ii) the number of diseases (Chao 1984, 1987). Species accumulation curve analysis was performed in EstimateS: version 8.2.0 (Colwell 2009).

**Prioritization of EMPs:** More than one method is often necessary to address research questions (Hoffman and Gallaher 2007). Therefore, in present study, different methods were compiled together to calculate Use Value (UV) index of EMPs. For each species, responses from respondents, parts used and their value, ability to cure diseases (no. of diseases in which that plant species is used; **Annexure II**), were considered to calculate UV by using following formula,

$$\mathbf{UV = RV + DV + PU + PV}, \text{ where,}$$

RV = Response value; DV = Disease value; PU = no. of Parts used; PV = Part value

**(Table 3.1)**

Based on the above formula UV of all EMPs were calculated and given in **Annexure III.** Top five EMPs, from each altitude zone, were prioritized based on their high UV (**Table 3.5**) for further analysis (population status and habitat suitability) of other objectives.

**Table 3.1 Calculation of Use Value using modified formula based on various methods given in literature**

| | |
|---|---|
| **Response Value (RV)** | **Response value = Total Respondents for Species/Total TK holder** (modified from Phillips and Gentry 1993a,b; Rossato *et al.* 1999; Gómez-Beloz 2002; Silva and Albuquerque 2004; Albuquerque *et al.* 2006) |
| **Disease Value (DV)** | No. of ailments cured by each species (Gómez-Beloz 2002) |
| **Parts Used (PU)** | Number of parts used for curing all diseases (Albuquerque *et al.* 2006) |
| **Part Value (PV)** | Underground parts (e.g. Roots, Rhizome) and whole plant rated highest value = 3; Use of stem = 2; Use of any other part (Flower, Fruit, Leaves) = 1 (Dhar *et al.* 2000; Kala *et al.* 2004) |
| **Use Value** | **UV = RV + DV + PU + PV** |

In concurrence of vegetation changes in Himalayas, mainly due to altitude variation, people's preference of using MPs might be changing. Therefore, UV was calculated separately for each altitude gradient.

## 3.3 Results

### 3.3.1 Current Status of TK and variation in its presence

Respondents from 62 (46.27%) villages shared that they possessed TK on therapeutic uses of EMPs. Even though respondents from almost half of the surveyed villages possess TK, within village, respondents possessing TK were less.

Out of 861 interviewed respondents only 31% respondent possess TK and only 0.93% practice it for self-medication as well as for others (**Figure 3.2**).

**3.3.1.1 Source of TK**: Majority of the TK holder (i.e. 85%) gained this knowledge from their parents, 10% gained from other TK holders or *vaidya* and 5% acquired it from books (**Figure 3.3**). Some respondents gained this wisdom from multiple sources. Thirteen respondents gained TK from their parents as well as other elderly person from the village. Two respondents achieved this TK from books as well as from other elderly person of the village, whereas only two respondents gained TK from all three sources.

**Figure 3.2: Possession of TK in the Uttarkashi district as shown by an interview survey (n=861 respondents)**

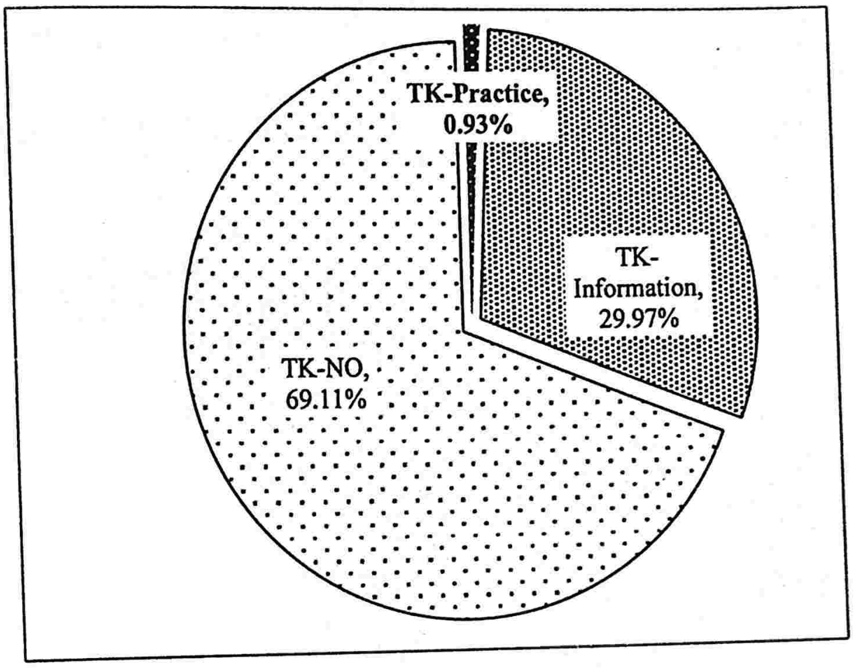
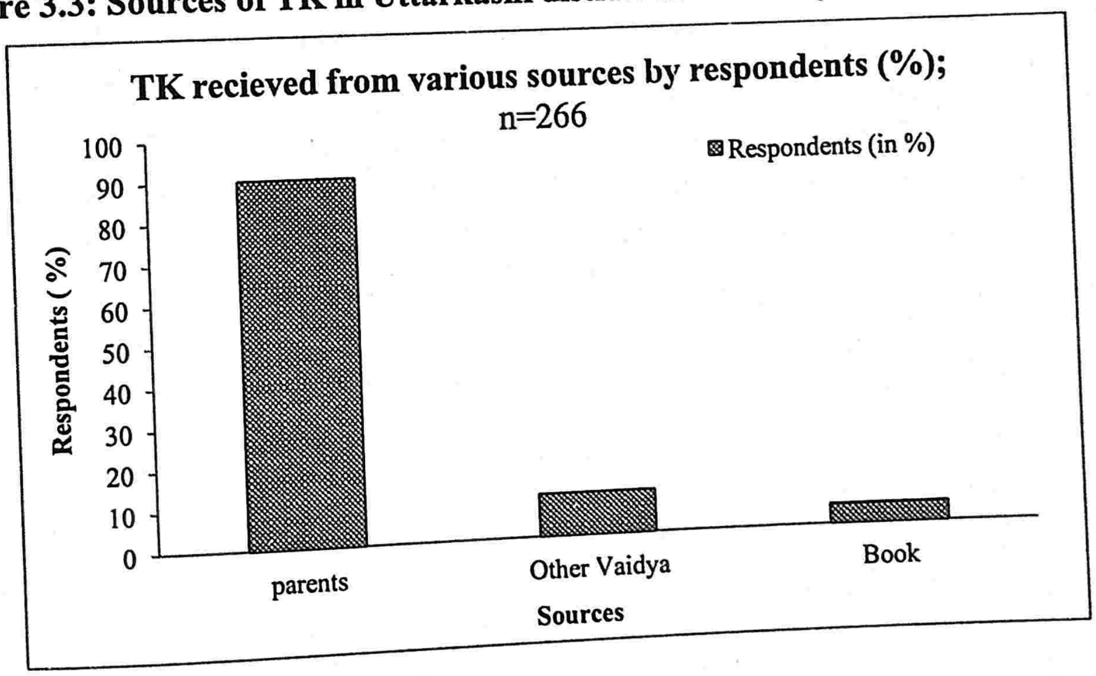



**Figure 3.3: Sources of TK in Uttarkashi district as shown by an interview survey**




**3.3.1.2 Role of gender and age in possession of TK:** Almost similar percentage of respondents from both genders shared that they possessed TK but more male respondents from age group 40-60 years and more female respondents from age group 60-80 years had TK related to healthcare. The chi square test results show that this difference was significant ($\chi^2 = 40.9$; df = 3, $p < 0.01$; **Figure 3.4**).

Male respondents were aware of 55 therapeutics while that of females were aware of 40. Among the males Age group 1 and 2 were aware of 30 therapeutics as against 55 among Age group 3 and 4. The similar trend reflected in female respondents where, therapeutics known to Age group 1 and 2 was 19 as against 40 in Age group 3 and 4. Thus there was a significant difference in TK of respondents from Age group 3 and 4 and those from Age group 1 and 2, irrespective of gender, in terms of plants parts used in various diseases ($\chi^2$ = 19.433, df = 3, $p < 0.01$; **Figure 3.5**).

**Figure 3.4: TK holders of Uttarakashi - Age wise difference**

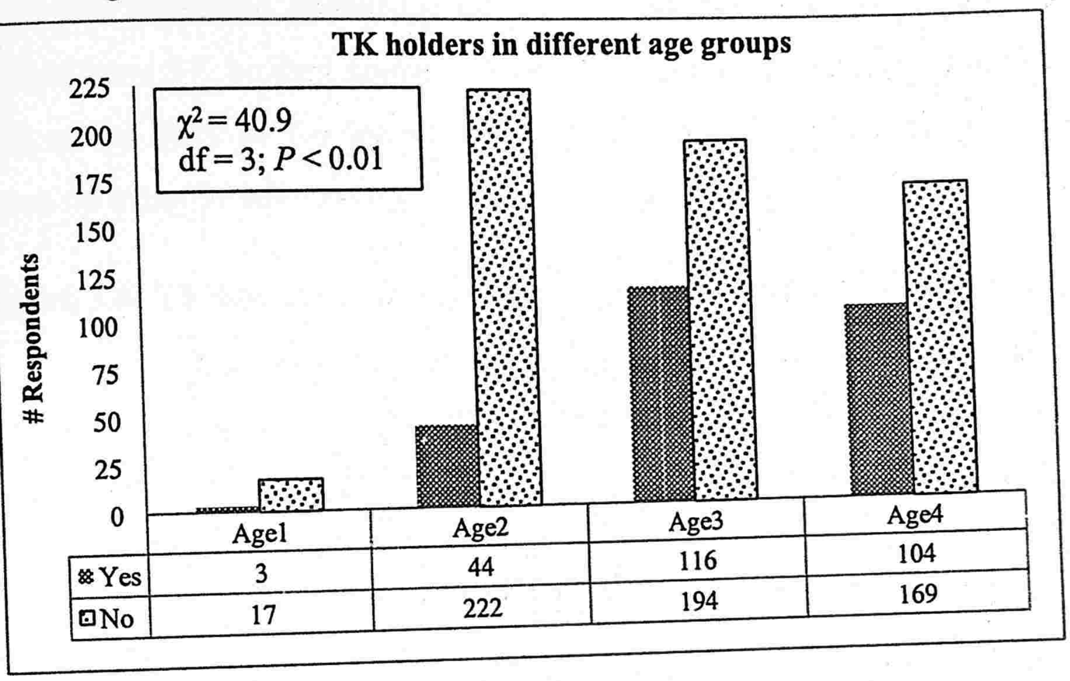
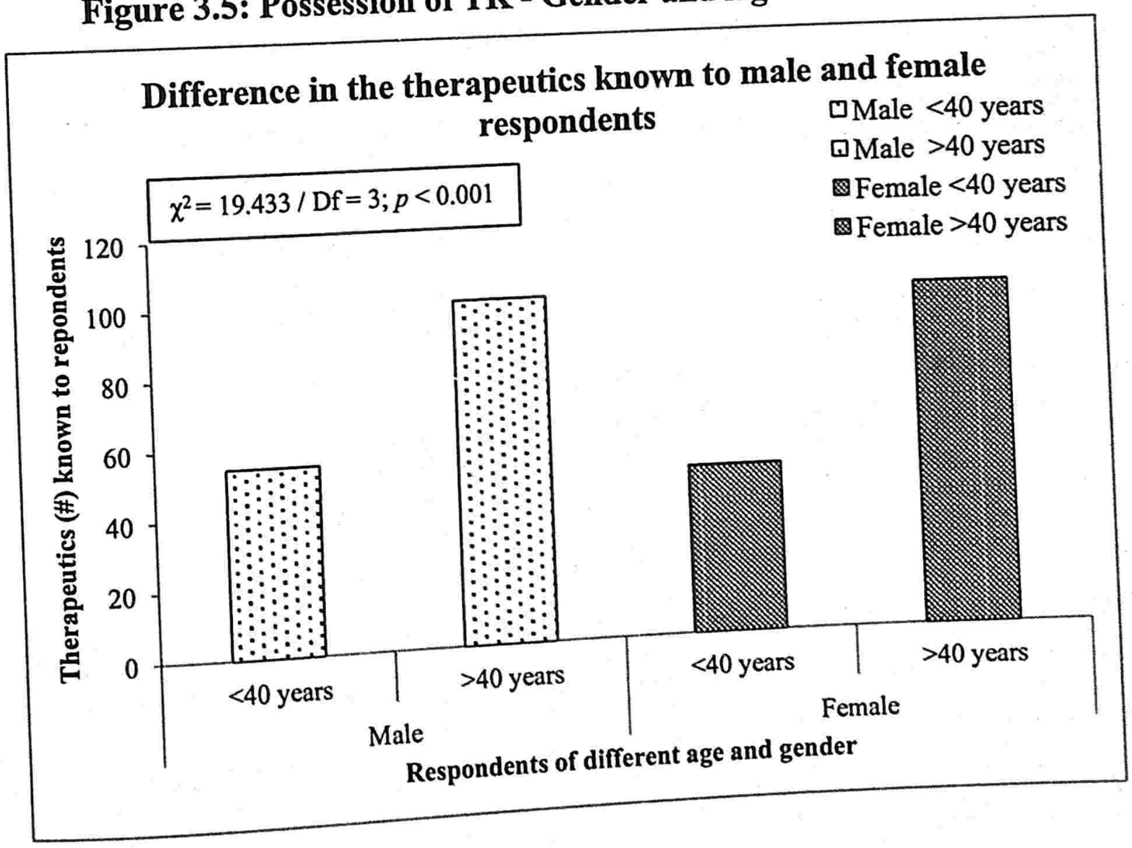


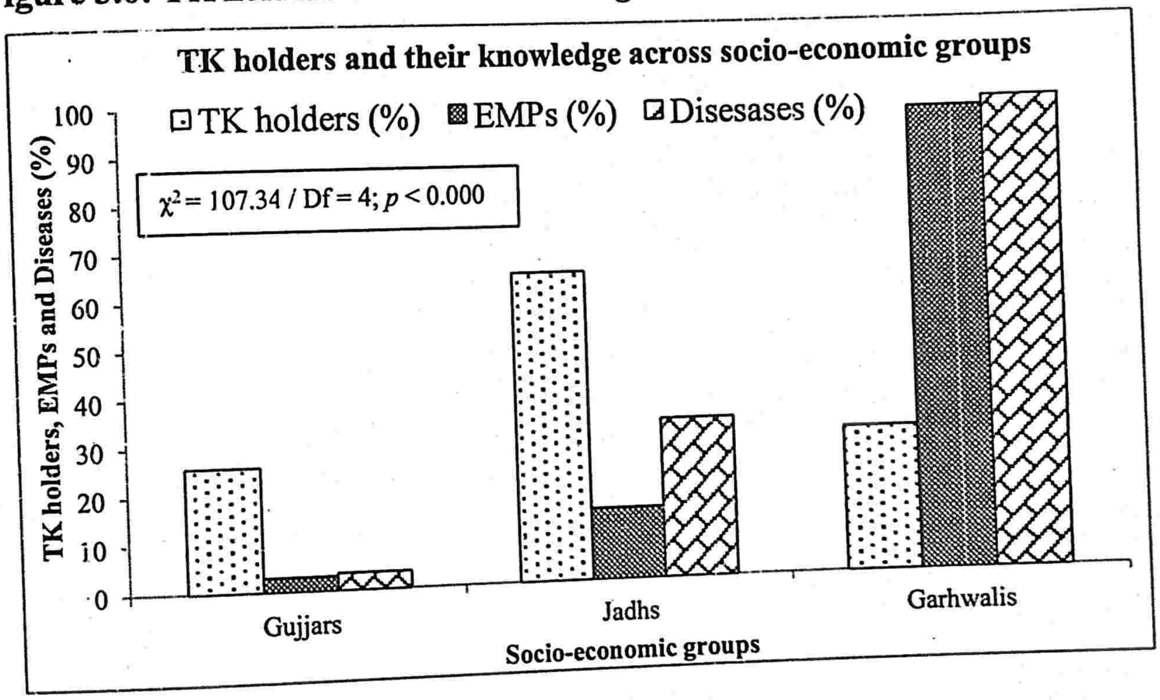

**Figure 3.5: Possession of TK - Gender and Age wise difference**



**3.3.1.3 TK holders and their knowledge across socio-economic group:**

TK holders and their knowledge (i.e. species known to them as well as number of diseases they can cure) were compared across three socio-economic groups (See Chapter 2.2.7 for more on socio-economic groups). In case of *Jadhs,* about 64% respondents were TK holders and possessed knowledge on using 15 EMPs to cure 19 ailments whereas 25% *Gujjars* were TK holders knowing 3 EMPs for curing 2 ailments. In case of other Garhwalis, about 30% of the interviewed respondents are TK holders and possessed information on using 99 MPs to cure 57 ailments. **(Figure 3.6)**

**Figure 3.6: TK holders and their knowledge across socio-economic group**




**3.3.1.4 TK status across altitude zones:** Study revealed that in all the three study valleys respondents who possessed TK are more at higher altitudes, especially above 1800m **(Figure 3.7)**. Not only all the respondents, from villages of Bhagirathi and Tons valleys, situated at higher altitude, acquired TK, but also all surveyed villages had presence of TK holders. All the surveyed villages in HAZ of Bhagirathi and Tons valley had presence of TK holders, with 100% respondents as TK holders. TK holders were more in villages from MAZ of Tons as compared to the other valleys. No TK holders were observed in villages at LAZ in Yamuna valley. **(Figure 3.8)**

**Figure 3.7: TK holders (%) across altitude gradient**

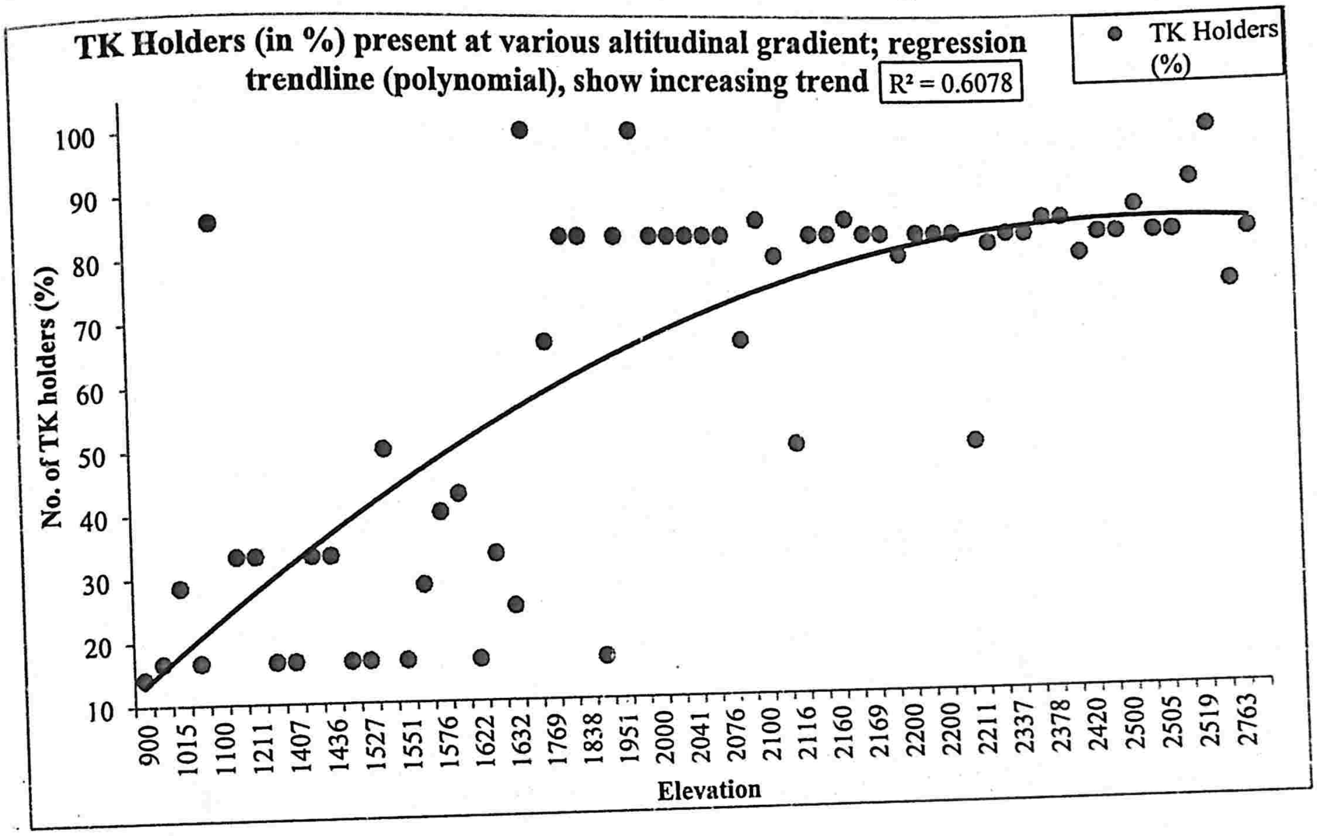
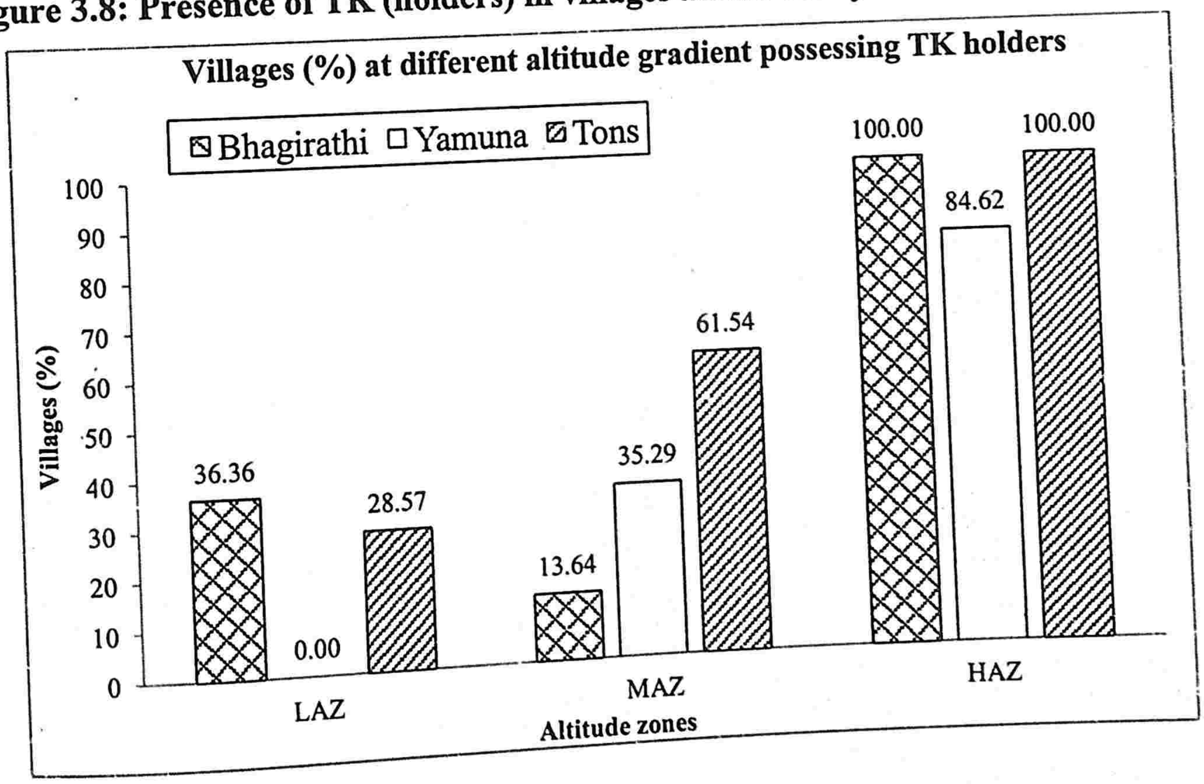



**Figure 3.8: Presence of TK (holders) in villages across valleys and altitude gradient**




**3.3.1.5 Depletion of TK**: Only 22.5% i.e., 60 respondents (n=266) revealed that they had pass TK to the next generation in response to the question whether they have passed this shared / passed this knowledge with their children (next generation). The sub-question, whether their children were utilizing this TK, revealed that only 8.33% of new generation, who received TK (n=60), were keen to use this knowledge (**Figure 3.9** and **3.10**). Thus, TK in the region is depleting.

**Figure 3.9: Use and transfer of TK (by present TK holders and young generation)**

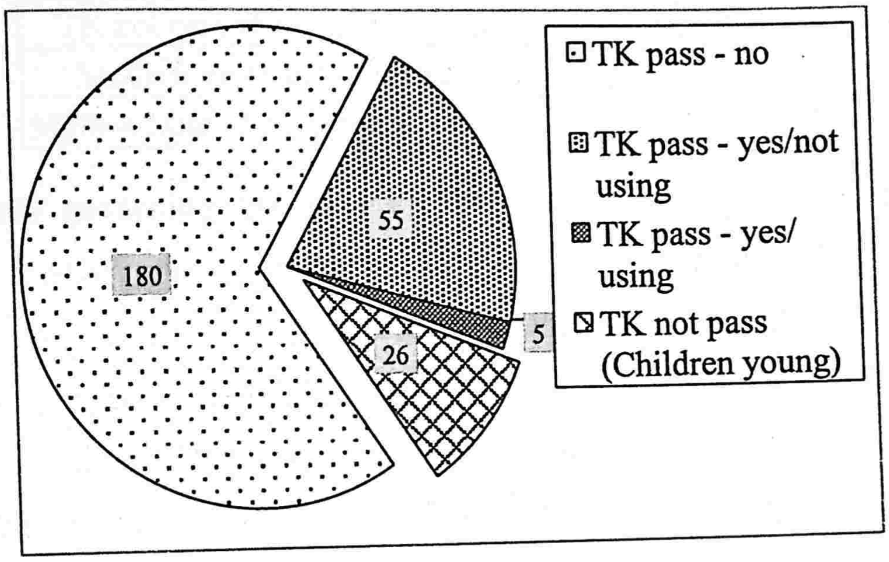
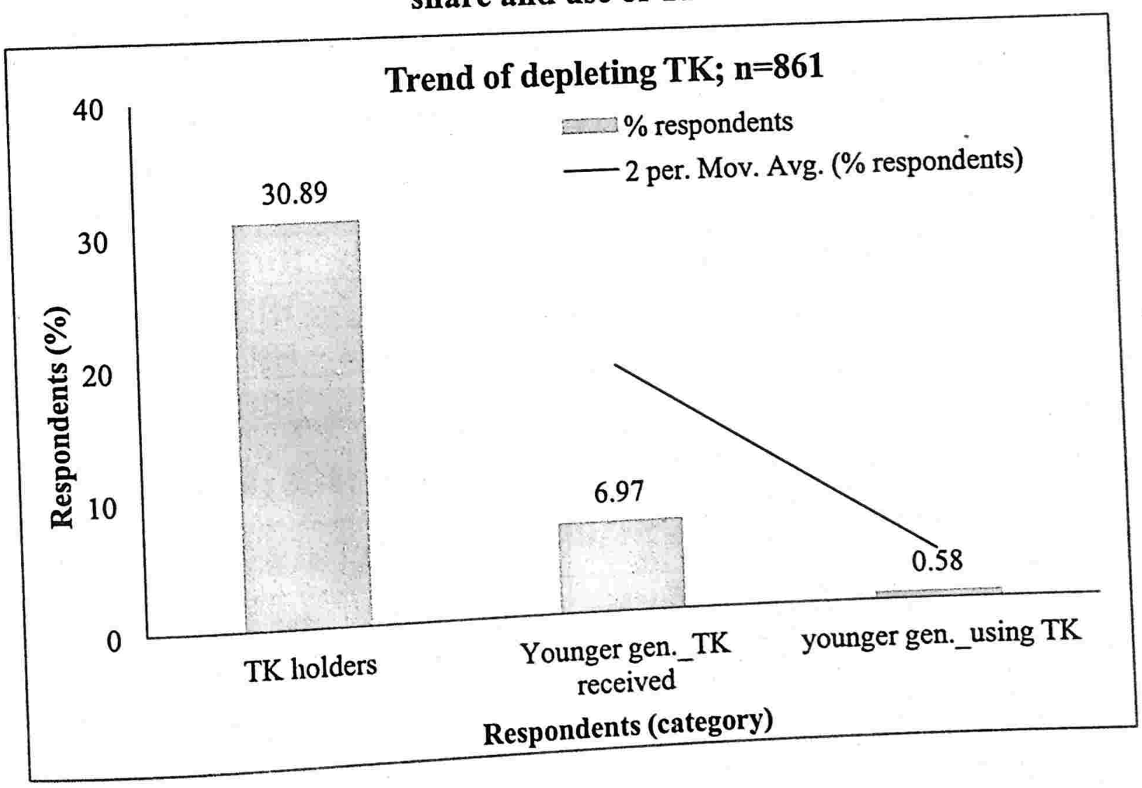



**Figure 3.10: Depletion of TK: Percentage of TK holders and TK holders willing to share and use of TK**




**Reasons of depleting TK:** Majority of respondents (93%) opined that TK had eroded. Major factors claimed by respondents were: loss of interest (82%), TK has not been passed by older generation (29%), availability of medical facility (28%), depletion of MPs (39%) and a myth about destruction of wisdom (6%). **(Table 3.2)**

**Table 3.2: Reasons of TK erosion – Locals' perception**

| Reasons | Respondents (%) |
|---|---|
| Loss of interest | 82 |
| No MAPs around | 39 |
| TK not passed by older generation | 29 |
| Modern medical facility present | 28 |
| Myth = Loss of effectiveness of MAPs | 6 |

**3.3.1.6 Factors governing presence of TK:** Out of the models on TK, the one incorporating the DfH and elevation obtained maximum support from data (Akaike wt. ~ 0.74). Both covariates had positive effects. Note that there was no correlation between elevation and distance to head-quarter, so the results describe realistic effects. The R-sq value of this model is 0.59 (which is reasonably high). Results showed that prevalence of TK was high in high elevation and farther away from district head-quarter, as hypothesized (**Table 3.3 a, b and c**).

**Table 3.3a: Modeling TK prevalence in a village as a binomial response against different covariates in general linear model (GLM)**

| Covariates incorporated in GLM | Sequence of models generated |
|---|---|
| Elevation | 1 |
| DfH | 2 |
| **Elevation + DfH** | 3 |
| Elevation * DfH | 4 |
| Elevation + DfH + Medfac | 5 |
| Elevation * DfH + Medfac | 6 |

**Table 3.3b: Best model selection based on AIC value**

| Model no. | (Int) | Elevation | DfH | Medfac | df | logLik | AICc | ΔAICc | Akaike weight |
|---|---|---|---|---|---|---|---|---|---|
| 3 | **-7.468** | **0.003161** | **0.03506** | | **3** | **-242.994** | **492.2** | **0** | **0.741** |
| 4 | -7.455 | 0.003155 | 0.0352 | -0.01279 | 4 | -242.984 | 494.3 | 2.11 | 0.259 |
| 1 | -6.627 | 0.003225 | | | 2 | -257.565 | 519.2 | 27.05 | 0 |
| 2 | -1.761 | | 0.03531 | | 2 | -361.551 | 727.2 | 235.02 | 0 |
| glm(formula = cbind(TK, No_TK) ~ Elevation + Dist_HQ, family = binomial, data = dat); **R-sq = 0.59** | | | | | | | | | |

**Table 3.3c: Parameter estimates for the best model**

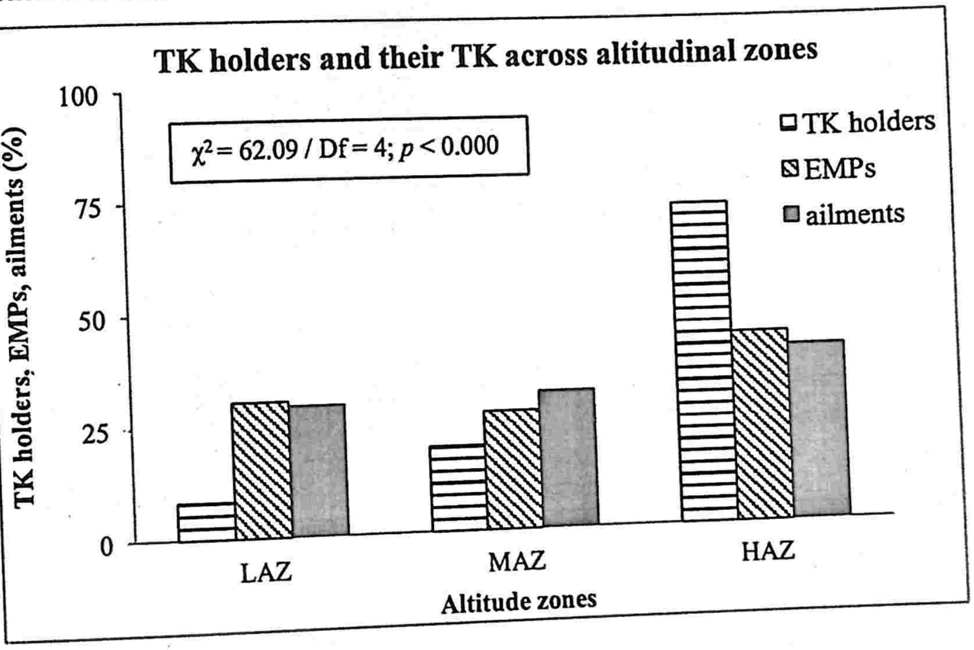
| Coefficients: | Estimate | SE | z value | *p* |
|---|---|---|---|---|
| (Intercept) | -7.468 | 0.5112074 | -14.609 | *** |
| Elevation | 0.0032 | 0.0002441 | 12.95 | *** |
| DfH | 0.0351 | 0.0065888 | 5.321 | *** |
| | Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 | | | |

### 3.3.2 Ethnomedicinal plants of Uttarkashi

#### 3.3.2.1 Ethnomedicinal Plants (EMPs) observed and expected:

Locals of Uttarkashi used total 101 EMPs for treating 57 ailments. Twenty two respondents belonging to LAZ (800-1500m), used 50 EMPs to cure 36 ailments whereas 51 respondents from MAZ (1501-2000m) were well verse of 44 species that can cure 38 diseases. HAZ (2001-2500 and above) has maximum TK holders i.e. 193 and they know about 71 EMPs that can cure 49 ailments. (**Figure 3.11**)

**Figure 3.11: Distribution of TK holders and their TK in different altitude zones**




But, according to Chao 1 asymptotic species richness estimator predicted that locals of Uttarkashi were expected to use 108 species to cure 62 diseases (**Figure 3.12** and **3.13**). Even though the saturation was achieved in both the cases, expected values were slightly more than observed values (7 in case of EMPs and 5 in case of ailments) of EMPs and diseases. This was justifiable as, some respondents mentioned few plants which are toxic and unintentional consumption of such plants could lead to death, but intentional use of such plants (e.g., *Coriaria nepalensis*) to cure any diseases were not reported by any of the respondents and thus, such plants were not considered for any analysis. In another case, it was critical to assess as some respondents shared that *Aconitum ferox*, in very small amount, which is of medicinal value whereas many mentioned it as 'poisonous'. So, it was treated as having medicinal value for treating any ailment wherever it was mentioned, while responses as 'poison' were removed during the analysis.

**Figure 3.12: No. of diseases cured by the respondents (Chao 1 species richness estimator)**

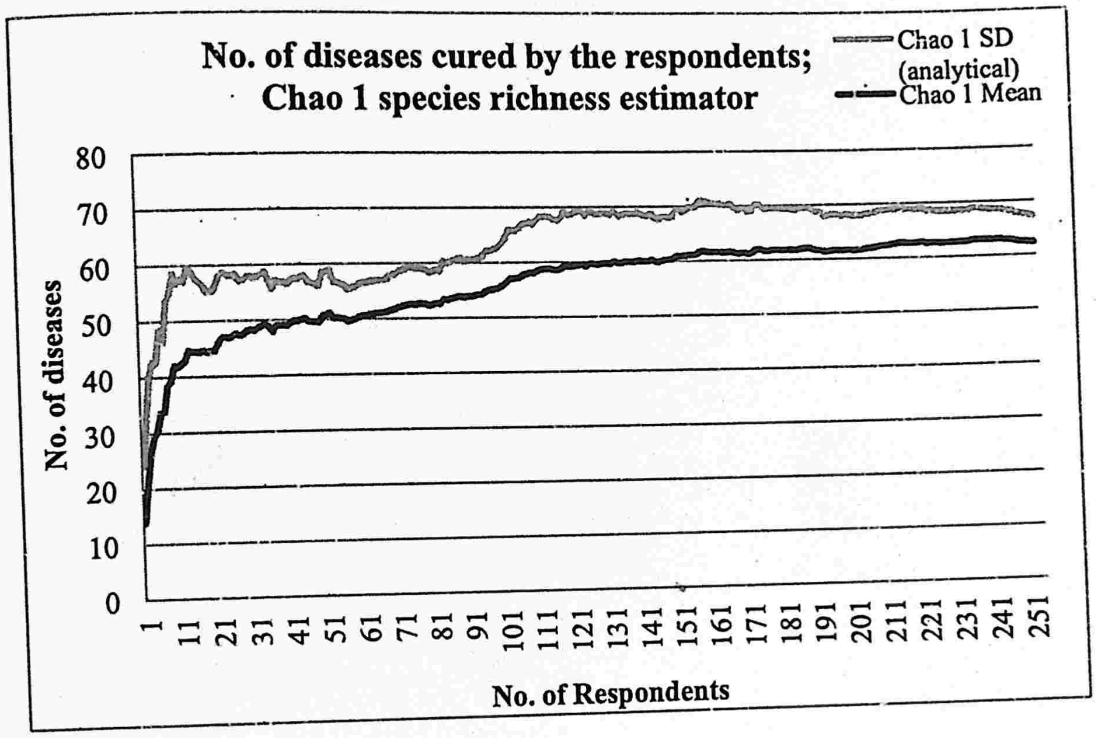
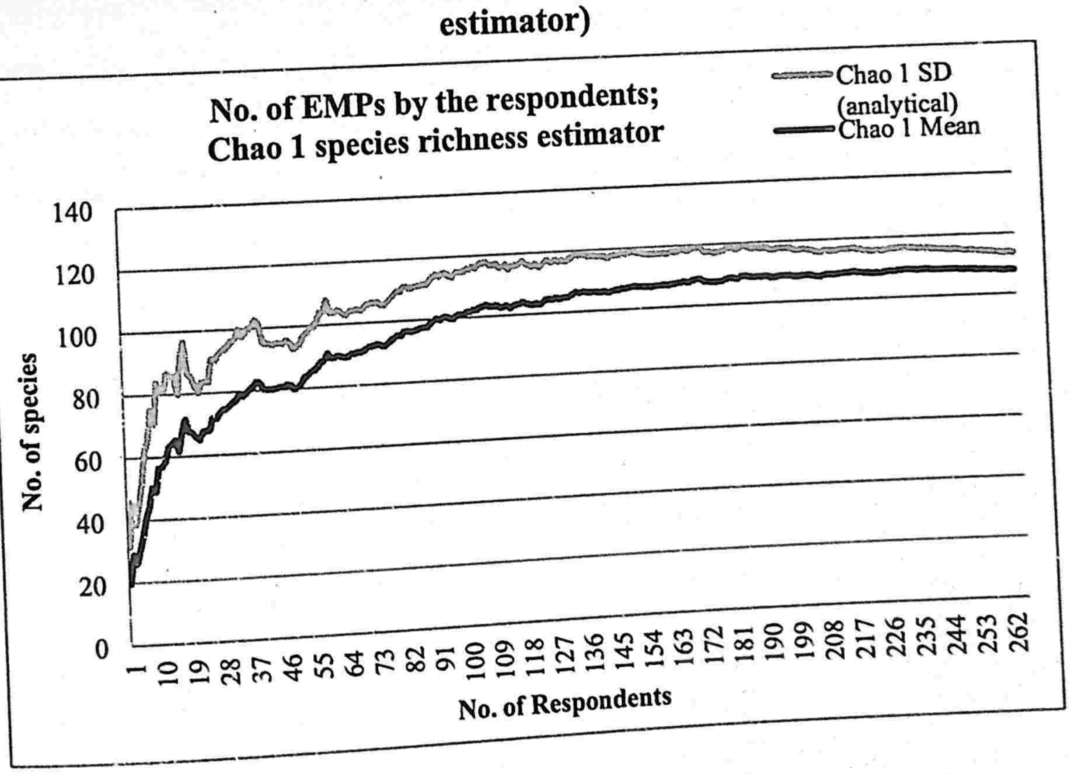


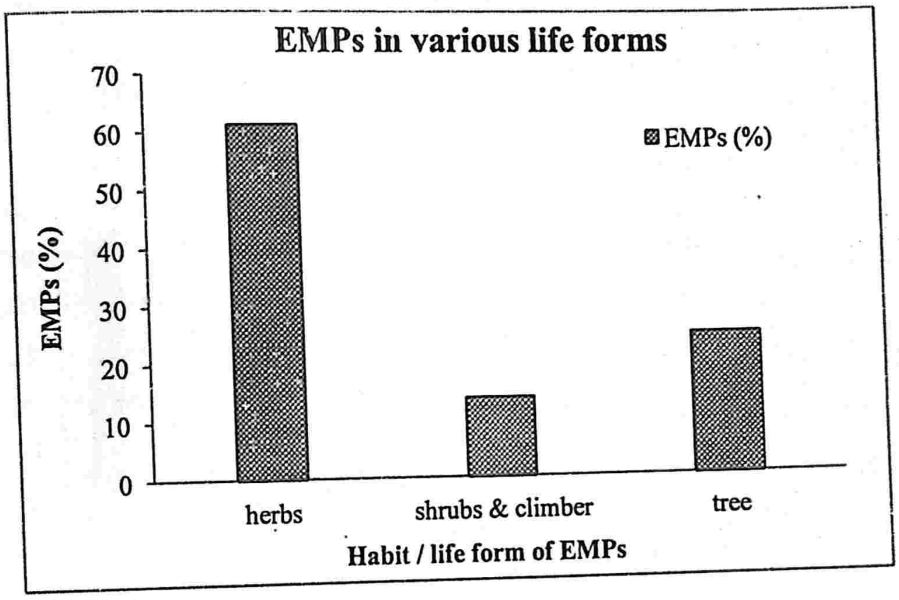

**Figure 3.13: No. of EMPs used by the respondents (Chao 1 species richness estimator)**




**Maximum used EMPs:** Analysis of the data revealed that, at LAZ, maximum respondents mentioned about *Berberis aristata* for being used followed by *Zanthoxylum armatum* followed by *Picrorhiza kurrooa*. At MAZ, the sequence is *Aconitum heterophyllum*, *P. kurrooa* and *B. aristata*; whereas at HAZ, *A. heterophyllum*, *P. kurrooa* and *Dactylorhiza hatagirea* are maximum used EMPs **(Table 3.5)**

**Life forms (Habit):** Out of 101 EMPs, 62 species are of herbs (and grasses), 14 are of shrubs and climbers whereas 25 are of tree species. **(Figure 3.14)**

**Figure 3.14: Distribution of EMPs across various life forms**




**3.3.2.2 Useful parts:** At LAZ, leaves of maximum species were used whereas root/rhizomes were slightly less used. Considerable numbers of EMPs were cited for use of their barks. In middle and higher altitude zones 'root' of maximum species were used followed by leaves. In the entire district, use of root/rhizome of 70 EMPs and leaves of 60 EMPs were reported **(Table 3.4)**. Use of roots of many plants puts pressure on the wild population of these plants. At LAZ, four parts of *Z. armatum* and at HAZ, three parts of *J. regia* are used **(Table 3.5)**.

**Table 3.4: Usage of plant parts in different altitude zone**

| Part | LAZ | MAZ | HAZ | Total |
|---|---|---|---|---|
| Bark | 8 | 3 | 5 | 16 |
| Entire plant | 0 | 0 | 2 | 2 |
| Flower | 4 | 2 | 3 | 9 |
| Fruit | 6 | 2 | 1 | 9 |
| Latex / resin | 1 | 0 | 1 | 2 |
| **Leaves** | **20** | **18** | **22** | **60** |
| **Root / rhizome** | **16** | **21** | **33** | **70** |
| Seed | 1 | 2 | 8 | 11 |
| Stem | 2 | 3 | 6 | 11 |
| Stem gall | 0 | 0 | 2 | 2 |

### 3.3.2.3 Traditional knowledge on use of ethnomedicinal plants:

TK holders of Uttarkashi were known to cure 57 ailments. Majority of respondents were aware about curing common symptoms such as fever, cold, cough, healing wounds, stomach-ache, etc. using these MPs (**Figure 3.15 and 3.16**).

**Figure 3.15: Top 10 diseases known to respondents of Uttarkashi**

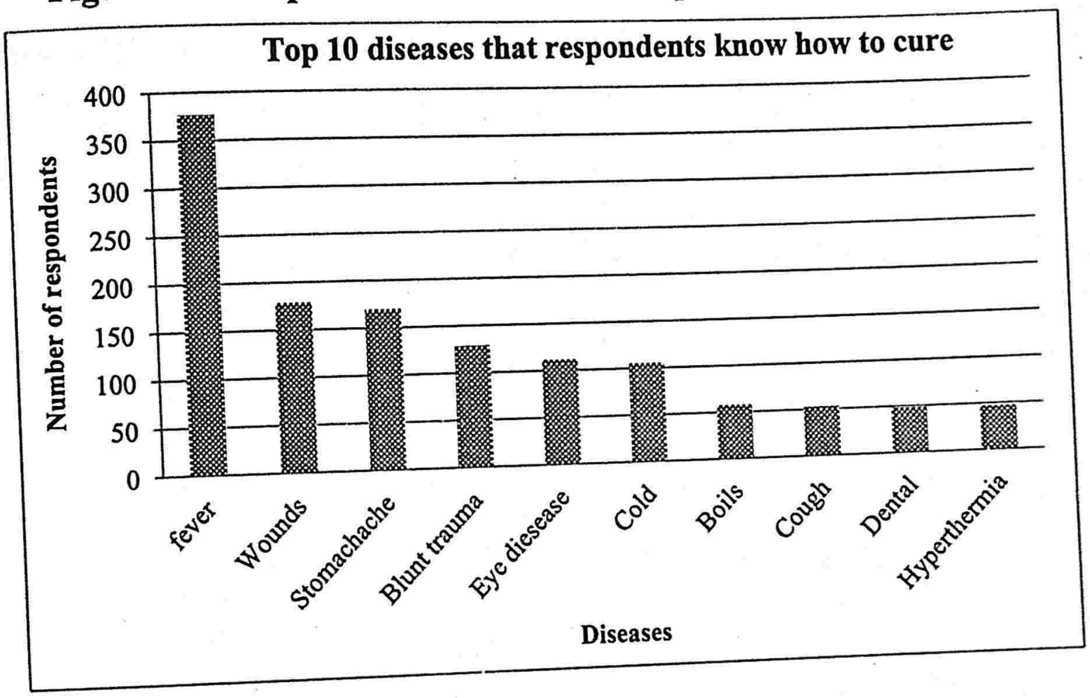
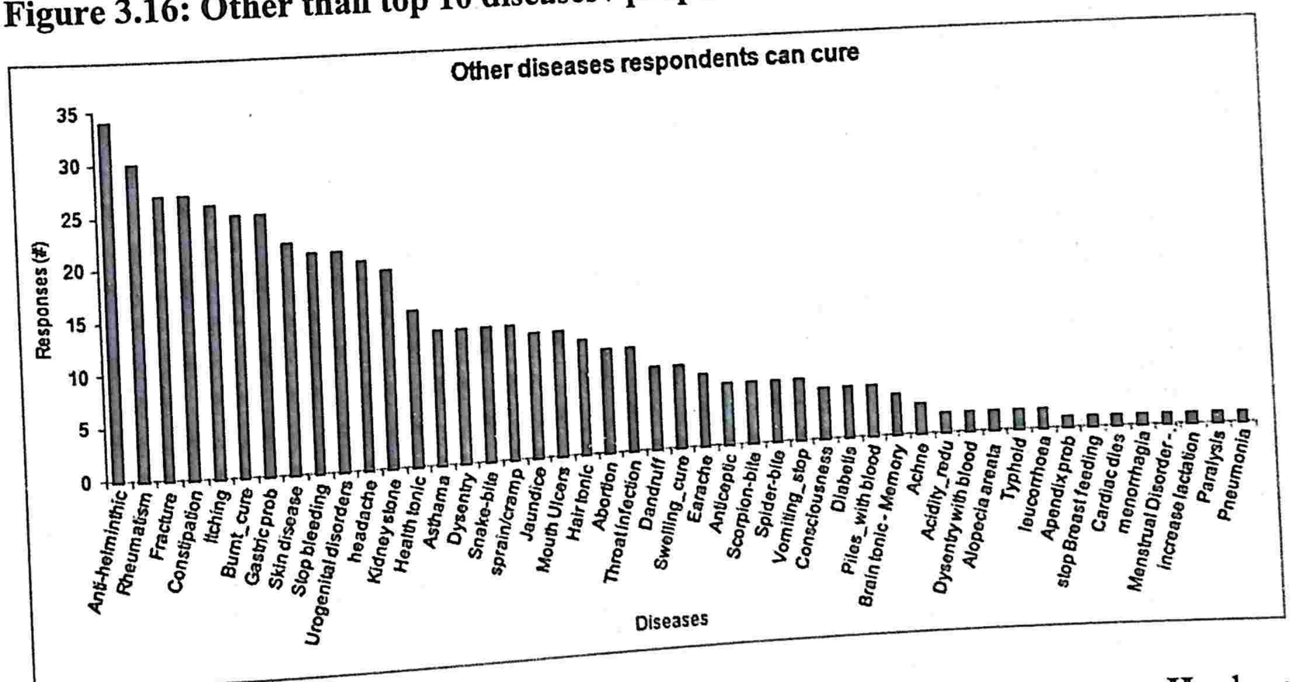



**Figure 3.16: Other than top 10 diseases / properties that are known to respondents**




The in details uses of each EMPs recorded in Uttarkashi is given in **annexure II**, along with its distribution and habit. It was observed that many plants that were traditionally used for curing ailments in the past are not being used now (**Annexure III**). During the survey respondents practicing TK related to EMPs were currently found to use only 46 species of EMPs as against 95 MPs traditionally. The TK was used as cure in 51 diseases as against 41 at present.

At LAZ, *Z. armatum* was used to cure maximum diseases (4). At MAZ, *Senecio nudicaulis* (7) and at HAZ, *A. heterophyllum* and *P. kurrooa* (7 each) were found to cure maximum diseases (**Table 3.5**).

**Maximum EMPs used to cure diseases:** Study showed that most EMPs (20) were used to cure boils followed by fever (17); **Figure 3.17** shows first 10 diseases on the basis of number of EMPs were used as cure.

**Figure 3.17: Number of EMPs used to cure top 10 diseases**

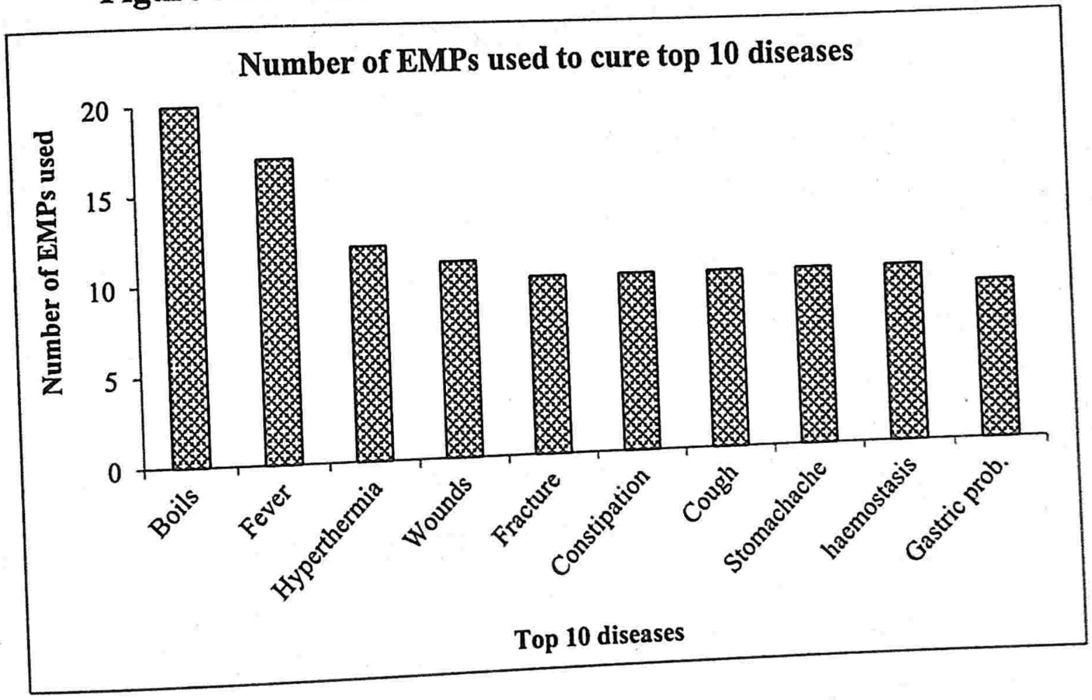



**Table 3.5: Top three species in each category at various altitude zones**

| Altitude zone | Species | Respondents (#) | Species | Diseases cured (#) | Species | Parts used (#) |
|---|---|---|---|---|---|---|
| LAZ | *B. aristata* | 10 | *Z. armatum* | 4 | *Z. armatum* | 4 |
| | *Z. armatum* | 9 | *V. pilosa* | 4 | *Q. leucotrichophora* | 2 |
| | *P. kurrooa* | 8 | *R. australe* | 3 | *D. salicifulia* | 2 |
| MAZ | *A. heterophyllum* | 34 | *S. nudicaulis* | 7 | *S. nudicaulis* | 2 |
| | *P. kurrooa* | 32 | *P. kurrooa* | 6 | *Z. armatum* | 2 |
| | *B. aristata* | 27 | *A. heterophyllum* | 4 | *V. pilosa* | 2 |
| HAZ | *A. heterophyllum* | 180 | *A. heterophyllum* | 7 | *J. regia* | 3 |
| | *P. kurrooa* | 166 | *P. kurrooa* | 7 | *V. pilosa* | 2 |
| | *D. hatagirea* | 125 | *O. vulgare* | 7 | *G. wallichianum* | 2 |

The popularity of plant among respondents, number of diseases cured and the number of plant parts used varied across the altitudinal gradient. The demand for a few species in TK overlapped through the altitudinal gradient (**Table 3.5**).

#### 3.3.2.4 Prioritization of EMPs:

Based on formula given in **Table 3.1**, UVI at three different altitude zones was calculated for each species cited by respondents (**Annexure III**) with and top five EMPs, from each altitude zone, were selected for further analysis (**Table 3.6**).

**Table 3.6: High Use Value EMPs in different altitude zones**

| LAZ | UV | MAZ | UV | HAZ | UV |
|---|---|---|---|---|---|
| *Zanthoxylum armatum* DC | 13.409 | *Senecio nudicaulis* Buch.-Ham. ex D.Don. | 13.157 | *Aconitum heterophyllum* Wall. | 11.933 |
| *Verbascum thapsus* L. | 8.136 | *Picrorhiza kurrooa* Benth. | 10.627 | *Picrorhiza kurrooa* Benth. | 11.860 |
| *Rheum australe* Don | 7.363 | *Aconitum heterophyllum* Wall. | 8.667 | *Geranium wallichianum* D.Don ex Sweet | 11.078 |
| *Aconitum heterophyllum* Wall. | 7.182 | *Dactylorhiza hatagirea* (Don) Soo | 8.431 | *Juglans regia* L. | 11.042 |
| *Quercus leucotrichophora* A. Camus | 7.136 | *Berberis aristata* DC | 7.529 | *Viola pilosa* Blume syn. *V. serpens* Wall. | 11.016 |
| **(Plate 3.2 and 3.3)** | | | | | |

Except for three EMPs, *viz.*, *S. nudicaulis*, *V. thapsus* and *Q. leucotrichophora*, all other species are in trade.

#### 3.3.2.5 Interesting and unique uses (observations):

a. Anti-microbial properties and many other uses of *Nardostachys jatamansi* (commonly known as *Jatamansi*) and *Junrinea dolomea* have been researched but during present study it was observed that people have forgotten this treasure and found that these two species (roots and rhizomes) are mainly used for fumigating purpose – *Dhoop* – for their incense without much knowledge about their medicinal effects.

b. *Solanum anguivi* (syn. *Solanum indicum*) was reported be used as abortifacient by three respondents (one female and two males) during the current study in Tons valley. Though the method was very crude and all respondents explained exactly the same method (it was made sure through discussion that they were not even distant relatives).

### 3.4 Discussion

#### 3.4.1 Current Status of TK and variation in its presence

Even in the past common knowledge is held by most people in a community but older people have different types of knowledge than the young (Langill and Landon 1998). This was evident even in the present study, with majority of the TK holders from age group of 40 years and above. The difference in TK on healthcare does not lie in the way of EMPs used but elderly people acquire more knowledge in terms of number of diseases and EMPs. Though the use of TK on healthcare has been practiced in daily life by most people in study area, this practice did not form the primary income source for the local traditional healers. Hence the next generation is not keen to forward the tradition. In some cases it was observed that the older generation did not pass on the TK due to myth that sharing of TK would result in MPs losing their medicinal effect. This has further restricted the number of TK holders.

It was observed that when human beings have very little access to modern medical facilities the use of TK on healthcare increases. Many villages in the study area are situated far from road head and inaccessibility in such areas has been identified as the main reason for lack of deployment of health staff (GoUK 2011). The community hence faces dual losses as despite the lure of the modern medical facilities, the health system is not fully equipped in the region. The data from District Chief Medical Office (CMO) shows that district has one district hospital, 2 rural female hospitals, 2 Community Health Center (CHCs), 5 primary health centers (PHCs), 6 Additional Primary Health Center (APHCs), 22 State Allopathic Dispensary (SADs) and 81 sub centers to serve the population of about three lakhs, residing in 686 villages (NHSRC 2008; NRHM 2008; Planning Commission 2009). In addition, there are 46 Ayurvedic and 5 Homeopathic dispensaries in the district. These facilities might be enough to cater for the needs of the locals but the real scene is not that eulogizing. About 59% of the positions, apart from key management posts, were vacant in the hospitals. The vacancy in posts of supporting medical staff and field workers for hospital was 49% and 43% respectively. Twenty-seven of 81 established sub-centres were nonfunctional. (Source: District CMO Office 2007; Planning Commission 2009). These figures corroborate with the findings from the study that TK is not dependent on the presence of medical facilities but on the remoteness represented by elevation and distance from main city.

Change in life style is the one of the cause of change in attitude of people towards the use of traditional healthcare (Uniyal *et al.* 2003). There is apathy about TK among younger generation. Many traditional medicines (i.e., EMPs) are available in their backyards but they were not preferred against *safed goli* (modern medicine). The source of allopathic medicine may be known or unknown to locals but their easy availability and faster effect has lured them. In fact, the shepherds going to high altitude now-a-days carry modern medicines along with them to cure many common diseases (**Plate 3.1 D**). It was also observed that, many times, these medicines were not prescribed by certified doctor but referred by someone who has used them. The study revealed that the *Gujjar* community that practiced pastoralism and spent maximum amount of time in various forests was less aware about TK on healthcare than other communities.

The lifestyle change has changed the outlook towards collection of medicinal plants. It was observed that many EMPs have been collected from wild were not for using at home but for sale in the market; a similar observation was recorded by Uniyal *et al.* (2002b). Before commercialization of the herbal sector, even the wild collection of MPs was made in proper season. Previously, many high-value MPs, found at high altitudes of Himalaya, were collected towards the onset of winters (roughly September – October) but in order to increase the economic benefits, now the collection starts in the month of July itself (Awasthi and Uniyal 2003; Uniyal *et al.* 2009). This is leading locals to dangerous predicament. On one hand, people still depend on forest for their basic needs and overexploit forest resources for short term economic gains. On the other hand they go for high-value market products which not only cause ecological degradation but are also detrimental for long term economic sustenance (Uniyal *et al.* 2002b, 2003; Awasthi and Uniyal 2003).

Generally, herbaceous plants contributes larger portion of MPs than shrubs and trees (Dhar *et al.* 2000; Planning Commission 2000; Uniyal *et al.* 2002a, b; Kala *et al.* 2004). Similar to these studies, except Kala *et al.* (2004), present study recorded more medicinal tree species than medicinal shrubs. This might be due to the considerably larger area is under pine forests which lacks diversity of understory species (Singh and Singh 1987). Owing to availability of many high market value EMPs and to their demand, more studies were undertaken in high altitude areas of the state. Alpine MAPs / EMPs that are already in trade have high demand in the market. The **Table 3.7** shows the trade figures for the high value EMPs of which, the annual consumption of four EMPs *viz.*, *A. heterophyllum*, *P. kurrooa*, *V. pilosa* and *B. aristata* is more than 200 MT.

**Table 3.7: Demand and supply of High Use Valued EMPs**

| Species name | Annual Consumption (in MT) | Demand (in tonnes) | Annual Trade (in MT) | Price (Rs./kg.) |
|---|---|---|---|---|
| *A. heterophyllum* | 210 | 192 (1999-00); 410 (2004-05) | 200 – 500 | 2000-4000 |
| *D. hatagirea* | N.A. | N.A. | N.A. | N.A. |
| *G. wallichianum* | N.A. | N.A. | N.A. | N.A. |
| *P. kurrooa* | 416 | 172.8 (1999-00); 317.0 (2004-05) | 200 – 500 | 220-230 |
| *R. australe* | N.A. | N.A. | 500-1000 | 25-30 |
| *S. nudicaulis* | N.A. | N.A. | N.A. | N.A. |
| *V. thapsus* | N.A. | N.A. | N.A. | N.A. |
| *V. pilosa** | 292 | N.A. | 200-500 | 300-350 |
| *B. aristata* | 521 | 890 (1999-00); 1805 (2004-05) | 500-1000 | 15 -30 |
| *Z. armatum* | N.A. | 19.5 (1999-00); 22.5 (2004-05) | N.A. | 20 -30 |
| *J. regia* | N.A. | N.A. | N.A. | N.A. |
| *Q. leucotrichophora* | N.A. | N.A. | N.A. | N.A. |
| * = Including few other species of *Viola* | | | | |
| **(Adapted from)** | (Ved and Goraya 2008) | (CERPA 2001) | (Ved and Goraya 2008) | |

Many of the high valued species are endemic to IHR if not to western Himalaya (Dhar 2002; Kala *et al.* 2004). Kala *et al.* (2004) documented 300 MPs used in curing 114 ailments from Uttarakhand. In later study covering three districts of the state Kala (2007) documented 34 MPs used in curing 30 ailments. Uniyal *et al.* (2002b), documented 85 MPs in Bhagirathi valley and in their subsequent study in the same area, depletion in the number of MPs was reported (Uniyal *et al.* 2003). Their study revealed that out of 31 MPs they had documented, people are actually using only 9 MPs and 22 were traditionally used. But, it was interesting to know that dynamic nature of TK has reverse side too. Some exotic species considered by many research scholars, for example, *Ageratina adenophora* syn. *Eupatorium adenophorum* (Pradhan 2000; Tiwari and Rajwar 2010; Singh *et al.* 2011; GISD 2012) were mentioned for its usage by respondents of Uttarkashi. Change in people's lifestyle due to ongoing economic development and modernization of infrastructure was considered a factor leading to erosion of overall TK

(Agarwal 1997; Maikhuri *et al.* 2001). The reason for depletion in use of MP was attributed to easy availability of medical facility and medicines through urbanisation of rural areas (Uniyal *et al.* 2003; Raut *et al.* 2012).

**3.4.2 Pressure on EMPs:** Almost all previous studies documented that underground parts i.e., roots and rhizomes, are the most used parts (Kala *et al.* 2004; Rawat 2005). But usage of these parts have raised the concerns, as usage of underground parts of MAPs involves uprooting of entire plant which increases negative impact of extraction on their population by manifolds (Uniyal *et al.* 2009). The erosion of TK can put pressure on existing EMPs population. Traditionally there were many EMPs to cure similar diseases. However loss of TK has restricted the number of EMPs. The present study has shown that the existing knowledge of 46 EMPs if far cry from traditional 95 EMPs.

**3.4.3 Use value of EMPs:** Quantitative techniques in ethnobotany, such as comparison between uses, cultural importance etc., are of great scientific interest. In Uttarakhand very few studies have prioritized MPs on the basis of various parameters. Most of the time such parameters were related to geographical distribution, population status and rarity (Uniyal *et al.* 2002a; Rawat 2005) and rarely related to usage by respondents, parts used etc. (Dhar *et al.* 2000; Kala *et al.* 2004). These quantitative techniques, after incorporating local demand for MPs, would serve important not only to prioritize species but people can be motivated to conserve such species (Dalal 1996; Albuquerque *et al.* 2006). Therefore, present study can play a critical role, in conservation of MAPs in the region, by identifying high-value species. Furthermore, plants valued in local or regional herbal preparations may differ from those that reach international markets, with many of the former having restricted local importance because of their traditional use, ready availability, low or absent cost and ease of preparation (Ibarra-Manrıquez *et al.* 1997).

**3.4.4 Protection of Traditional Knowledge related to healthcare:** The term 'traditional' used in describing TK does not imply that, this knowledge is old or non-technical in nature, but it is tradition-based; the way in which it is created, preserved and disseminated which, in a way, reflects the traditions of the communities (WIPO 2002). But, globally, many examples proved that this traditional way of preserving and disseminating has been led to misappropriation of TK and/or biological material from communities (Hansen and VanFleet 2003). This means there are concerns that, most of the times, TK on healthcare is being used and patented by third parties without the prior informed consent of TK holders and/or communities in which this knowledge originated and exists. Therefore, it became important to protect and document TK to stop bio-piracy. But even after getting theoretical protection under various international agreements such as, Universal Declaration of Human Rights (UDHR; article 27) in 1948 and Convention on Biological Diversity (CBD; article 8-j) TK remained unprotected due to its intangible nature. One kind of protection is by means of asserting an intellectual property rights (IPR), such as patent, copyrights or trade secret. In case of TK related to MPs does not fall within any of these established categories. Western intellectual law, which is rapidly assuming global acceptance, often unintentionally facilitates and reinforces a process of economic exploitation and cultural erosion (Hansen and VanFleet 2003). On the other hand, the use of technology, including biotechnology, to develop a useful product using TK is generally protected under categories mentioned above. Yet there are chances of TK being protected under similar categories through IPR and one of them is a 'TK Registries' which supports *sui generis* protection systems under defensive protection (Kutty 2002; UNCTAD 2005). Such TK registries can be private or public. Public registries place information in the public domain but information on private registry which is not accessible to public may not constitute to prior art capable of preventing a patent based on knowledge by an outsider (Hansen and VanFleet 2003).

As a unique example for this type of protection, India had developed Traditional Knowledge Digital Library (TKDL), the reason for development TKDL was nothing but a bad experience from patent cases of Turmeric, Basmati and Neem in western countries (Hansen and VanFleet 2003; UNCTAD 2005). Through TKDL, India is capable of protecting some 0.226 million medicinal formulations and at zero direct cost. Access to the database helps patent examiners root out those applications which clearly do not satisfy the novelty requirement at an early stage. Without a TKDL database, the process of revoking a patent can be a costly and time-consuming affair. It takes, on average, five to seven years and costs between 0.2-0.6 million US dollars to oppose a patent granted by a patent office. Multiply this by India's 0.226 million medicinal formulations and it is clear that the cost of protection, without a TKDL, would be prohibitive (Gupta 2011a).

### 3.4.5 Interesting uses of EMPs

An important dilemma in ethno-medico-botanical studies is validation of the treatment. The repeated report of use of a plant against particular disease/s would be one indicator. But particular plant could be a part of secret formulation known only to a healer. Such a dilemma was encountered at Tons valley, where use of *S. anguivi* was reported as abortificient by three respondents. The method reported was precisely same, despite the respondents being spatially far apart and unrelated. The species and the use had not been reported in any of the studies carried hitherto. Further investigation revealed that two crude method of abortion existed. One where the practitioner is aware of the chemical constituents of the plant, which on contact with uterus results in abortion. In second (rather dangerous) method, any pointed material like plant part or metal object is use to dislodge the immature fetus from the uterus lining (Guillaume and Lerner 2007; pers. comm. Dr. Napalchyal (2009), Medical Officer at Dunda, Uttarkashi and Dr. Ameya Patil (2010), General Practitioner at Mumbai). The details provided by the respondents, confirmed that they were unaware about phytochemicals but the selection of *S. anguivi* was due to TK received from parents. The decline in number of locals opting for such abortion might be due to availability of medical facilities in towns, awareness about proper / hygienic methods at hospitals and reduced shyness to visit doctors for such reasons.

### 3.5 Conclusion

#### 3.5.1 Variation in TK:

i. TK holding was age specific, with the older generation (40 year and above) possesing almost double TK than that with younger generation (below 40 years). Thus the older generation is the custodians of TK.
ii. The TK holding was not gender specific, with 30.99 % men and 30.69% female TK holders among all the respondents.
iii. The number of Jadhs respondents were less in number but they had more number of TK holders (64.71%). The Gujjars and other locals formed 25.71% and 30. 4% of the TK holders.

#### 3.5.2 Current status of TK:

i. Among 861 respondents, only 30% were TK holder and 1% practiced it. The 22.5% of TK holders, passed their knowledge to next generation. Only about 8.33% of young generation, who received TK from parents, was ready to use. This indicates depletion of TK.
ii. The lack of interest in next generation was major reason for depletion of TK.

#### 3.5.3 Factors governing TK:

i. Villages situated at higher elevation in all valleys and Tons valley, indicates that TK is influenced by remoteness, underdevelopment and availability of MPs. A binomial model confirmed the results that prevalence of TK was high in high elevation and farther away from district head-quarter; due to shortage of staff, mere presence of medical facility in villages does not influence absence of TK. Presence of more TK holders in Tons valley could be reasons of marginal development of the region owing to less tourism due to absence of places of attractions and infrastructure. The prevalence of TK was dependent on altitude and the distance from district headquarters.

### 3.5.4 Ethnomedicinal plants and prevalent diseases:

i. 101 MPs were recorded that can cure 57 ailments during the study. There is a decline in number of plants used to cure known diseases. Herbs constitute greater use, followed by trees and then shrubs in TK related to EMPs. Roots and rhizomes followed by leaves are more preferred parts in TK. Commonly cured diseases were boils, fever, healing wounds, cough, gastric and digestion related disorders.

### 3.5.5 Prioritization of ethnomedicinal plants

i. Based on the UV of species calculated across three altitude zones, five species from each zone, totaling to 12 EMPs were selected as high value species.

ii. It is difficult to protect TK under IPR through patent and copyright. However, defensive mode of protection can prevent third parties from patenting based on TK that is already documented and available in public domain to crosscheck.

**Plate 3.1**

**Documentation of TK by conducting semi-structured interviews in villages**

A: Identification of EMPs by traditional healer

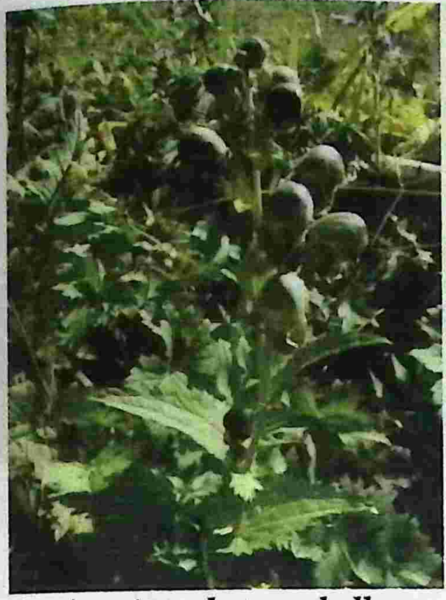
B: Identification of dried plant parts by a *Jadh* respondent

C: Collection of Information on TK related to healthcare in highest situated village (Osla 2600m asl) in study area

D: A respondent showing allopathic medicine

**Plate 3.2**

**High Use Value Ethnomedicinal Plants of Uttarkashi District-I**



A: *Aconitum heterophyllum*

B: *Dactylorhiza hatagirea*

C: *Picrorhiza kurrooa*

D: *Berberis aristata*

E: *Geranium wallichianum*

F: *Juglans regia*

G: *Quercus leucotrichophora*

**Plate 3.3**

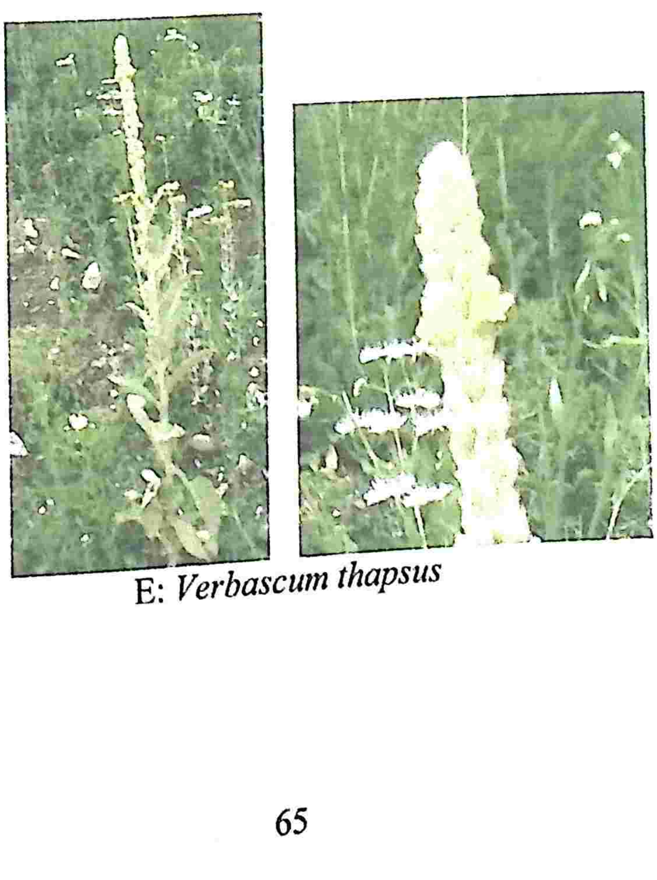
**High Use Value Ethnomedicinal Plants of Uttarkashi District-II**

A: *Viola pilosa*

B: *Zanthoxylum armatum*

C: *Rheum australe*

D: *Senecio nudicaulis*



E: *Verbascum thapsus*

# Chapter 4:
# Population Status of High Value Ethnomedicinal Plants

# 4.0 POPULATION STATUS OF HIGH VALUE ETHNOMEDICINAL PLANTS

## 4.1 Introduction

The Himalaya is well known for rich array of high value medicinal and aromatic plants (MAPs) since ancient times which are evident from literature on healthcare systems (Sarin 2008). Out of about 1750 MAPs found in Indian Himalayan region (IHR), *ca.* 300 MAPs are in high demand from herbal industries and are exploited heavily (Samant *et al.* 1998, Ved and Goraya 2008). Other MAPs are used locally and may have similar therapeutic use that of many high value endangered MAPs. The importance of herbal sector in the development of hill region was recognized as early as 1950s by then government of Uttar Pradesh (U.P.). Accordingly, several initiatives were taken towards development of herbal sector thereby opening the scope for bio-prospecting through further research. The importance of the sector was identified long back in the late 1940s, soon after independence of India, by the then Government of Uttar Pradesh (U.P.) under the leadership of first Chief Minister, Pt. G. B. Pant. He took several initiatives towards development of herbal sector in U.P. hills (present Uttarakhand) such as establishment of *Bheshaj Vikas Yojana* (medicinal plants development scheme) under the department of cooperatives. Cultivation of high value MAPs was highly prioritized during 1960s but outcome was not promising (Rawat *et al.* 2012). Need of separate research institute dealing with MAPs was felt in 1980s and so Herbal Research and Development Institute (HRDI) was established in Gopeshwar (Uttarakhand) under the state horticulture department. Uttarakhand, after being carved out of erstwhile Uttar Pradesh in year 2000, saw the paradigm shift in the approach of development from agriculture centric to integrated forest and rural development based. Since major portion of the state is hilly and unfavourable for agricultural activities, rich forests were thought to sustain local livelihood, if managed sustainably and scientifically. The newly created state possessed highest numbers of MAPs compared to other Himalayan states due to varied eco-climatic zones and therefore it was projected as Herbal State of India (Kala 2004). The establishment of State Medicinal Plant Board (SMPB), on the lines of National Medicinal Plant Board (NMPB) and Aromatic Plants Development Centre, Selaqui - Dehra Dun were few initiations taken in this direction. In Uttarakhand, *ca.* 241 pharmaceuticals companies (which include 10 small scale industries and 89 cottage industries) are known to consume nearly 1500MT of herbs costing Rs. 64.15 Crores. The annual demand is estimated to be 7500 MT and is likely to increase in future (Rawat *et al.* 2012). Considering high demand for MAPs present within the state, Government of Uttarakhand has taken several steps for reformation of policies for long-term sustainable conservation and management of MAPs. Scientific management of MAPs by including this section into forestry working plans for adoption of conservation, development and harvest (CDH) plan, is one of such moves (Rawat *et al.* 2004). According to the plan, three different areas (in each forest division) should identify as conservation, development and harvest areas within reserve forests of the state (Kala *et al.* 2006). This highlights the urgency of detailed inventory and rapid mapping of high value MAPs in various forest divisions of the state.

**Objective**

**To investigate the population status of the high value ethnomedicinal plants in the district Uttarkashi.**

Two research questions were posed to achieve the above objective.

1. What is the current population status of locally important EMPs in Uttarkashi district?
2. What is the spatial distribution of locally important EMPs in forests of Uttarkashi district?

To address the above research questions following methodology was used.

## 4.2 Methodology

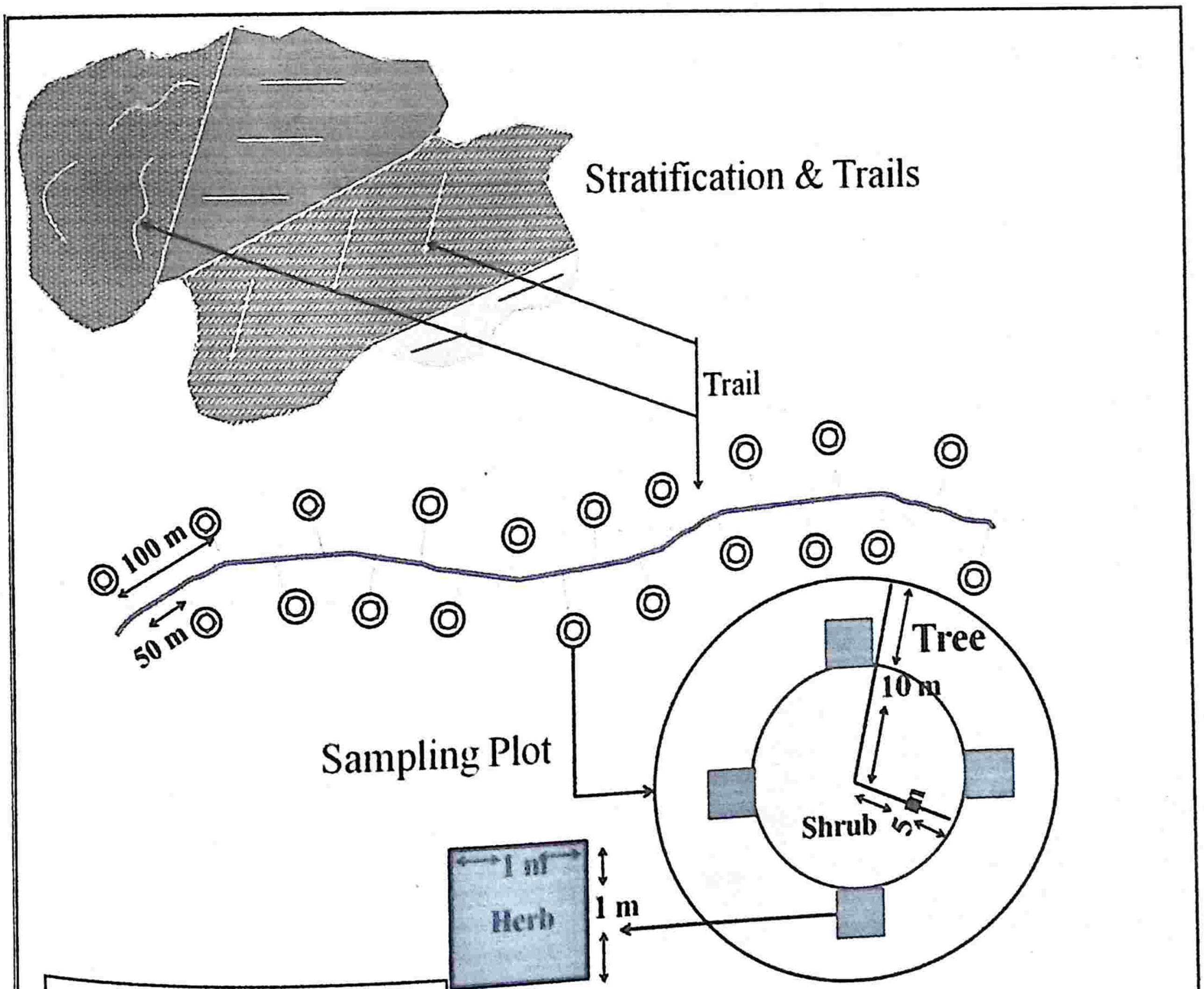
**4.2.1 Selection of species**: High use value species were selected based on use value index calculated in previous chapter (See Chapter 3.3.2.4; Annexure III). Five species each from three altitudinal zones were selected. One species (*Aconitum heterophyllum*) occurred in all three zones and another species i.e. *Picrorhiza kurrooa* occurred in two zones, totalling to 12 high value EMPs from the study area.

**4.2.2 Estimation of population**: Extensive surveys were conducted in various Forest Divisions (Reserved Forests) of Uttarkashi district. Stratification of survey area was done using geographical condition and vegetation type in various beats (smallest administrative unit of Indian forests), following Rapid Mapping Exercise (RME; Rawat *et al.* 2004) (**Figure 4.1**). Conservation and development plans, based on detailed quantitative information can be used for suitable harvest plan for the areas lying outside PAs *viz.*, Gangotri NP, Govind NP and WLS.

**4.2.2.1 Reconnaissance:** During reconnaissance the administrative and ecological zones of the survey area were delineated. Information on forest types, existing trails and size of the area were gathered for respective division/range from office as well as from frontline staff.

**4.2.2.2 Stratification:** Based on the initial reconnaissance and knowledge of the area each survey locality, block or compartment was divided into smaller natural units or strata. For the present study, the strata were beats, altitude and vegetation types considering accessibility of the area. But main focus were given on geographical condition especially altitudinal gradient and forest types. Stratified random sampling was used to conduct ecological studies following Mueller-Dombois and Ellenberg (1974).

**Figure 4.1: Stratification and Layout of Transect and Sample Plots**




(Adapted from Rawat *et al.* 2004)

**4.2.2.3 Trail/Transect selection and marking:** Transects were laid in random directions but in a rugged and hilly terrain it was not feasible to lay a straight line or random transect. Therefore, for the practical reason transect was selected along least beaten tracts, such as fodder collection trails, wherever feasible avoiding main motorable road and permanent foot paths. On a steep hill slope it was rather practical to lay transects along the contour, within a limit of altitudinal zone. The length of transect/trails was one km. but, in rugged and rough terrain of Himalaya, sometimes it becomes highly impossible to complete transect. Therefore, at times length was reduced depending on size of forest though about 95% transects are of one km.

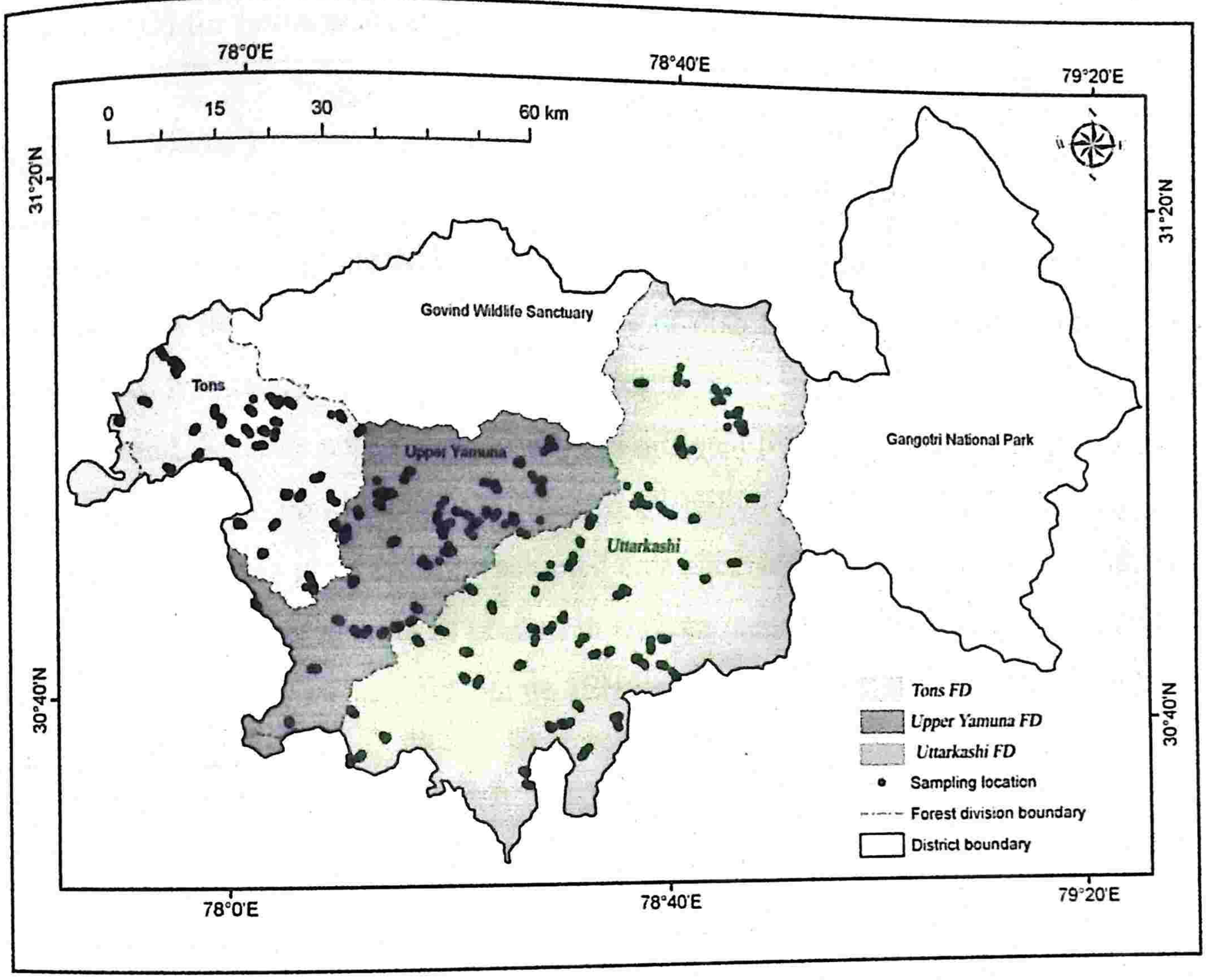
**Laying out the sample plots (Figure 4.1):** Sampling within each stratum was done on either side along the trails or transects. 20 sample plots were laid along each transect, at an interval of 50m. The centre of the plot was marked using Garmin 72 GPS. 10m circular plots (314m$^2$) were laid for sampling medicinal tree species. A 5m circular plot (78.5m$^2$) was laid within the larger plot for medicinal shrubs. On the outer boundary of smaller circle, four 1 X 1m quadrats were laid in cardinal direction (East, West, North and South) to enumerate medicinal herbs. Hence, in one transect 20 plots of 10m, 20 plots of 5m and 80 plots of 1m$^2$ were laid.

All together 135 transects (comprising 2624 plots for trees and shrubs and 10496 for herbs) were laid in the intensive study area (**Figure 4.2**). Due to inaccessibility and improper network of roads in certain areas, especially while laying transects in alpine meadows, average 12-15km walk (one way) was accomplished.

**4.2.2.4 Enumeration of species:** The individuals of EMPs were counted within the sample plots. Populations of woody perennials were estimated during the most part of the year and the herbaceous plants, in alpine areas, were enumerated (quantified) during peak growing seasons.

**4.2.2.5 Data analysis and Interpretation:** The abundance data of EMPs gathered was transferred to an electronic template using MS Excel spreadsheet. Data on the availability of EMPs and their population status in an area was shown in terms of density, frequency (%) and abundance across transects laid in different forest administration units (Curtis and McIntosh 1950).

**Figure 4.2: Transect locations in three Forest Divisions of Uttarkashi District**




**Density** - It is the number of counting units per unit area. For present study, the above-ground expression (of individual EMPs) i.e. genets were calculated using following formula.

$$\text{Density (D)} = \frac{\text{Total number of individuals (of a given species) in all plots}}{\text{Total numbers of plots sampled X area of plot}}$$

The fact that density is reported as a, 'per area measure' which allows comparison between sites even if the plot shape used for sampling differs (Elzinga *et al.* 1998). In addition, normally density for trees and shrubs are shown in terms of number per hectare (/ha or $ha^{-1}$) and for herbs it is per square meter (/$m^2$ or $m^{-2}$). So, in context with present study Density (D) for trees and shrubs was calculated using formula,

$$\text{Density}_{\text{trees/shrubs}} \text{ (D/ha)} = \frac{\text{Total number of individuals (of a given species) in all plots}}{\text{Total numbers of plots sampled X area of plot}} \text{ X10000}$$

in different types of areas shows that distribution of the species at different places. A higher A/F ratio at one place, of any species, than at other place denotes more contiguous distribution of that species. If the difference in the values, of same species at different locations, is small then conclusion can be inferred that the species has very general distribution (Whitford 1949; Curtis and McIntosh 1950).

**Coefficient of Variation (CV)**: The CV is used to compare the variability of two samples that have widely differing means and is calculated by dividing the standard deviation by the mean (Zar 2010). CV was calculated for each transect location of every species and used for comparing distribution of that species across various locations. The population of species with the smaller CV is less dispersed than the population of species with the larger CV.

### 4.3 Results

Population status of 12 high value EMPs, consisting two tree species, two shrub species and eight herb species, was calculated. For most of the herbs (except *G. wallichianum* and *V. pilosa*) density did not vary much and therefore, only two classes were made (low density and high density) by dividing density range into exact half.

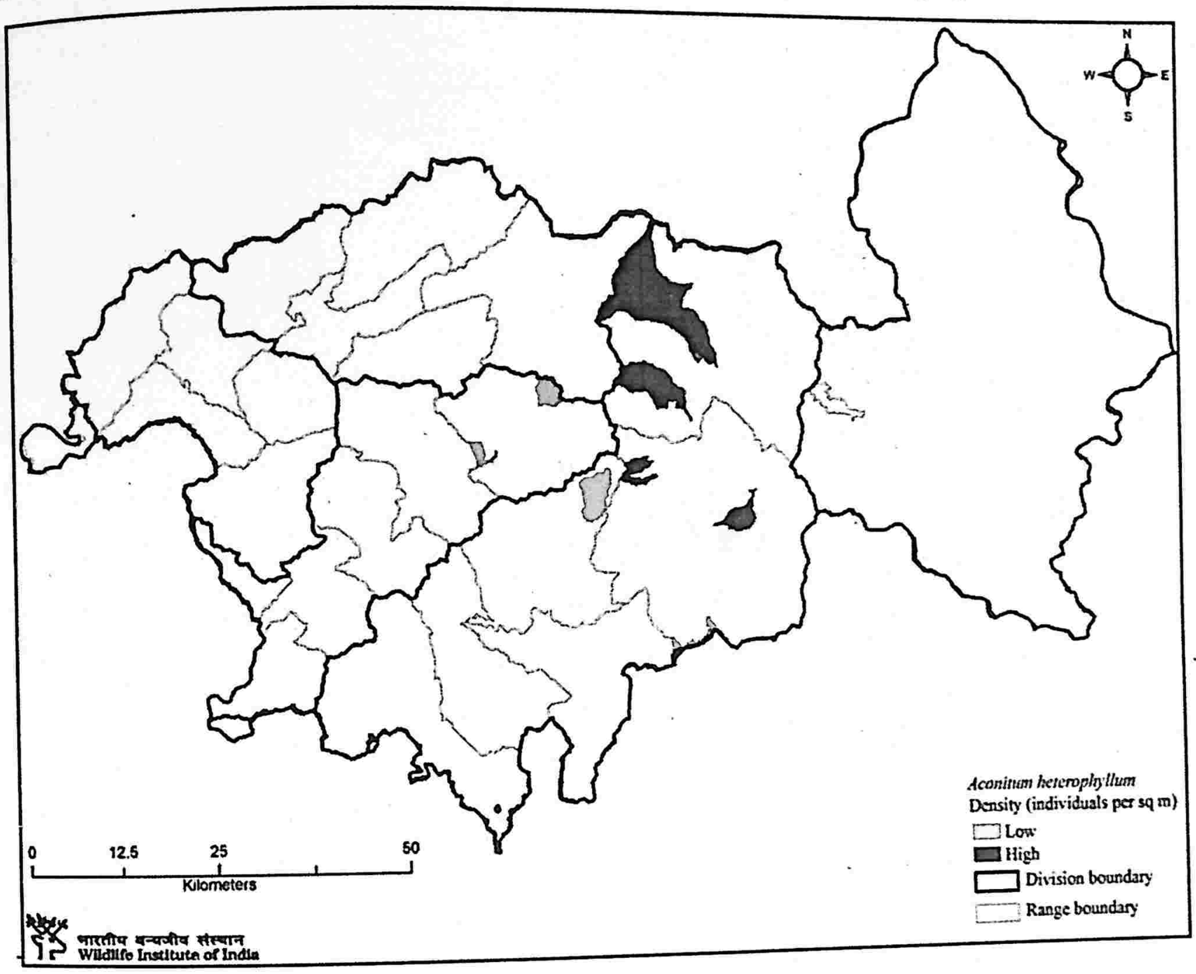
**4.3.1 *Aconitum heterophyllum***: Distribution of *Aconitum heterophyllum* was very sporadic and patchy in all eight transect locations (F = 4-25%). It was found maximum ($Dm^{-2}$ = 2.95 ± 7.18 SD; F = 20%) in Ganganani block (Taknaur Range, Uttarkashi FD). Moderate population was observed in Suki and Harsil blocks (Gangotri Range, Uttarkashi FD). At all these locations population was more evenly distributed than rest of the locations. **(Table 4.1, Figure 4.3)**.

**Table 4.1: Population status of *Aconitum heterophyllum* in Uttarkashi**

| FD | Range | Beat | Block | Comp-artment | Density (ind./m²) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Taknaur | Gangnani-II | Gangnani | 4b | 2.95±7.18 | 2.43 | 20 | 0.738 |
| UFD | Gangotri | Songad | Suki | 3c | 1.70±4.08 | 2.40 | 25 | 0.272 |
| UFD | Taknaur | Huri-I | Huri | 1c | 1.40±3.33 | 2.38 | 25 | 0.224 |
| UFD | Gangotri | Jaspur | Harsil | 10b | 1.38±3.95 | 2.85 | 15 | 0.585 |
| UYFD | Yamunotri | Yamunotri | Yamunotri | 8 | 1.00±2.05 | 2.05 | 25 | 0.160 |
| UFD | Taknaur | Pilang-II | Pilang | 2d | 0.30±0.98 | 3.26 | 10 | 0.300 |
| UFD | Badahat | Dodital-I | Dodital | 4b | 0.13±0.63 | 4.79 | 4 | 0.690 |
| UYFD | Yamunotri | Durvil | Bhairab | 1 | 0.05±0.22 | 4.47 | 5 | 0.200 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.3: Population status and distribution of *Aconitum heterophyllum* in Uttarkashi**



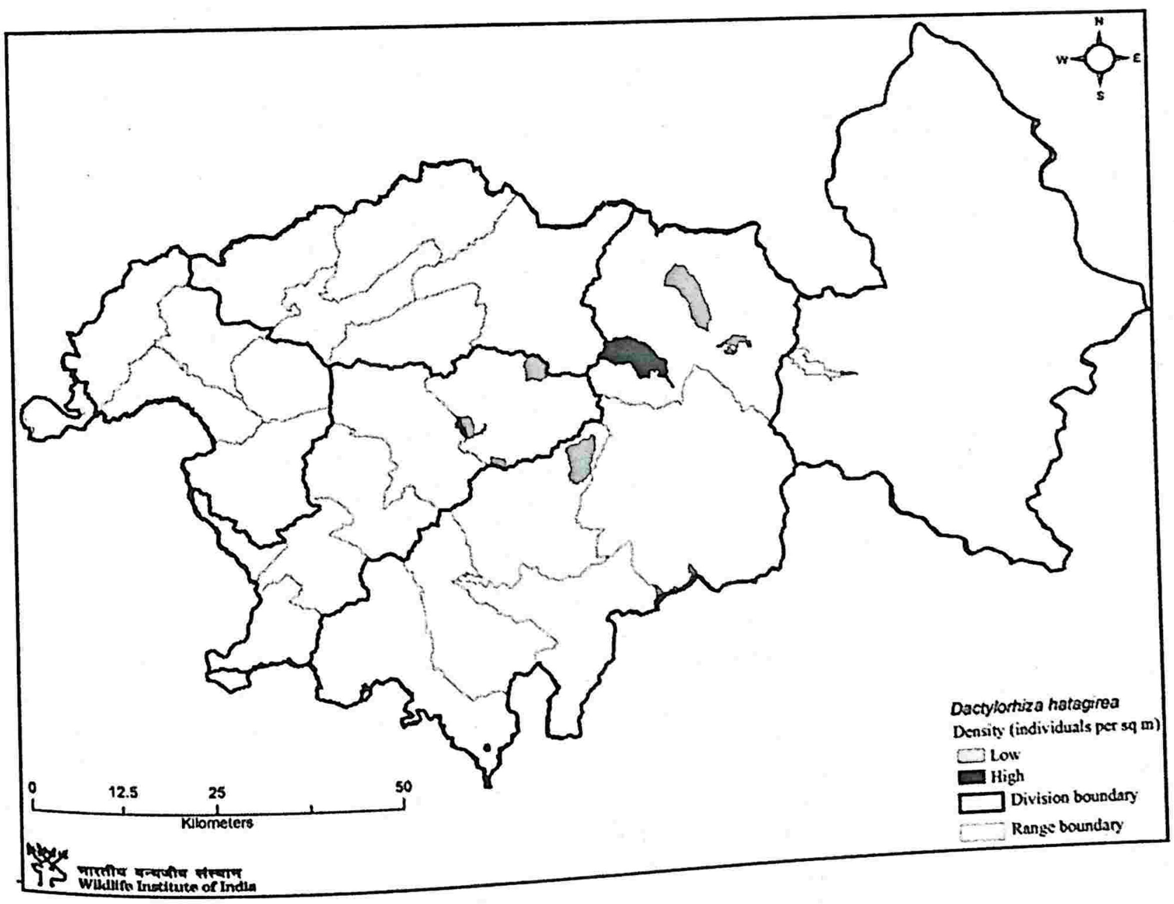

**4.3.2 *Dactylorhiza hatagirea***: Population of *Dactylorhiza hatagirea* was found maximum ($Dm^{-2} = 3.15 \pm 3.33$ SD; F = 60%) in Suki block (Gangotri Range, Uttarkashi FD) and Wazri block ($Dm^{-2} = 2.60 \pm 6.99$ SD; F = 15%) (Yamunotri Range, Upper Yamuna FD). At Suki *D. hatagirea* was most frequent with occurrence in 60% of plots. But very high CV and A/F ratio as well as low frequency in Wazri block denoted highly patchy distribution. In Kyarki bugyal (Pinswar block), which is on the boundary of Uttarkashi and Tehri FDs, the species was comparatively well distributed (**Table 4.2, Figure 4.4**).

**Table 4.2: Population status of *Dactylorhiza hatagirea* in Uttarkashi**

| FD | Range | Beat | Block | Comp-artment | Density (ind./m$^2$) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Gangotri | Songad | Suki | 3c | 3.15±3.33 | 1.06 | 60 | 0.088 |
| UYFD | Kuthnaur | Wazri | Wazri | 12 | 2.60±6.99 | 2.69 | 15 | 1.156 |
| UYFD | Yamunotri | Yamunotri | Yamunotri | 8 | 1.75±3.68 | 2.10 | 25 | 0.280 |
| UFD | Taknaur | Pilang-II | Pilang | 2d | 1.70±4.32 | 2.54 | 30 | 0.189 |
| UYFD | Yamunotri | Rana | Rana | 5a | 1.05±3.03 | 2.89 | 15 | 0.467 |
| UFD | Balganga | Kyarki | Pinswar | 10 | 1.00±1.75 | 1.75 | 35 | 0.082 |
| UFD | Gangotri | Bagori | Harsil | 7b | 0.45±1.00 | 2.22 | 20 | 0.113 |
| UYFD | Yamunotri | Durvil | Bhairab | 1 | 0.45±2.01 | 2.95 | 5 | 1.800 |
| UFD | Badahat | Dodital-I | Dodital | 4b | 0.35±1.03 | 4.47 | 13 | 0.204 |
| UFD | Gangotri | Gangotri | Gangotri | 2a | 0.33±1.53 | 4.58 | 5 | 1.470 |
| UFD | Gangotri | NF | NF | NF | 0.04±0.19 | 5.20 | 4 | 0.270 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.4: Population status and distribution of *Dactylorhiza hatagirea* in Uttarkashi**




**4.3.3 *Geranium wallichianum***: *Geranium wallichianum* was contiguously distributed and frequent at three transect locations out of 52 transect locations where it occurred. The population was abundant at Harsil block (Dm$^{-2}$ = 23.15 ± 19.49 SD; F = 70%) (Gangotri

Range), Suki block ($Dm^{-2}$ = 14.05 ± 13.95 SD; F = 55%) (Gangotri Range), Dodital block ($Dm^{-2}$ = 13.09 ± 15.53 SD; F = 47%) (Badahat Range) of Uttarkashi FD; Abundant population with patchy distribution observed at Bhairab block ($Dm^{-2}$ = 9.05 ± 13.33 SD; F = 40%) (Yamunotri Range, Upper Yamuna FD) and Dedragad block ($Dm^{-2}$ = 7.75 ± 12.59 SD; F = 30%) (Kotigad Range, Tons FD). **(Table 4.3, Figure 4.5)**

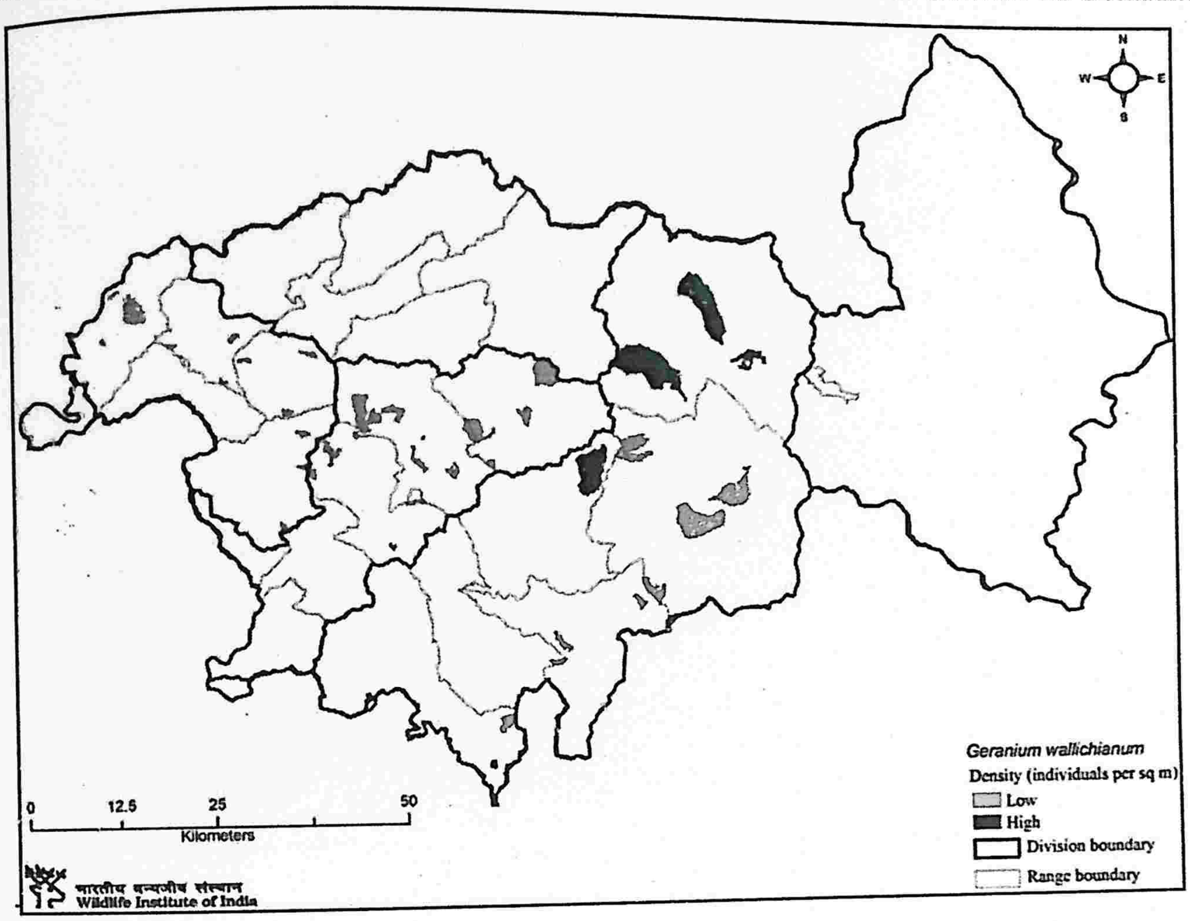
**Table 4.3: Population status of *Geranium wallichianum* in Uttarkashi**

| FD | Range | Beat | Block | Comp-artment | Density (ind./$m^2$) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Gangotri | Bagori | Harsil | 7b | 23.15±19.49 | 0.84 | 70 | 0.472 |
| UFD | Gangotri | NF | NF | NF | 15.00±13.54 | 0.90 | 59 | 0.427 |
| UFD | Gangotri | Songad | Suki | 3c | 14.05±13.95 | 0.99 | 55 | 0.464 |
| UFD | Badahat | Dodital-I | Dodital | 4b | 13.09±15.53 | 1.19 | 47 | 0.572 |
| UFD | Taknaur | Huri-I | Huri | 1c | 10.45±20.85 | 2.00 | 30 | 1.161 |
| UYFD | Yamunotri | Durvil | Bhairab | 1 | 9.05±13.33 | 1.47 | 40 | 0.566 |
| UYFD | Kuthnaur | Wazri | Wazri | 12 | 8.45±9.23 | 1.09 | 75 | 0.150 |
| UYFD | Yamunotri | NF | NF | NF | 8.10±10.65 | 1.32 | 45 | 0.400 |
| TFD | Kotigard | Chiwan | Dedragad | 4a | 7.75±12.59 | 1.62 | 30 | 0.861 |
| UFD | Taknaur | Pilang-I | Pilang | 1c | 7.35±11.31 | 1.54 | 35 | 0.600 |
| UYFD | Yamunotri | Yamunotri | Yamunotri | 8 | 7.00±12.70 | 1.81 | 25 | 1.120 |
| UFD | Gangotri | Songad | Suki | 3c | 6.95±17.19 | 2.47 | 15 | 3.089 |
| UFD | Dunda | Chorgi | Dhanari | 15b | 6.80±10.93 | 1.61 | 35 | 0.555 |
| UFD | Taknaur | Gangnani-II | Gangnani | 4b | 5.70±9.23 | 1.62 | 30 | 0.633 |
| UYFD | Yamunotri | Rana | Rana | 2a | 5.65±10.28 | 1.82 | 25 | 0.904 |
| UFD | Taknaur | Tyar | Gangnani | 5 | 5.45±6.79 | 1.25 | 45 | 0.269 |
| TFD | Singtoor | Gandugad | Tyas | 6a | 4.95±9.77 | 1.97 | 25 | 0.792 |
| UFD | Mukhem | Sauragad-IV | Sauragad | 5a | 4.55±11.24 | 2.47 | 15 | 2.022 |
| TFD | Sandra | Salla | Saras | 3 | 4.45±7.69 | 1.73 | 30 | 0.494 |
| UFD | Gangotri | Harsil-I | Harsil | 2a | 4.00±6.30 | 2.49 | 30 | 0.444 |
| UYFD | Yamunotri | Beef | Yamunotri | 3 | 4.00±9.96 | 1.57 | 15 | 1.778 |
| UYFD | Yamunotri | Rana | Rana | 5a | 3.75±7.54 | 2.01 | 35 | 0.306 |
| UFD | Taknaur | Huri-II | Huri | 6a | 3.70±8.97 | 2.43 | 25 | 0.592 |
| UYFD | Yamunotri | Foolchatti | Digdara | 3 | 3.55±6.18 | 1.71 | 50 | 0.142 |
| TFD | Kotigard | NF | NF | NF | 3.55±6.08 | 1.74 | 40 | 0.222 |
| TFD | Singtoor | Kamda | Kamda | 3a | 3.35±11.08 | 3.31 | 10 | 3.350 |
| TFD | Kotigard | NF | NF | NF | 3.30±5.29 | 1.60 | 40 | 0.206 |
| UYFD | Yamunotri | Yamunotri | Yamunotri | 8 | 3.05±8.67 | 2.84 | 15 | 1.356 |
| UFD | Taknaur | Bhukki-III | Bhuki | 6d | 2.85±7.34 | 2.58 | 15 | 1.267 |
| UFD | Dharasu | Matridhar | Dichli | 6c | 2.80±5.37 | 2.26 | 30 | 0.311 |

| FD | Range | Beat | Block | Comp-artment | Density (ind./m$^2$) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| TFD | Purola | Nauri | Devdhunga | 3 | 2.80±6.33 | 2.26 | 30 | 0.311 |
| TFD | Purola | Gundiatgaon | Gundiatgaon | 7 | 2.80±6.33 | 1.92 | 30 | 0.311 |
| TFD | Singtoor | Nanai | Nanai | 1a | 2.25±10.06 | 4.47 | 5 | 9.000 |
| UYFD | Kuthnaur | NF | NF | NF | 2.20±5.78 | 2.63 | 20 | 0.550 |
| TFD | Kotigard | Kaleech | Kaleech | 8 | 1.90±4.69 | 2.47 | 15 | 0.844 |
| UFD | Badahat | Dodital-III | Dodital | 5e | 1.86±4.80 | 2.58 | 13 | 1.002 |
| UFD | Badahat | Dodital-I | Dodital | 4b | 1.86±4.91 | 2.65 | 14 | 0.910 |
| UYFD | Kuthnaur | Kupra | Kupra | 3 | 1.80±2.95 | 1.64 | 30 | 0.200 |
| TFD | Sandra | Sandra | Sandra | 5b | 1.55±3.86 | 2.49 | 15 | 0.689 |
| TFD | Sandra | Bainol | Bainol | 13 | 1.25±3.21 | 2.57 | 15 | 0.556 |
| TFD | Purola | Binai | Binai | 9 | 1.10±4.92 | 4.47 | 5 | 4.400 |
| UYFD | Yamunotri | Foolchatti | Digdara | 4a | 1.05±4.70 | 4.47 | 5 | 4.200 |
| UYFD | Rawain | Masalgaon | Masalgaon | 1d | 0.90±2.77 | 3.08 | 10 | 0.900 |
| UYFD | Rawain | Pathargad | Pathargad | 4b | 0.85±3.00 | 3.52 | 10 | 0.850 |
| UYFD | Kuthnaur | Ponti | Kimdaara | 8a | 0.75±1.62 | 2.16 | 20 | 0.188 |
| UFD | Mukhem | Baragaddi-I | Baragaddi | 8c | 0.75±3.35 | 4.47 | 5 | 3.000 |
| UYFD | Kuthnaur | NF | NF | NF | 0.45±2.01 | 4.47 | 5 | 1.800 |
| UYFD | Rawain | Bigrari | Bigrari | 7a | 0.40±1.23 | 3.08 | 10 | 0.400 |
| UYFD | Rawain | NF | NF | NF | 0.40±1.23 | 3.08 | 10 | 0.400 |
| UYFD | Rawain | Syalna | Syalna | 6a | 0.40±1.23 | 3.08 | 10 | 0.400 |
| TFD | Sandra | Salla | Kanda | 2 | 0.35±0.88 | 2.50 | 15 | 0.156 |
| UYFD | Kuthnaur | NF | NF | NF | 0.30±1.13 | 3.76 | 10 | 0.300 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.5: Population status and distribution of *Geranium wallichianum* in Uttarkashi**



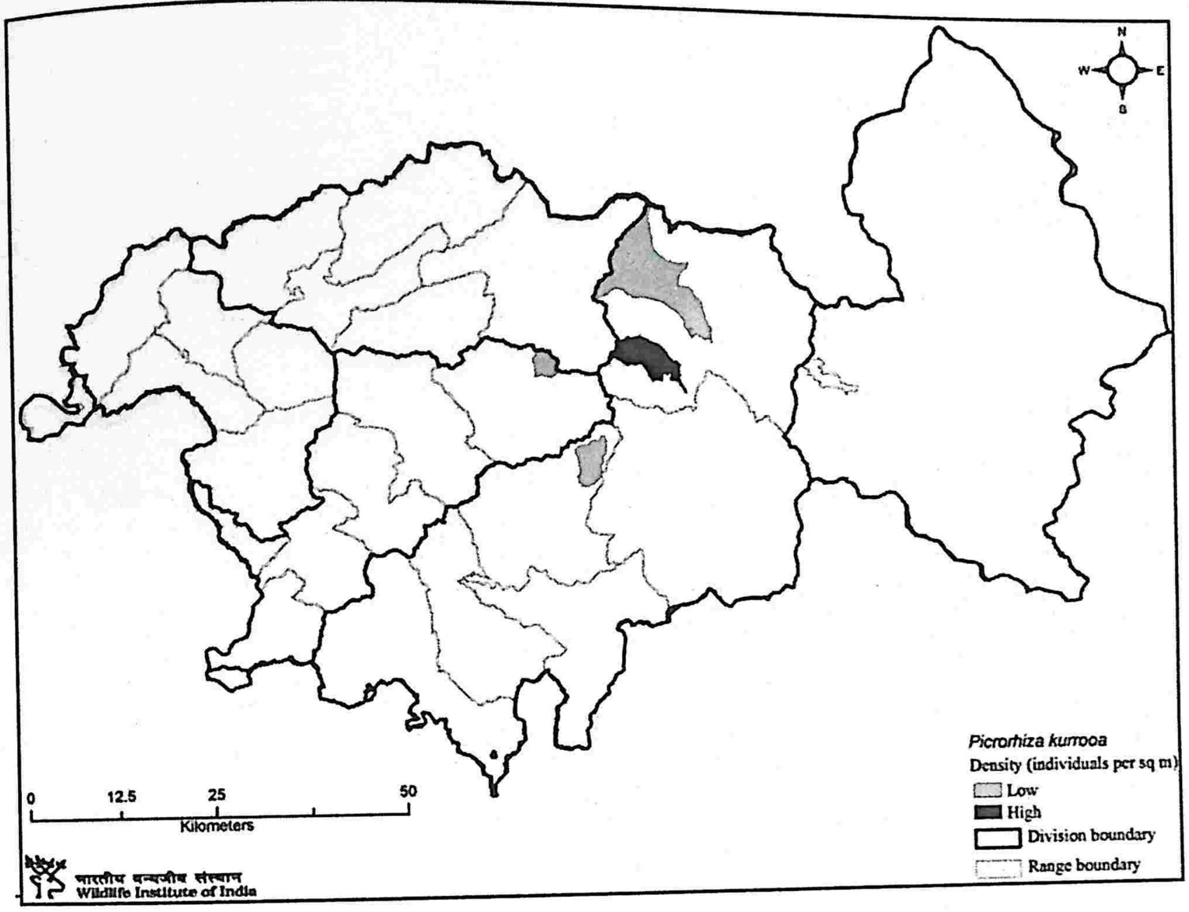

4.3.4 ***Picrorhiza kurrooa***: *Picrorhiza kurrooa* was found sporadically distributed at seven transect locations but at all locations it was frequent near rocky patches. Maximum population was observed at Suki block ($Dm^{-2}$ = 6.65 ± 13.77 SD; F = 20% and $Dm^{-2}$ = 3.85 ± 10.87 SD; F = 15%) (Gangotri Range), Dodital block ($Dm^{-2}$ = 4.71 ± 12.47 SD; F = 14%) (Badahat Range) of Uttarkashi FD and Yamunotri block ($Dm^{-2}$ = 2.00 ± 8.05 SD; F = 10%) (Yamunotri Range, Upper Yamuna FD). **(Table 4.4, Figure 4.6)**

**Table 4.4: Population status of *Picrorhiza kurrooa* in Uttarkashi**

| FD | Range | Beat | Block | Comp-artment | Density (ind./m$^2$) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Gangotri | Songad | Suki | 3c | 6.65±13.77 | 2.07 | 20 | 1.663 |
| UFD | Badahat | Dodital-I | Dodital | 4b | 4.71±12.47 | 2.65 | 14 | 2.310 |
| UFD | Gangotri | Songad | Suki | 3c | 3.85±10.87 | 2.82 | 15 | 1.711 |
| UYFD | Yamunotri | Yamunotri | Yamunotri | 8 | 2.00±8.05 | 4.03 | 10 | 2.000 |
| UYFD | Yamunotri | Yamunotri | Yamunotri | 8 | 1.85±5.83 | 3.15 | 15 | 0.822 |
| UFD | Gangotri | Jaspur | Harsil | 10b | 1.38±4.70 | 3.39 | 15 | 0.585 |
| UYFD | Yamunotri | Beef | Yamunotri | 7 | 0.95±4.25 | 4.47 | 5 | 3.800 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.6: Population status and distribution of *Picrorhiza kurrooa* in Uttarkashi**



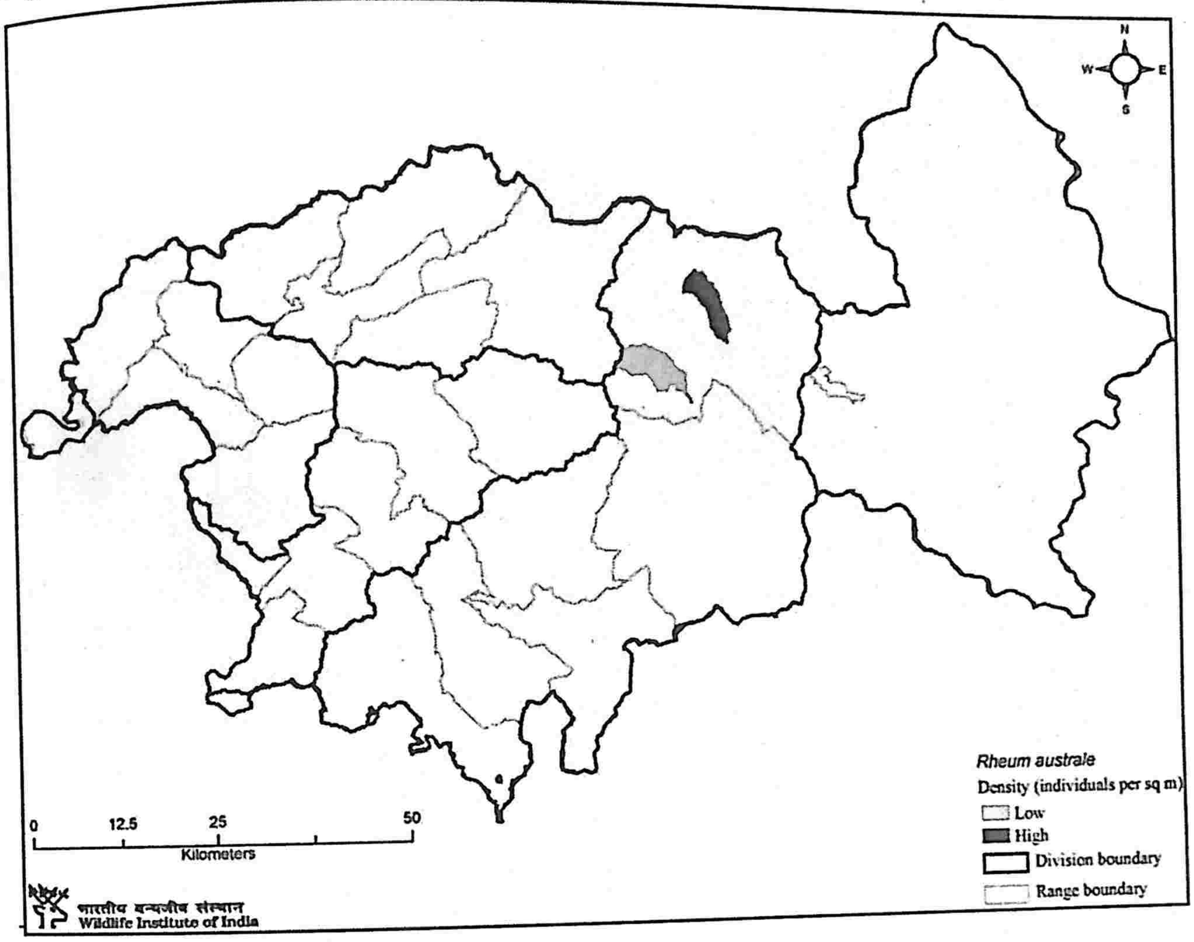

**4.3.5 *Rheum australe***: *Rheum australe* was found at only two sites, Harsil block ($Dm^{-2}$ = 0.60 ± 2.09 SD; F = 10%) and Suki block ($Dm^{-2}$ = 0.30 ± 0.98 SD; F = 10%) of Gangotri Range, Uttarkashi FD where the distribution of the species was very patchy. **(Table 4.5, Figure 4.7)**

**Table 4.5: Population status of *Rheum australe* in Uttarkashi district**

| FD | Range | Beat | Block | Compartment | Density (ind./$m^2$) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Gangotri | Bagori | Harsil | 7b | 0.60±2.09 | 3.48 | 10 | 0.600 |
| UFD | Gangotri | Songad | Suki | 3c | 0.30±0.98 | 3.26 | 10 | 0.300 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.7: Population status and distribution of *Rheum australe* in Uttarkashi**




**4.3.6 *Senecio nudicaulis***: Population of *Senecio nudicaulis* was sporadic at almost all transects locations. Dilasur block ($Dm^{-2}$ = 3.60 ± 6.04 SD; F = 40%) and Jalkurgad block ($Dm^{-2}$ = 2.75 ± 5.33 SD; F = 35%) of Mukhem Range as well as Huri block ($Dm^{-2}$ = 2.15 ± 3.62 SD; F = 35) of Taknaur Range belonging to Uttarkashi FD showed highest population with moderately frequent distribution. The species was also occurred in forest-village fringes in Kotigad and Purola Ranges of Tons FD. **(Table 4.6, Figure 4.8)**

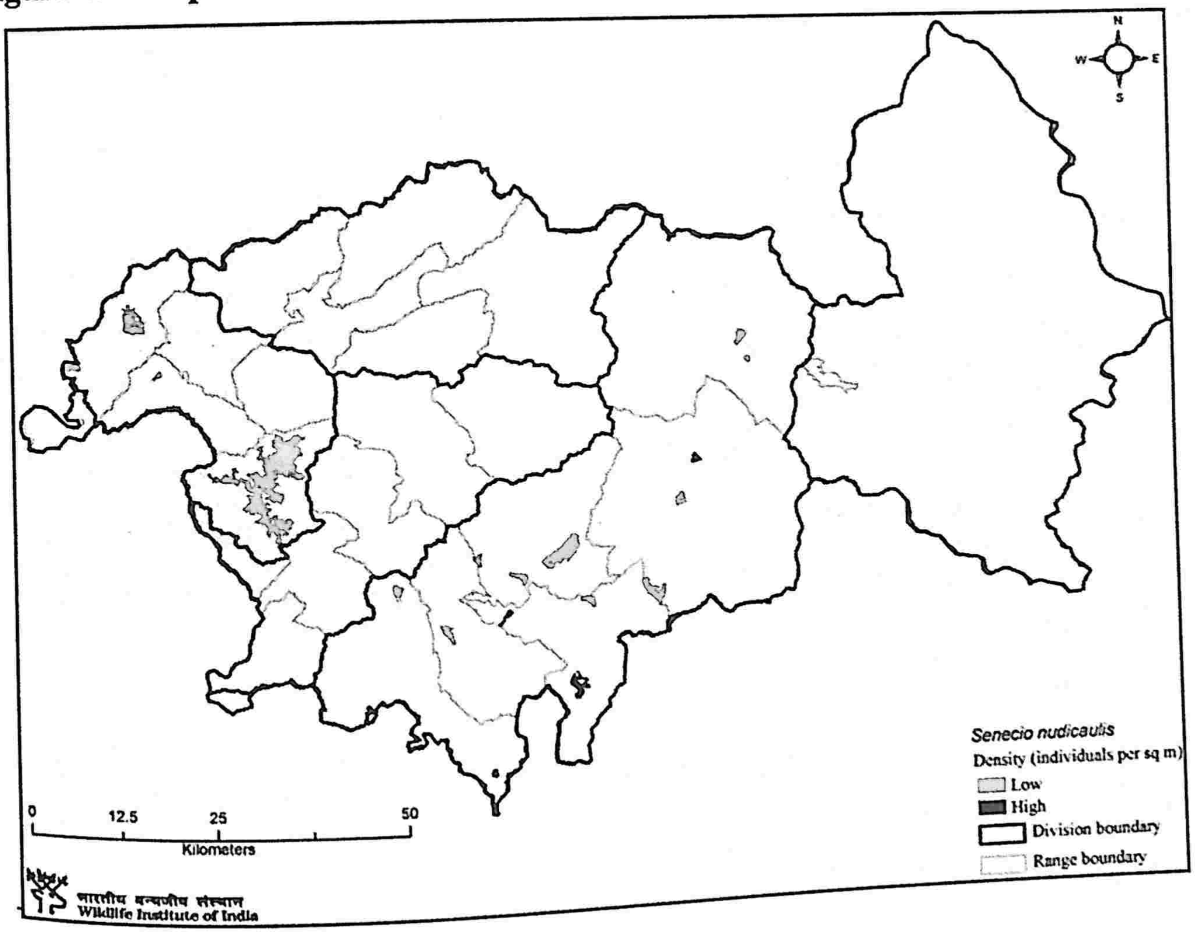
**Table 4.6: Population status of *Senecio nudicaulis* in Uttarkashi**

| FD | Range | Beat | Block | Comp-artment | Density (ind./m²) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Mukhem | Dilasaur-I | Dilasur | 7b | 3.60±6.04 | 1.68 | 40 | 0.225 |
| UFD | Mukhem | Dhotri-II | Jalkurgad | 27a | 2.75±5.33 | 1.94 | 35 | 0.224 |
| UFD | Taknaur | Huri-II | Huri | 6b | 2.15±3.62 | 1.68 | 35 | 0.176 |
| UFD | Taknaur | Bhukki-I | Bhuki | 6b | 2.00±4.58 | 2.29 | 20 | 0.500 |
| UFD | Taknaur | Pilang-I | Pilang | 1c | 1.55±2.54 | 1.64 | 30 | 0.172 |
| UFD | Dharasu | Khurmola | Khurmola | 4 | 1.25±2.94 | 2.35 | 25 | 0.200 |
| UFD | Mukhem | Jamak-IV | Jamak | 6b | 1.10±2.36 | 2.15 | 20 | 0.275 |
| TFD | Purola | NF | NF | NF | 0.95±10 | 4.00 | 10 | 0.950 |

| FD | Range | Beat | Block | Comp-artment | Density (ind./m$^2$) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Gangotri | Harsil-II | Harsil | 3a | 0.90±2.49 | 2.77 | 15 | 0.400 |
| UFD | Badahat | Badahat | Utraun | 7 | 0.75±2.57 | 3.43 | 10 | 0.750 |
| UFD | Gangotri | Dharali-I | Dharali | 4a | 0.59±1.72 | 2.89 | 11 | 0.480 |
| TFD | Kotigard | Kasta | Baanpur | 2 | 0.45±1.39 | 3.10 | 15 | 0.200 |
| UFD | Badahat | Gawana-II | Gawanagad | 4b | 0.40±1.79 | 4.47 | 5 | 1.600 |
| UFD | Dunda | Dunda | Dunda | 4a | 0.35±1.09 | 3.11 | 10 | 0.350 |
| UFD | Badahat | Kawan | Kawan | 3b | 0.20±0.89 | 4.47 | 5 | 0.800 |
| TFD | Kotigard | NF | NF | NF | 0.20±0.89 | 4.47 | 5 | 0.800 |
| UFD | Dharasu | Khurmola | Khurmola | 6b | 0.15±0.67 | 4.47 | 5 | 0.600 |
| UFD | Mukhem | Jamak-IV | Jamak | 7b | 0.15±0.67 | 4.47 | 5 | 0.600 |
| TFD | Devta | Devta | Partil | 4 | 0.05±0.22 | 4.47 | 5 | 0.200 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.8: Population status and distribution of *Senecio nudicaulis* in Uttarkashi**




**4.3.7 *Verbascum thapsus***: Population of *Verbascum thapsus* was sporadically distributed at all transect locations of which Kukreda block (Dm$^{-2}$ = 6.45±10.36 SD; F = 35%) (Devta Range, Tons FD) holds maximum population. At other places like, Harsil block (Dm$^{-2}$ = 1.55±3.17 SD; F = 25%) (Gangotri Range, Uttarkashi FD) and Salla block (Dm$^{-2}$ = 1.25±3.06

SD; F = 20%) (Sandra Range, Tons FD) population was low and patchy. **(Table 4.7, Figure 4.9)**

**Table 4.7: Population status of *Verbascum thapsus* in Uttarkashi**

| FD | Range | Beat | Block | Comp-artment | Density (ind./m$^2$) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| TFD | Devta | Kukreda | Kukrera | 1 | 6.45±10.36 | 1.61 | 35 | 0.527 |
| UFD | Gangotri | Bagori | Harsil | 7b | 1.55±3.17 | 2.05 | 25 | 0.248 |
| TFD | Sandra | Salla | Salla | 4 | 1.25±3.06 | 2.45 | 20 | 0.313 |
| TFD | Devta | Khunigad | Rausa | 1 | 0.85±2.85 | 3.36 | 10 | 0.850 |
| UFD | Gangotri | NF | NF | NF | 0.74±2.25 | 3.03 | 11 | 0.600 |
| TFD | Kotigard | Kaleech | Kaleech | 5 | 0.55±1.43 | 2.60 | 15 | 0.244 |
| TFD | Purola | Binai | Deothal | 1 | 0.50±1.82 | 3.64 | 10 | 0.500 |
| UFD | Dharasu | Khurmola | Khurmola | 4 | 0.45±0.94 | 2.10 | 20 | 0.113 |
| UFD | Mukhem | Jamak-IV | Jamak | 7b | 0.45±1.10 | 2.44 | 20 | 0.113 |
| TFD | Devta | Ringali | Jorion | 13 | 0.45±1.39 | 3.10 | 10 | 0.450 |
| TFD | Sandra | Sandra | Sandra | 5b | 0.45±2.01 | 4.47 | 5 | 1.800 |
| TFD | Sandra | Bainol | Bainol | 13 | 0.35±1.57 | 4.47 | 5 | 1.400 |
| TFD | Devta | Mora | Mora | 4 | 0.30±0.98 | 3.26 | 10 | 0.300 |
| TFD | Purola | Purola | Purola | 1 | 0.25±0.72 | 2.87 | 15 | 0.111 |
| UFD | Dharasu | NF | NF | NF | 0.15±0.67 | 4.47 | 5 | 0.600 |
| UFD | Mukhem | Dilasaur-I | Dilasur | 7b | 0.05±0.22 | 4.47 | 5 | 0.200 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**4.3.8 *Viola pilosa***: Population of *Viola pilosa* was found abundant and contiguously distributed in as many as 10 transect locations out of 67 locations (F = 5 to 95 %). The maximum population was found at Dichli block (Dm$^{-2}$ = 25.85 ± 13.93 SD; F = 90%) (Dharasu Range, Uttarkashi FD), Dodital block (Dm$^{-2}$ = 21.70 ± 15.80 SD; F = 82%) (Badahat Range, Uttarkashi FD), Dhanari block (Dm$^{-2}$ = 17.20 ± 8.54 SD; F = 95%) (Dunda Range, Uttarkashi FD) which was contiguous in distribution. High density with patchy distribution of species occurred at Devdhunga block (Dm$^{-2}$ = 11.15 ± 15.54 SD; F = 45%) (Purola Range, Tons FD) and Patangani block (Dm$^{-2}$ = 6.10 ± 9.28 SD; F = 50%) (Rawain Range, Upper Yamuna FD). **(Table 4.8, Figure 4.10)**

**Figure 4.9: Population status and distribution of *Verbascum thapsus* in Uttarkashi**

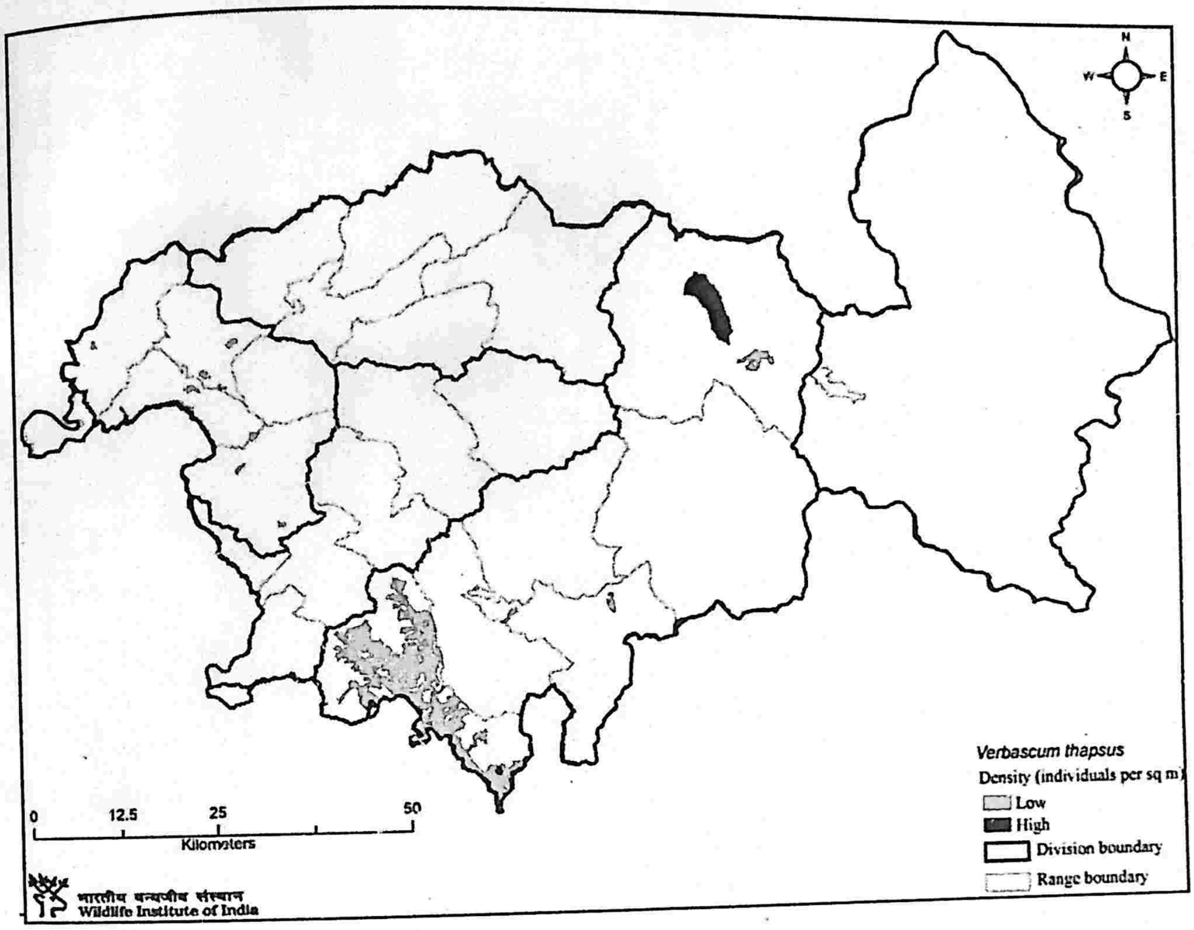



**Table 4.8: Population status of *Viola pilosa* in Uttarkashi**

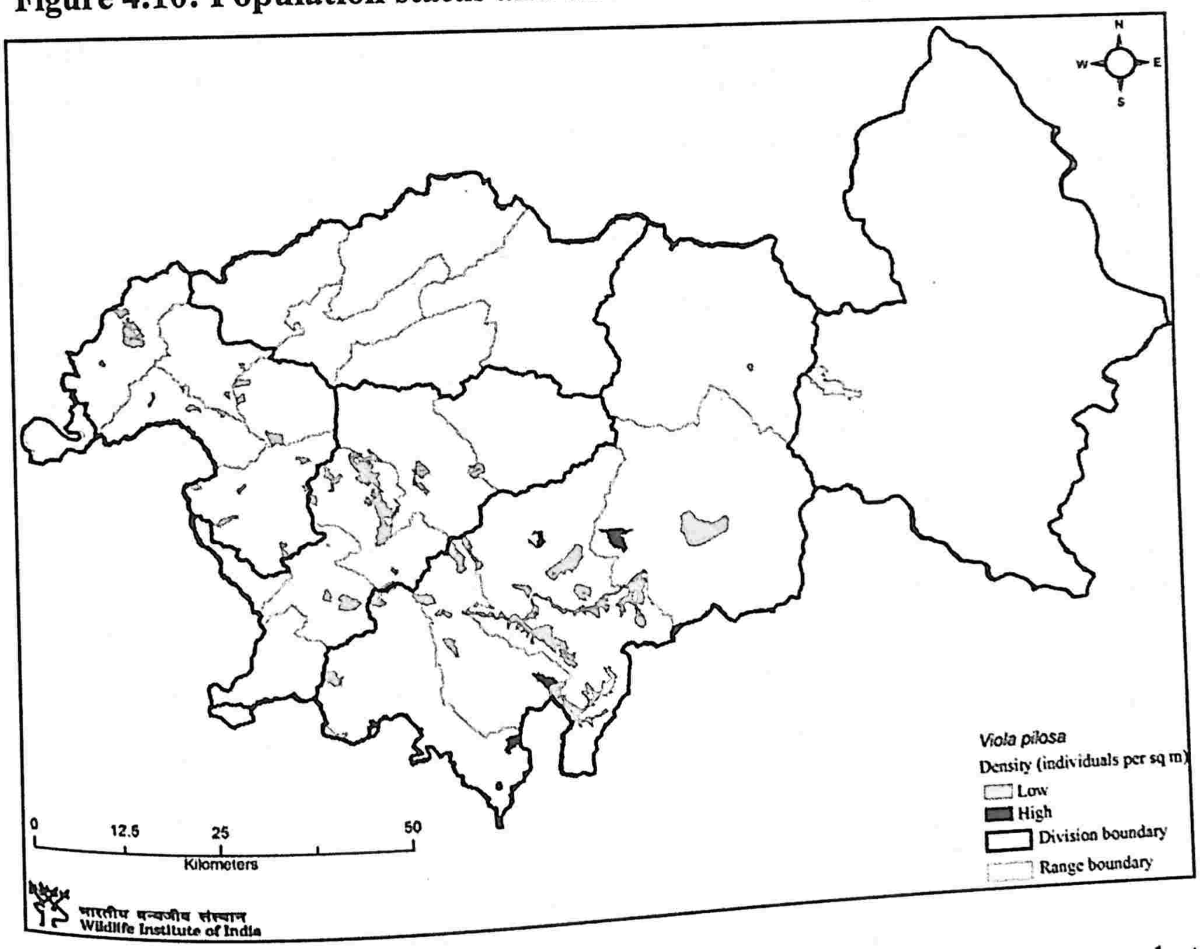
| FD | Range | Beat | Block | Comp-artment | Density (ind./m$^2$) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Dharasu | Matridhar | Dichli | 6c | 25.85±13.93 | 0.54 | 90 | 0.319 |
| UFD | Badahat | Seku-I | Dodital | 1a | 21.70±15.80 | 0.73 | 82 | 0.318 |
| UFD | Dunda | Chorgi | Dhanari | 14b | 17.20±8.54 | 0.50 | 95 | 0.191 |
| UFD | Mukhem | Sauragad-IV | Sauragad | 5a | 16.05±20.59 | 1.28 | 45 | 0.793 |
| UFD | Taknaur | Barsu | Raithal | 6b | 15.35±23.25 | 1.51 | 40 | 0.959 |
| UFD | Badahat | Gawana-II | Gawanagad | 4b | 13.50±12.56 | 0.93 | 60 | 0.375 |
| UFD | Mukhem | NF | NF | NF | 13.25±13.90 | 1.05 | 50 | 0.530 |
| UFD | Dunda | Chakon | Dhanari | 10b | 11.60±13.36 | 1.15 | 55 | 0.383 |
| TFD | Purola | Nauri | Devdhunga | 2 | 11.15±15.54 | 1.39 | 45 | 0.551 |
| TFD | Purola | Gundiatgaon | Gundiatgaon | 7 | 11.15±15.54 | 1.39 | 45 | 0.551 |
| UFD | Badahat | Kawan | Kawan | 2 | 10.95±13.70 | 1.25 | 55 | 0.362 |
| UFD | Dharasu | Patharkhol | Nagungad | 6b | 10.00±11.62 | 1.16 | 50 | 0.400 |
| UFD | Dharasu | Khurmola | Khurmola | 6b | 9.35±9.59 | 1.03 | 60 | 0.260 |
| TFD | Devta | Devta | Partil | 6 | 8.70±11.81 | 1.36 | 40 | 0.544 |
| UFD | Taknaur | Bhukki-III | Bhuki | 6d | 8.55±19.11 | 2.23 | 20 | 2.138 |
| TFD | Purola | Shikaru | Shikaru | 3 | 7.80±9.96 | 1.28 | 60 | 0.217 |

| FD | Range | Beat | Block | Compartment | Density (ind./m²) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Mukhem | Sauragad-III | Sauragad | 4f | 7.35±14.56 | 1.98 | 25 | 1.176 |
| UYFD | Mugarsanti | Molda | Molda | 1b | 7.25±9.55 | 1.32 | 40 | 0.453 |
| UYFD | Mugarsanti | Tiyan | Tiyan | 4 | 7.20±10.96 | 1.52 | 35 | 0.588 |
| UFD | Mukhem | Dhotri-IV | Jalkurgad | 29c | 7.15±10.31 | 1.44 | 60 | 0.199 |
| TFD | Kotigard | Kaleech | Kaleech | 8 | 7.15±10.27 | 1.44 | 40 | 0.447 |
| UFD | Dharasu | Patharkhol | Nagungad | 6c | 6.95±7.01 | 1.01 | 55 | 0.230 |
| UFD | Badahat | Dodital-I | Dodital | 4b | 6.83±21.14 | 3.10 | 13 | 4.012 |
| TFD | Sandra | Sandra | Sandra | 2a | 6.50±9.10 | 1.40 | 40 | 0.406 |
| UYFD | Rawain | Patangni | Patangni | 10b | 6.10±9.28 | 1.52 | 50 | 0.244 |
| TFD | Sandra | Bainol | Bainol | 8 | 5.75±7.35 | 2.00 | 45 | 0.284 |
| UYFD | Rawain | NF | NF | NF | 5.75±11.49 | 1.28 | 25 | 0.920 |
| UFD | Mukhem | Baragaddi-I | Baragaddi | 8c | 5.60±9.45 | 1.69 | 35 | 0.457 |
| UFD | Mukhem | Jamak-IV | Jamak | 6b | 5.55±15.33 | 2.76 | 15 | 2.467 |
| TFD | Purola | Jakh | Dalnu | 6 | 5.50±7.48 | 1.36 | 60 | 0.153 |
| TFD | Kotigard | Andrigad | Dedragad | 11a | 5.40±7.57 | 1.40 | 40 | 0.338 |
| UYFD | Kuthnaur | Pali | Pali | 16b | 5.40±13.67 | 2.53 | 15 | 2.400 |
| TFD | Singtoor | Gandugad | Jarmola | 1 | 5.15±10.89 | 2.12 | 20 | 1.288 |
| UFD | Badahat | Dodital-I | Dodital | 4b | 4.71±8.46 | 1.79 | 28 | 0.578 |
| UFD | Dharasu | Dichli | Dichli | 5b | 4.40±9.72 | 2.21 | 20 | 1.100 |
| UYFD | Mugarsanti | Bhatia | Bhatia | 4 | 4.05±5.38 | 1.33 | 55 | 0.134 |
| UFD | Gangotri | Dharali-I | Dharali | 4a | 3.78±9.41 | 2.49 | 14 | 1.721 |
| UFD | Dharasu | Diwarikhol | Daski | 7 | 3.60±5.42 | 1.51 | 40 | 0.225 |
| UFD | Mukhem | NF | NF | NF | 3.60±7.92 | 2.20 | 20 | 0.900 |
| UYFD | Rawain | NF | NF | NF | 3.55±6.32 | 1.78 | 60 | 0.099 |
| TFD | Sandra | Salla | Odatta | 1b | 3.40±7.21 | 2.12 | 20 | 0.850 |
| TFD | Kotigard | NF | NF | NF | 3.20±6.84 | 2.14 | 25 | 0.512 |
| TFD | Kotigard | NF | NF | NF | 3.05±7.94 | 2.60 | 20 | 0.763 |
| UFD | Dunda | Dunda | Dunda | 4a | 2.55±6.24 | 2.45 | 15 | 1.133 |
| UFD | Badahat | Heena | Maneri | 6 | 2.21±5.63 | 2.54 | 14 | 1.085 |
| UFD | Mukhem | NF | NF | NF | 2.10±6.54 | 3.11 | 10 | 2.100 |
| UFD | Dharasu | Diwarikhol | Daski | 9a | 1.80±3.93 | 2.18 | 20 | 0.450 |
| UYFD | Rawain | Barkot | Barkot | 5b | 1.75±3.48 | 1.99 | 25 | 0.280 |
| TFD | Singtoor | Pasa | Nasna | 1 | 1.75±4.38 | 2.50 | 15 | 0.778 |
| UYFD | Rawain | Bigrari | Bigrari | 7a | 1.65±5.63 | 3.41 | 10 | 1.650 |
| UFD | Dunda | Nakuri | Singot | 6 | 1.40±3.80 | 2.72 | 15 | 0.622 |
| UYFD | Rawain | Pathargad | Pathargad | 4b | 1.30±3.37 | 2.59 | 15 | 0.578 |
| UFD | Dunda | Von-I | Ranukigad | 4b | 1.20±3.09 | 2.57 | 15 | 0.533 |
| UYFD | Yamunotri | NF | NF | NF | 1.10±4.92 | 4.47 | 5 | 4.400 |

| FD | Range | Beat | Block | Comp-artment | Density (ind./m$^2$) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UYFD | Rawain | Bigrari | Bigrari | 8a | 1.05±2.11 | 2.01 | 25 | 0.168 |
| UFD | Badahat | Naitala | Gawanagad | 5a | 0.95±3.61 | 3.79 | 10 | 0.950 |
| TFD | Purola | Purola | Purola | 1 | 0.90±2.77 | 3.08 | 15 | 0.400 |
| TFD | Kotigard | Kasta | Baanpur | 2 | 0.90±2.85 | 3.16 | 10 | 0.900 |
| TFD | Devta | Mora | Mora | 4 | 0.65±2.06 | 3.17 | 10 | 0.650 |
| UFD | Badahat | Badahat | Utraun | 7 | 0.65±2.91 | 4.47 | 5 | 2.600 |
| UFD | Dunda | NF | NF | NF | 0.50±1.54 | 3.08 | 10 | 0.500 |
| TFD | Purola | Binai | Deothal | 1 | 0.50±2.24 | 4.47 | 5 | 2.000 |
| UYFD | Kuthnaur | NF | NF | NF | 0.50±2.24 | 4.47 | 5 | 2.000 |
| TFD | Devta | Khunigad | Luna | 1 | 0.30±1.34 | 4.47 | 5 | 1.200 |
| TFD | Devta | Khunigad | Khunigad | 13 | 0.25±0.79 | 3.15 | 10 | 0.250 |
| UYFD | Kuthnaur | Ponti | Kimdaara | 10b | 0.15±0.67 | 4.47 | 5 | 0.600 |
| TFD | Singtoor | Nanai | Chungadu | 6 | 0.15±0.67 | 4.47 | 5 | 0.600 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.10: Population status and distribution of *Viola pilosa* in Uttarkashi**




**4.3.9 *Berberis aristata*:** *Berberis aristata,* occurred in 17 transect locations but was sporadically distributed at almost all locations. Maximum population was found in

Ranukigad block ($Dha^{-1}$ = 311.82 ± 6.39 SD; F = 25%) (Dunda Range, Uttarkashi FD), Pali block ($Dha^{-1}$ = 299.10 ± 3.77 SD; F = 35%) (Kuthnaur Range, Upper Yamuna FD), Nagungad block ($Dha^{-1}$ = 159.09 ± 2.02 SD; F = 35%) (Dharasu Range, Uttarkashi FD). It was also occurred on forest-village fringes of Yamunotri Range (Upper Yamuna FD), Dunda and Gangotri Ranges (Uttarkashi FD). **(Table 4.9, Figure 4.11).**

**Table 4.9: Population status of *Berberis aristata* in Uttarkashi**

| FD | Range | Beat | Block | Comp-artment | Density (ind./ha) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Dunda | Maatli | Ranukigad | 3b | 311.82 ±6.39 | 2.61 | 25 | 0.392 |
| UYFD | Kuthnaur | Pali | Pali | 16b | 299.10 ±3.77 | 1.61 | 35 | 0.192 |
| UFD | Dharasu | Patharkhol | Nagungad | 6a | 159.09 ±2.02 | 1.62 | 35 | 0.102 |
| UFD | Dunda | Chorgi | Dhanari | 14b | 152.73 ±1.61 | 1.34 | 45 | 0.059 |
| UFD | Dharasu | Diwarikhol | Daski | 7 | 146.37 ±1.35 | 1.17 | 50 | 0.046 |
| UFD | Badahat | Kawan | Kawan | 2 | 133.64 ±1.67 | 1.59 | 30 | 0.117 |
| UYFD | Yamunotri | NF | NF | NF | 101.82 ±1.58 | 1.97 | 25 | 0.128 |
| UFD | Badahat | Badahat | Utraun | 7 | 89.09 ±1.84 | 2.63 | 15 | 0.311 |
| UFD | Dharasu | Khurmola | Khurmola | 6b | 82.73 ±1.18 | 1.82 | 25 | 0.104 |
| UFD | Dunda | NF | NF | NF | 50.91 ±0.75 | 1.88 | 25 | 0.064 |
| UFD | Dharasu | Patharkhol | Nagungad | 6b | 38.18 ±0.98 | 3.26 | 10 | 0.300 |
| UFD | Dunda | Ranadi | Ranaki | 5 | 31.82 ±0.79 | 3.15 | 10 | 0.250 |
| UYFD | Yamunotri | Durvil | Bhairab | 1 | 31.82 ±0.91 | 3.64 | 10 | 0.250 |
| UFD | Gangotri | NF | NF | NF | 28.28 ±0.80 | 3.60 | 7 | 0.405 |
| UYFD | Mugarsanti | Kanseru | Kanseru | 6b | 25.46 ±0.89 | 4.47 | 5 | 0.800 |
| UYFD | Yamunotri | Rana | Rana | 4b | 19.09 ±0.67 | 4.47 | 5 | 0.600 |
| UFD | Taknaur | Bhukki-I | Bhuki | 6b | 12.73 ±0.45 | 4.47 | 5 | 0.400 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**4.3.10 *Zanthoxylum armatum*:** *Zanthoxylum armatum* was seen sporadically growing on forest-village fringes. Within the reserve forests, following areas show maximum population but patchy distribution: Molda block ($Dha^{-1}$ = 127.28 ± 2.88 SD; F = 15%) and Devrana block ($Dha^{-1}$ = 101.82 ± 2.26 SD; F = 15%) (Mugarsanti Range, Upper Yamuna FD), Ranaki block ($Dha^{-1}$ = 76.37 ± 1.67 SD; F = 20%) (Dunda Range, Uttarkashi FD) **(Table 4.10, Figure 4.12).**

**Figure 4.11: Population status and distribution of *Berberis aristata* in Uttarkashi**

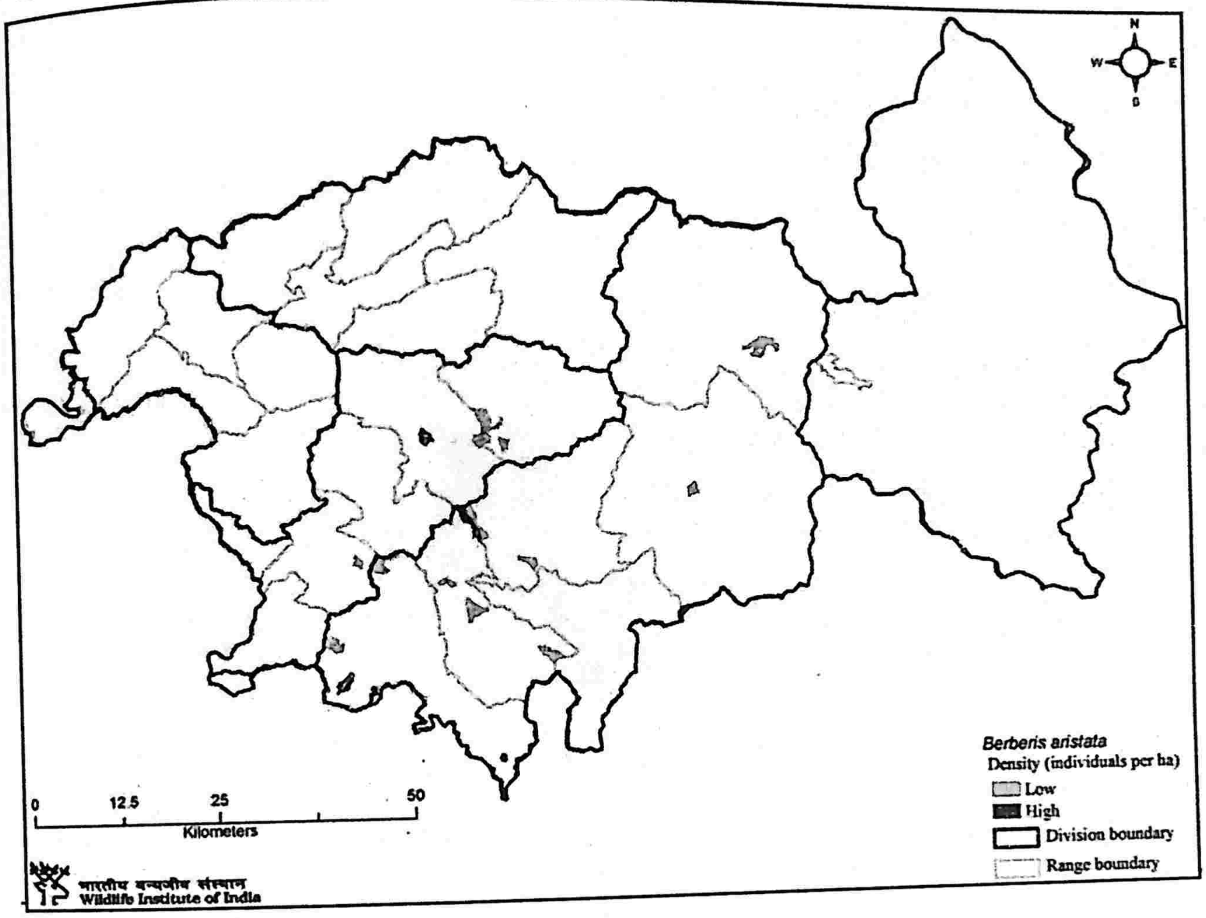



**Table 4.10: Population status of *Zanthoxylum armatum* in Uttarkashi**

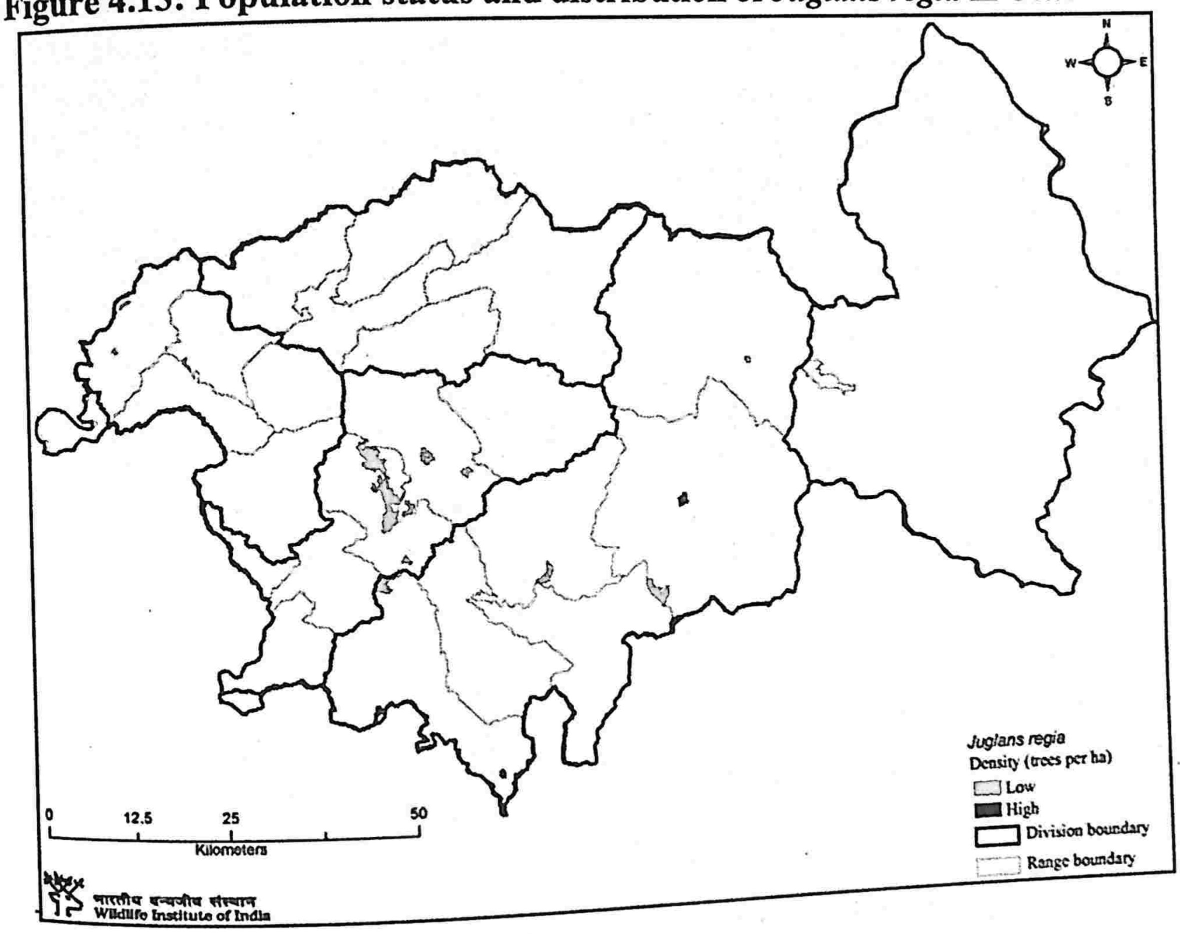
| FD | Range | Beat | Block | Comp-artment | Density (ind./ha) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UYFD | Mugarsanti | Molda | Molda | 1b | 127.28 ±2.88 | 2.88 | 15 | 0.444 |
| UYFD | Mugarsanti | Devrana | Devrana | 2a | 101.82 ±2.26 | 2.83 | 15 | 0.356 |
| UFD | Dunda | Ranadi | Ranaki | 5 | 76.37 ±1.67 | 2.78 | 20 | 0.150 |
| UFD | Mukhem | NF | NF | NF | 50.91 ±1.39 | 3.48 | 10 | 0.400 |
| TFD | Devta | Mora | Danda | 88 | 25.46 ±0.70 | 3.48 | 10 | 0.200 |
| UFD | Badahat | Kawan | Kawan | 3b | 19.09 ±0.67 | 4.47 | 5 | 0.600 |
| UFD | Mukhem | NF | NF | NF | 19.09 ±0.67 | 4.47 | 5 | 0.600 |
| UYFD | Kuthnaur | Pujargaon | Pali | 1a | 19.09 ±0.67 | 4.47 | 5 | 0.600 |
| TFD | Kotigard | NF | NF | NF | 12.73 ±0.31 | 3.08 | 10 | 0.100 |
| UFD | Mukhem | Dhotri-II | Jalkurgad | 27a | 12.73 ±0.31 | 3.08 | 10 | 0.100 |
| TFD | Purola | NF | NF | NF | 6.36 ±0.22 | 4.47 | 5 | 0.200 |
| TFD | Kotigard | Kasta | Baanpur | 2 | 6.36 ±0.22 | 4.47 | 5 | 0.200 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

| FD | Range | Beat | Block | Comp-artment | Density (trees/ha) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| TFD | Sandra | Salla | Kanda | 1 | 4.78 ±0.37 | 2.44 | 15 | 0.067 |
| UFD | Dharasu | Khurmola | Khurmola | 6b | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| TFD | Kotigard | Kaleech | Kaleech | 8 | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| UYFD | Kuthnaur | Kishala | Kishala | 1 | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| UYFD | Rawain | Pathargad | Pathargad | 5a | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| UYFD | Kuthnaur | Kupra | Kupra | 3 | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| UYFD | Kuthnaur | Pali | Pali | 16b | 1.59 ±0.22 | 4.47 | 5 | 0.200 |

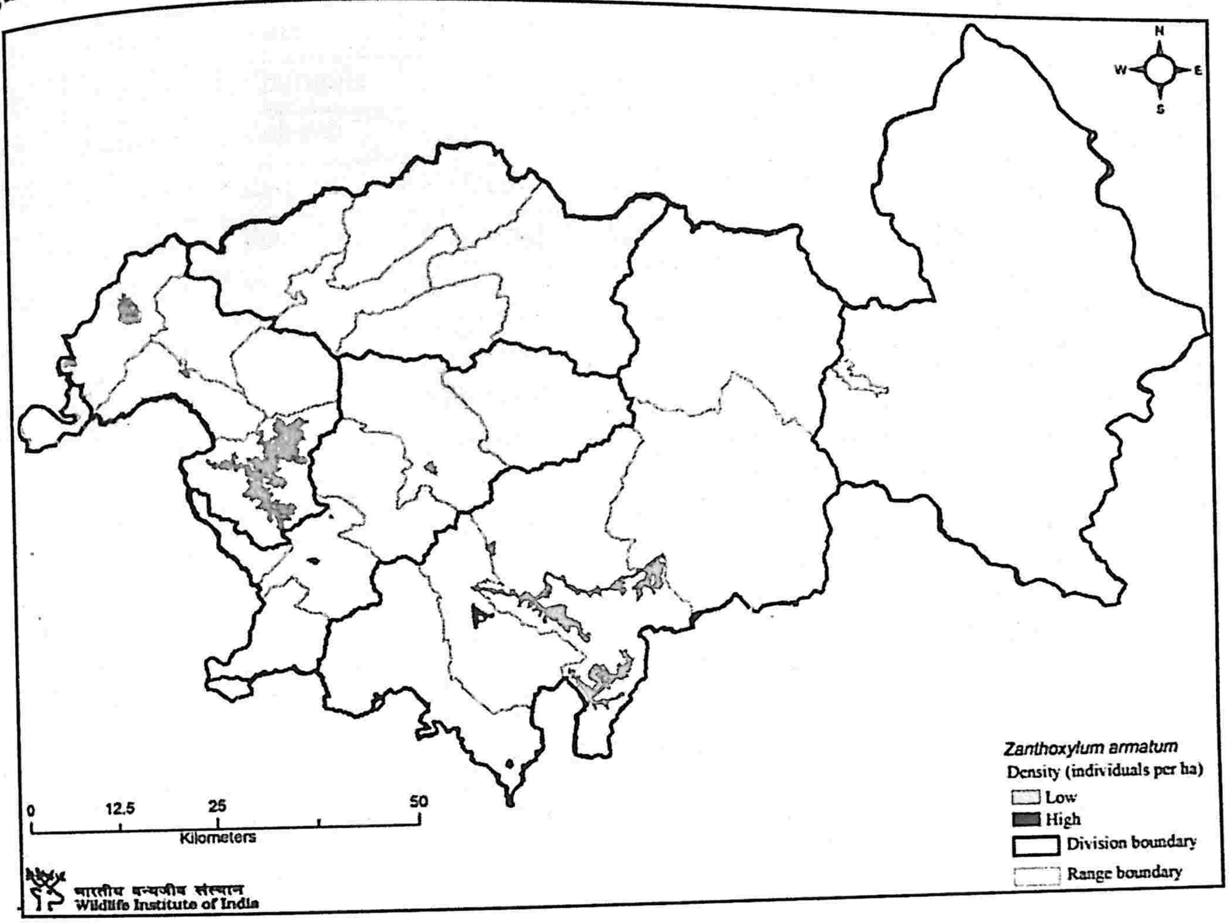
Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.13: Population status and distribution of *Juglans regia* in Uttarkashi**




**4.3.12** ***Quercus leucotrichophora***: *Quercus leucotrichophora* was found at 58 transect locations, with good population and contiguous distribution at almost 30 locations. It was found abundant in Godar block ($Dha^{-1}$ = 366.24 ± 6.03 SD; F = 95%) (Naugaon Range, Upper Yamuna FD). Baragaddi block ($Dha^{-1}$ = 261.15 ± 4.96 SD; F = 90%) and Sauragad block ($Dha^{-1}$ = 261.15 ± 5.81 SD; F = 85%) (Mukhem Range, Uttarkashi FD), Tyas block ($Dha^{-1}$ = 229.30 ± 4.27 SD; F = 100%) (Singtoor Range, Tons FD). **(Table 4.11, Figure 4.14)**.

**Figure 4.12: Population status and distribution of *Zanthoxylum armatum* in Uttarkashi**




4.3.11 ***Juglans regia***: Distribution of *Juglans regia* was sporadic in Uttarkashi. It was found maximum in Bhuki block ($Dha^{-1} = 28.66 \pm 1.37$ SD; F = 35%) (Taknaur Range, Uttarkashi FD). Debragad block ($Dha^{-1} = 14.33 \pm 0.76$ SD; F = 30%) (Kotigad Range, Tons FD), Pilang block ($Dha^{-1} = 9.55 \pm 0.80$ SD; F = 15%) (Taknaur Range, Uttarkashi FD), Kupra block ($Dha^{-1} = 9.55 \pm 1.13$ SD; F = 10%) (Kuthnaur Range, Upper Yamuna FD) were among few other sites where it was observed in low density with patchy distribution. (**Table 4.11, Figure 4.13**).

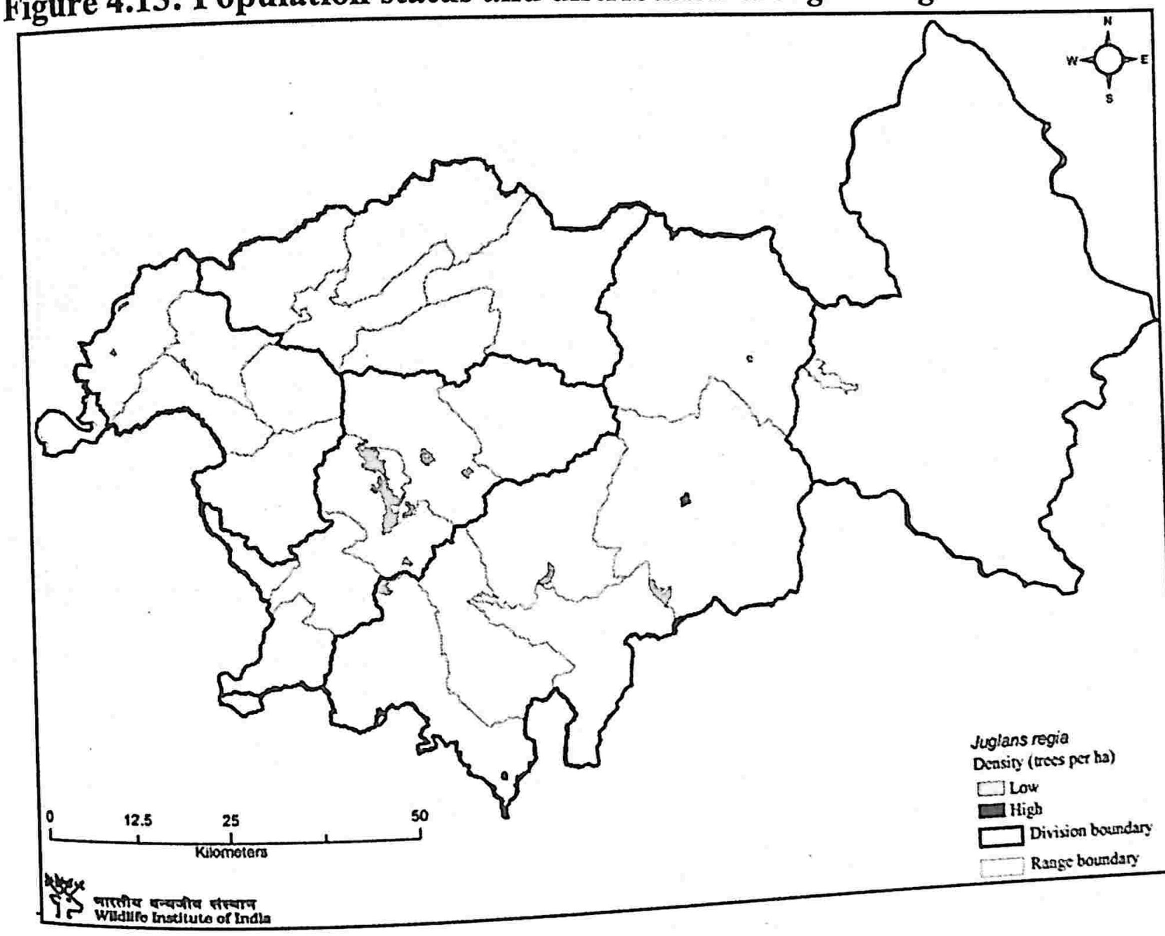
**Table 4.11: Population status of *Juglans regia* in Uttarkashi**

| FD | Range | Beat | Block | Comp-artment | Density (trees/ha) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UFD | Taknaur | Bhukki-I | Bhuki | 6b | 28.66 ±1.37 | 1.53 | 35 | 0.073 |
| TFD | Kotigard | Chiwan | Dedragad | 4a | 14.33 ±0.76 | 1.69 | 30 | 0.050 |
| UFD | Taknaur | Pilang-I | Pilang | 1c | 9.55 ±0.80 | 2.67 | 15 | 0.133 |
| UYFD | Kuthnaur | Kupra | Kupra | 5c | 9.55 ±1.13 | 3.76 | 10 | 0.300 |
| UFD | Badahat | Naitala | Gawanagad | 5a | 7.96 ±0.64 | 2.55 | 15 | 0.111 |
| UYFD | Rawain | NF | NF | NF | 7.96 ±0.79 | 3.15 | 10 | 0.250 |
| UFD | Gangotri | Dharali-I | Dharali | 4a | 7.08 ±0.85 | 3.81 | 7.41 | 0.405 |

| FD | Range | Beat | Block | Comp-artment | Density (trees/ha) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| TFD | Sandra | Salla | Kanda | 1 | 4.78 ±0.37 | 2.44 | 15 | 0.067 |
| UFD | Dharasu | Khurmola | Khurmola | 6b | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| TFD | Kotigard | Kaleech | Kaleech | 8 | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| UYFD | Kuthnaur | Kishala | Kishala | 1 | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| UYFD | Rawain | Pathargad | Pathargad | 5a | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| UYFD | Kuthnaur | Kupra | Kupra | 3 | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| UYFD | Kuthnaur | Pali | Pali | 16b | 1.59 ±0.22 | 4.47 | 5 | 0.200 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.13: Population status and distribution of *Juglans regia* in Uttarkashi**




**4.3.12 *Quercus leucotrichophora***: *Quercus leucotrichophora* was found at 58 transect locations, with good population and contiguous distribution at almost 30 locations. It was found abundant in Godar block ($Dha^{-1}$ = 366.24 ± 6.03 SD; F = 95%) (Naugaon Range, Upper Yamuna FD). Baragaddi block ($Dha^{-1}$ = 261.15 ± 4.96 SD; F = 90%) and Sauragad block ($Dha^{-1}$ = 261.15 ± 5.81 SD; F = 85%) (Mukhem Range, Uttarkashi FD), Tyas block ($Dha^{-1}$ = 229.30 ± 4.27 SD; F = 100%) (Singtoor Range, Tons FD). **(Table 4.11, Figure 4.14)**.

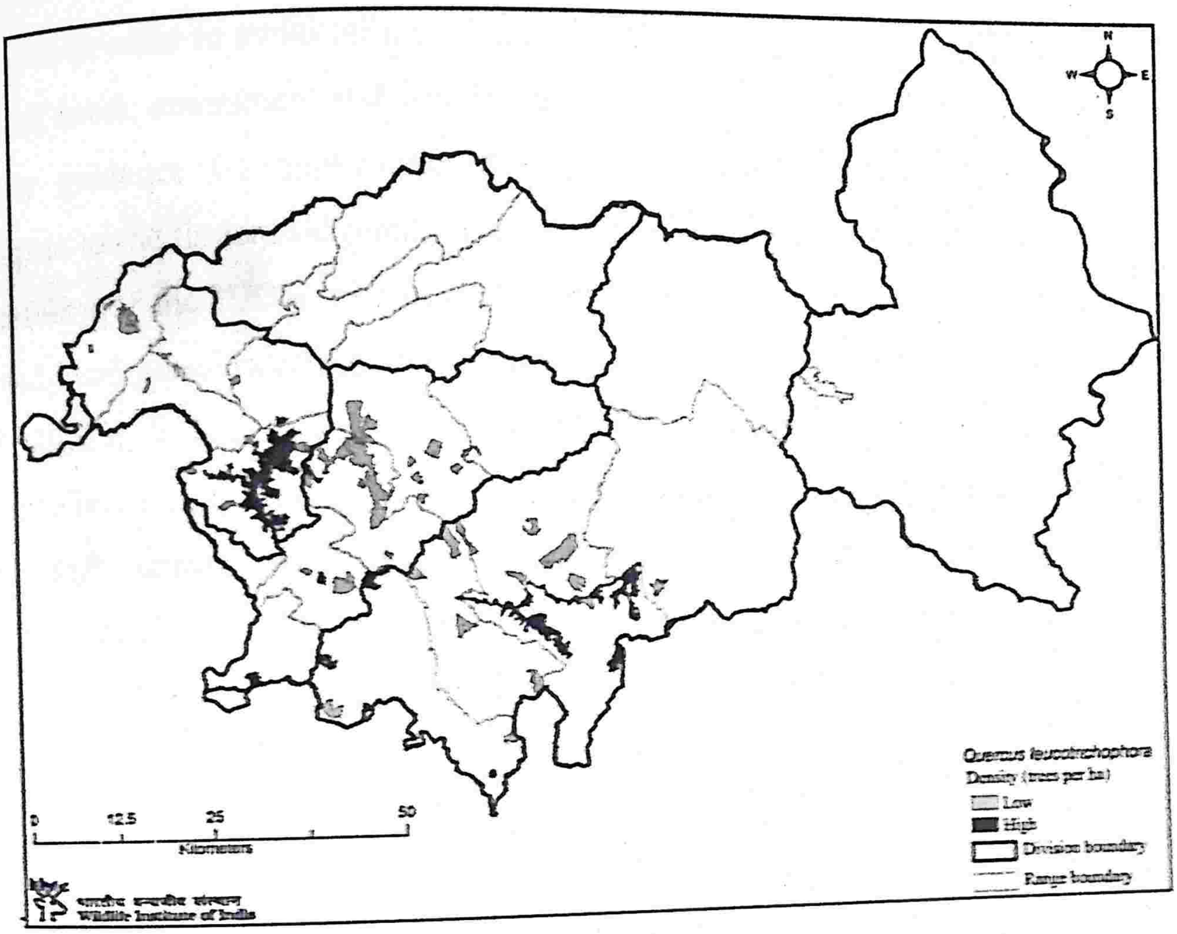
**Table 4.12: Population status of *Quercus leucotrichophora* in Uttarkashi**

| FD | Range | Beat | Block | Compartment | Density (trees/ha) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UYFD | Naugaon | Godar | Godar | 6 | 366.24 ±6.03 | 0.52 | 95 | 0.127 |
| UFD | Mukhem | Baragaddi-I | Baragaddi | 8c | 261.15 ±4.96 | 0.60 | 90 | 0.101 |
| UFD | Mukhem | Sauragad-III | Sauragad | 4f | 261.15 ±5.81 | 0.71 | 85 | 0.113 |
| UFD | Dharasu | Diwarikhol | Daski | 7 | 259.55 ±6.03 | 0.74 | 75 | 0.145 |
| UFD | Dharasu | Khurmola | Khurmola | 6b | 230.89 ±5.25 | 0.72 | 95 | 0.080 |
| TFD | Singtoor | Gandugad | Tyas | 6a | 229.30 ±4.27 | 0.59 | 100 | 0.072 |
| TFD | Purola | NF | NF | NF | 222.93 ±3.29 | 0.47 | 95 | 0.078 |
| UYFD | Mugarsanti | Bhatia | Bhatia | 4 | 203.82 ±5.92 | 0.93 | 70 | 0.131 |
| UYFD | Rawain | Kotla | Bhiali | 2b | 194.27 ±3.40 | 0.56 | 95 | 0.068 |
| UFD | Mukhem | NF | NF | NF | 191.08 ±5.09 | 0.85 | 85 | 0.083 |
| UFD | Badahat | Seku-I | Dodital | 1a | 182.77 ±6.23 | 1.09 | 60.87 | 0.155 |
| TFD | Purola | Gundiatgaon | Gundiatgaon | 8 | 181.53 ±3.15 | 0.55 | 100 | 0.057 |
| UFD | Dunda | Von-I | Ranukigad | 4b | 173.57 ±4.36 | 0.80 | 85 | 0.075 |
| UYFD | Mugarsanti | Tiyan | Tiyan | 4 | 168.79 ±5.17 | 0.98 | 90 | 0.065 |
| UYFD | Rawain | Pathargad | Pathargad | 4b | 167.20 ±3.24 | 0.62 | 85 | 0.073 |
| UFD | Dharasu | Patharkhol | Nagungad | 6c | 144.90 ±4.31 | 0.95 | 95 | 0.050 |
| UFD | Mukhem | Baghi-III | Jalkurgad | 22b | 132.17 ±3.18 | 0.77 | 80 | 0.065 |
| UFD | Dunda | Singot | Singot | 5 | 128.98 ±2.63 | 0.65 | 90 | 0.050 |
| UFD | Dunda | Chakon | Dhanari | 10b | 128.98 ±3.66 | 0.90 | 75 | 0.072 |
| UYFD | Rawain | Barkot | Barkot | 5b | 127.39 ±3.57 | 0.89 | 75 | 0.071 |
| TFD | Purola | Shikaru | Shikaru | 2 | 125.80 ±2.67 | 0.67 | 95 | 0.044 |
| UFD | Badahat | Gawana-II | Gawanagad | 4b | 114.65 ±3.98 | 1.11 | 70 | 0.073 |
| UYFD | Kuthnaur | Pali | Pali | 16a | 108.28 ±2.62 | 0.77 | 85 | 0.047 |
| UFD | Mukhem | Baghi-III | Jalkurgad | 21b | 105.10 ±1.69 | 0.51 | 95 | 0.037 |
| UYFD | Rawain | NF | NF | NF | 103.50 ±3.32 | 1.02 | 65 | 0.077 |
| UFD | Taknaur | Pilang-I | Pilang | 1e | 92.36 ±2.22 | 0.77 | 80 | 0.045 |
| TFD | Purola | Jakh | Dalnu | 6 | 68.47 ±2.35 | 1.09 | 65 | 0.051 |
| UYFD | Kuthnaur | Wazri | Wazri | 3 | 66.88 ±2.17 | 1.36 | 80 | 0.033 |
| TFD | Kotigard | Kaleech | Kaleech | 5 | 66.88 ±2.86 | 1.04 | 50 | 0.084 |
| UFD | Dunda | Chorgi | Dhanari | 14b | 63.69 ±2.70 | 1.35 | 50 | 0.080 |
| UYFD | Kuthnaur | Ponti | Kimdaara | 10b | 55.73 ±2.00 | 1.14 | 60 | 0.049 |
| TFD | Devta | Ringali | Jorion | 13 | 54.14 ±1.53 | 0.90 | 80 | 0.027 |
| TFD | Sandra | Salla | Kanda | 2 | 52.55 ±1.35 | 0.82 | 70 | 0.034 |
| UYFD | Kuthnaur | Wazri | Wazri | 6 | 50.96 ±2.68 | 1.68 | 40 | 0.100 |
| UYFD | Rawain | Bigrari | Bigrari | 7a | 44.59 ±2.19 | 1.56 | 35 | 0.114 |
| UYFD | Rawain | NF | NF | NF | 42.99 ±1.95 | 1.45 | 50 | 0.054 |
| UFD | Badahat | Kawan | Kawan | 2 | 39.81 ±1.65 | 1.32 | 50 | 0.050 |

| FD | Range | Beat | Block | Comp-artment | Density (trees/ha) ± SD | CV | F (%) | A/F |
|---|---|---|---|---|---|---|---|---|
| UYFD | Rawain | Patangni | Patangni | 8 | 30.25 ±2.76 | 2.91 | 25 | 0.152 |
| TFD | Devta | Devta | Partil | 6 | 28.66 ±1.33 | 1.48 | 40 | 0.056 |
| UYFD | Kuthnaur | Pujargaon | Pali | 1a | 28.66 ±1.48 | 1.65 | 35 | 0.073 |
| UYFD | Kuthnaur | Pali | Pali | 18a | 23.89 ±2.05 | 2.73 | 25 | 0.120 |
| UYFD | Kuthnaur | NF | NF | NF | 22.29 ±1.78 | 2.54 | 20 | 0.175 |
| TFD | Kotigard | Chiwan | Dedragad | 4a | 17.52 ±1.00 | 1.82 | 30 | 0.061 |
| TFD | Kotigard | NF | NF | NF | 14.33 ±1.19 | 2.65 | 20 | 0.113 |
| UYFD | Mugarsanti | Devrana | Devrana | 2a | 11.15 ±0.81 | 2.32 | 20 | 0.088 |
| UYFD | Kuthnaur | Kuthnaur | Kuthnaur | 1a | 9.55 ±0.73 | 2.44 | 20 | 0.075 |
| UFD | Badahat | Badahat | Utraun | 7 | 9.55 ±0.73 | 2.44 | 15 | 0.133 |
| UYFD | Kuthnaur | Kupra | Kupra | 5c | 9.55 ±0.73 | 2.44 | 15 | 0.133 |
| UYFD | Rawain | Bigrari | Bigrari | 7a | 7.96 ±0.64 | 2.55 | 15 | 0.111 |
| TFD | Sandra | Salla | Saras | 3 | 4.78 ±0.49 | 3.26 | 10 | 0.150 |
| TFD | Singtoor | Nanai | Chungadu | 6 | 4.78 ±0.49 | 3.26 | 10 | 0.150 |
| UYFD | Yamunotri | Rana | Rana | 1c | 4.78 ±0.49 | 3.26 | 10 | 0.150 |
| UFD | Badahat | Naitala | Gawanagad | 5a | 4.78 ±0.67 | 4.47 | 5 | 0.600 |
| UFD | Mukhem | Jamak-IV | Jamak | 6b | 4.78 ±0.67 | 4.47 | 5 | 0.600 |
| UYFD | Mugarsanti | Kanseru | Kanseru | 6b | 3.18 ±0.31 | 3.08 | 10 | 0.100 |
| UFD | Badahat | Heena | Maneri | 6 | 2.27 ±0.27 | 0.27 | 7.14 | 0.140 |
| UFD | Dharasu | Diwarikhol | Daski | 9a | 1.59 ±0.22 | 4.47 | 5 | 0.200 |
| UFD | Dunda | Ranadi | Ranaki | 5 | 1.59 ±0.22 | 4.47 | 5 | 0.200 |

Note: UFD: Uttarkashi FD; UYFD: Upper Yamuna FD; TFD: Tons FD; CV: Coefficient of Variance; F: Frequency

**Figure 4.14: Population status and distribution of *Quercus leucotrichophora* in Uttarkashi**




## 4.4 Discussion

There is a tremendous pressure on the wild populations of many EMPs, in form of exploitation, due to increasing demand from pharmaceutical sector (Maikhuri *et al.* 1998, Singh 2002, Kala 2005b, Kala *et al.* 2006). Though over-harvesting of EMPs from wild has been identified as one of the major threats, habitat destruction (alteration and fragmentation) due to fodder and fuel wood collection, agricultural practices, livestock (over) grazing, rapid urbanisation, and presence of invasive species are also enhancing the rate of depletion of wild MAPs by manifolds (Agarwal 1997; Maikhuri *et al.* 2001; Uniyal *et al.* 2003; Jablonski 2004; Dhyani and Kala 2005; Lulekal *et al.* 2008). Top of all, several MAPs have slow growth rates, low population densities and narrow geographic ranges (Nautiyal *et al.* 2002; Kala 2005b; Rawat 2005), which make them more prone to extinction (Jablonski 2004). High demand, high market value and faster rate of depletion have made few MAPs very rare. *Aconitum heterophyllum, Dactylorhiza hatagirea, Picrorhiza kurrooa* and *Rheum australe* are among such rare species. These EMPs were at the centre point of many previous studies.

Due to depletion few species have been banned from export (negative list of export by Department of Commerce, Government of India) or their trade has been monitored and controlled in order to avoid utilization incompatible with their survival (CITES). At national and local level, assessment and conservation status has been carried out in order to provide strategic guidance for application of intensive management and information collection techniques to the threatened plants. They also provide a comprehensive means of testing the applicability of the IUCN criteria to the threatened taxa (CAMP) and several studies have recorded local pressure of use and distribution status of the species in its range (e.g., Uniyal *et al.* 2002a; Rawat 2005) **(Table 4.13)**. Two of the four rare species, namely, *A. heterophyllum* and *D. hatagirea*, showed restricted distribution in the Uttarakhand state but other two (*P. kurrooa* and *R. australe*) were marked locally common, having used heavily by locals (Rawat 2005). In Kumaon region (of the state) all four species have been categorized under restricted distribution and high used pressure **(Table 4.13)**.

**Table 4.13: Threatened status and distribution-use category of EMPs**

| Species | CITES +^ | Export_ve +^ | CAMP UK $ | AMU + | AMKh ^ |
|---|---|---|---|---|---|
| *A. heterophyllum* | | Y | CR | RDHP | RDHP |
| *D. hatagirea* | II | Y | CR | RDHP | RDHP |
| *J. regia* | | | | | |
| *P. kurrooa* | II | Y | CR | LCHP | RDHP |
| *R. australe* | | Y | EN | LCHP | RDHP |
| *Z. armatum* | | | VU | | |

CR = Critically Endangered; EN = Endangered; VU = Vulnerable; RDHP = Restricted distribution heavy pressure; LCHP = Locally common heavy pressure; Export -ve = Public notice regarding negative list of export issued by Dept. of Commerce (Govt. of India); CAMP UK= Regional status as per the Shimla CAMP; AMU = alpine meadow of Uttarakhand; AMKh = Alpine meadow of Upper Gori Valley (Kumaon, Uttarakhand); ^ Uniyal *et al.* 2002a; $ Ved *et al.* 2003; + Rawat 2005;

Not only these four species are under heavy pressure of demand but also species like *Q. leucotrichophora*, *Z. armatum* and *B. aristata* are under heavy pressure due to their use in daily life as well as owing to having cultural significance (Farooquee 1994; Kala *et al.* 2005; Singh and Rawat 2011; Tiwari 2011; Singh and Rawat 2012). Other species (except, *V. pilosa* and *G. wallichianum*) may not necessarily face a high pressure of use but may have restricted distribution, which was depicted through the present study. Considering these facts the only option which could be visualized is the cultivation; but even cultivation also has some restrictions.

The cultivation of medicinal plants could be thought as a potential alternative for meeting the raw material needs for pharmaceutical companies. Apart from meeting the demand, farming might produce uniform material of standardized products that can be obtained consistently. Cultivation can also lead to better species identification, improved quality control, and increased prospects for genetic improvements (Kala *et al.* 2006). But information on the propagation of medicinal plants is available for less than 10% and agro-technology is available only for 1% of the total known plants globally (Lozoya 1994; Lambert *et al.* 1997; Khan and Khanum 2000). A more culturally driven yet partly scientifically proven fact was that medicinal efficacy of wild plants is reduced or remain absent once they are brought into cultivation (Giblette 2004; Schafer 2011). On the other hand, it is realized that *in situ* conservation is the most reliable and cost effective method of conserving the diverse genetic base of various plant species. It only requires identifying natural vegetation zones of high medicinal plant diversity (Canter *et al.* 2005). However, *ex situ* conservation should not be used as a reason for failing to safeguard representative samples of the medicinal plants and their habitats in nature (WHO-IUCN-WWF 1993).

Many previous studies estimated population status of MAPs in various regions of Uttarakhand as well as in western Himalayan region (**Table 4.14**). However, alpine MAPs remained in the focus of such studies, may be due to their market value. Population status of many alpine MAPs, across western Himalaya, was found to be very low even in previous studies (**Table 4.14**). Based on the findings from present and previous studies, both from protected and unprotected areas, highest and lowest densities of EMPs (alpine) have been given in **Table 4.14**. This range of density could be a possible range of optimum densities across the western Himalayan landscape.

In case of *A. heterophyllum*, population across western Himalaya was very low (**Table 4.1 and 4.14**), except at Kedarnath WLS (Semwal *et al.* 2007) in Uttarakhand and Chhota Bhangal area in Himachal Pradesh. According to Uniyal *et al.* (2006), in alpine areas of Chhota Bhangal (Himachal Pradesh) it was abundant and evenly distributed wherever found ($Dm^{-2}$ = 3.7 ± 0.6 SD; F = 100% and $Dm^{-2}$ = 2.7 ± 1.7 SD; F = 66.6%). Rawat (2005) recorded its presence in various alpine meadows of Uttarakhand and found very low density in Gidara and Kushkalyani-Kyarki regions (0.08 and 0.01 respectively) of Uttarkashi.

Wadhawa *et al.* (1987) recorded it from VoF but it did not reappear in study conducted by Kala *et al.* (1998).

**Table 4.14: Population status of high value alpine medicinal herbs across western Himalaya**

| Herbaceous MAPs | Highest and lowest densities$ (D = individuals $m^{-2}$) (Forest Block, Forest Range, FD) | Previous work |
|---|---|---|
| *Aconitum heterphyllum* | 2.95 (Gangnani , Taknaur, UFD)<br>0.05 (Bhairab, Yamunotri, UYFD) | 0.33(KEWS); 0.003 (Mdl); 0.86*(GV); **3.6** (KWLS) |
| *Dactylorhiza hatagirea* | 3.15 (Suki, Gangotri, UFD)<br>0.33 (Gangotri, Gangotri,UFD) | 4.2 (VOFNP); 3.16 (KEWS); 6.66 (PVNP); 18 (KIWS); 0.37 (KAWS); 0.48 (GV); **16.19** (ITH); 4.2 (NDBR); 1 (VoF); 3.5 (KWLS) |
| *Picrorhiza kurrooa* | **6.65** (Suki, Gangotri, UFD)<br>0.95 (Yamunotri, Yamunotri, UYFD) | 4.5 (VOFNP); 3.36 (KEWS); 0.017 (Mdl); 3.90 (GV); 0.01 (ITH); 4.5 (VoF); 2.2 (KWLS) |
| *Rheum australe* | 0.60 (Harsil, Gangotri, UFD)<br>0.30 (Suki, Gangotri, UFD) | 0.24 (VOFNP); 0.34 (KEWS); 2.00 (PVNP); 0.11 (GV); **2.66** (ITH); 0.24 (VoF) |

* highest Density in one of the habitat (overall not given)

Kala *et al.* 1998 - VoF [Valley of Flowers National Park (NP)]; Maikhuri *et al.* 1998 - NDBR (Nadadevi Biosphere Reserve); Kala 2000 - ITH (Indian Trans-Himalaya); Uniyal *et al.* 2002a - GV (Gori Valley, Kumaon); Kala 2005b - VOFNP (Valley of Flowers NP), KAWS [Karakoram Wildlife Sanctuary (WLS)], KEWS (Kedarnath WLS), KIWS (Kibber WLS), PVNP (Pin Valley NP); Semwal *et al.* 2007 – KWLS (Kedarnath WLS); Singh *et al.* 2011 - Mdl (Mandal Valley, Garhwal); $ = present study
[(**0.00** = highest density; 0.00 = lowest density) among all studies mentioned in this table]

*D. hatagirea* shows wider distribution across the western Himalaya and its population density in Uttarkashi is comparable and almost similar to many protected areas such as, Kedarnath wildlife sanctuary (WLS), Karakoram WLS, Nadadevi Biosphere Reserve (NDBR) and VoF. Outside the protected areas (of Uttarakhand), Rawat (2005), recorded this species at various places but it occurred in the sampling plots only at three places, namely, Darma ($Dm^{-2}$=0.02), Johar ($Dm^{-2}$=0.03) and at Gidara (Uttarkashi; $Dm^{-2}$=0.08). This also suggests that though species is widely present but has restricted and patchy distribution and low abundance. In Indian trans-Himalaya (ITH) it showed very high density but outside protected areas (in Uttarakhand) population of *D. hatagirea* was comparable (and equal) to many locations from present study (**Table 4.2 and 4. 14**).

Due to over harvest from many of its natural habitat once plentiful, *P. kurrooa,* is now restricted to areas not accessible to man (Virdi 2004; Uniyal *et al.* 2009). In addition to studies given in **Table 4.14,** additional studies conducted in some alpine region of Uttarakhand and Himachal Pradesh states showed high density at Gori valley ($Dm^{-2}$ = 11.3 ± 25.09 SD; F = 76.11%) and Uhl valley ($Dm^{-2}$ = 9.38 ± 5.5 SD; F = 55.5%). In all three valleys authors have identified some areas to treat as control sites for future monitoring (Uniyal *et al.* 2009). A survey carried out by Rawat (2005) recorded low population status of the species in the state when compared to other studies. The study also revealed that, Gidara and Kushkalyani-Kyarki regions (of Uttarkashi) showed better population than Upper Gori valley region. Uniyal *et al.* (2009) also mentioned that density was low where extraction was high. Population of *R. australe* in Uttarakhand seems to be very low. Studies carried out in VoF, Kedarnath WLS, Gori Valley confirms the findings of present study (**Table 4.5 and 4.14**). A population status found in VoF, is intermediate of population found in Uttarkashi at two locations. It was not only found in low abundance but also showed very low frequency ($Dm^{-2}$ = 0.40 ± 0.12 SD; F = 10%), exactly similar to present findings. It was found frequent in the meadows of Gidara and Kushkalyani-Kyarki, in survey conducted by Rawat (2005), but was not observed during present study at those places. It was found abundant ($Dm^{-2}$ = 5.3 ± 0.8 SD; F = 100%) in undulating meadows of Chhota Bhangal area (Himachal Pradesh) as well as showed good population in ITH (Kala 2000).

Owing to either their wide distribution or not so high economic importance, of the vast number of medicinal plants, only a small number have received considerable attention (Briskin 2000; Elferink 2008). Population status of *Geranium wallichianum, Senecio nudicaulis, Viola pilosa* and *Verbascum thapsus* have been rarely studied. Singh *et al.* (2011) recorded very low density of *G. wallichianum* in Mandal valley of Garhwal Himalaya ($Dha^{-1}$ = 1770.83 and 6533 individuals). Adnan (2011) has reported high density of *G. wallichianum* from less disturbed forest of Pakistani Himalaya, where the species is more studied. *Verbascum thapsus*, on the other hand, has been considered as invasive in many parts of the world. Having large native range (Eurasian and African, through Himalayan Mountain till east Tibet) of distribution, an introduced (but now naturalized) species in the United States (and many temperate areas of Australia and New Zealand) prefers disturbances by fire (Juvik and Juvik 1992; Wilbur *et al.* 2010). Due to its invasiveness, in Canada, United States and Hawaii, it was studied more in those regions. A study conducted to examine the life history of this temperate plant which invades in the tropics, showed that germination, survival, growth, and reproduction in *V. thapsus* varied among sites along the elevational gradient, in Mauna Kea (Hawaii) (Ansari and Daehler 2010). Many such studies have stated that species was found abundant in disturbed areas. *Viola pilosa* was found abundant in lower (1500-2200m) and middle (2201-2700m) altitude zones in Mandal valley, Garhwal Himalaya (Singh *et al.* 2011).

Contiguous distribution has not been restricted to only herbaceous EMPs which are rare and endangered but distribution pattern of most of the species is contiguous in natural vegetation (Greig-Smith 1957; Singh and Yadava 1974; Pala *et al.* 2012). Therefore, even shrub and tree species also showed contiguous distribution in Uttarkashi. Lower A/F value of Banj oak in some areas like, Kanda block, Sandra Range and Jorion block, Devta Range of Tons FD, indicate the even distribution of the species. However, at other surveyed areas it was random or sporadic. In Mandal valley, it was found abundant ($Dha^{-1}$ = 173.08; F = 32.61%) at lower elevation zone (1500m-2200m). A recent study carried out in Uttarakhand, by Tiwari (2011), revealed that *B. aristata* was widely distributed in the state in all types slope and aspect categories, between altitude range of 2300m asl to 3600m asl. Tiwari (2011) also stated that species was under heavy pressure not only for medicinal purpose but also for fuel wood. Stems were also collected to sell in the form of sticks to pilgrims visiting famous *Char-Dham* of Uttarakhand (Kala *et al.* 2005). In fact, at many places, in recent past, it was observed that collection of medicinal plants is more for selling than local usage (Kala *et al.* 2005; Uniyal *et al.* 2002b; Raut *et al.* 2012).

*Z. armatum* grows naturally as an understory species, in both pine and oak forests (Den Hertog and Wiersum 2000). It showed high abundance at lower altitudinal areas of Mandal valley compare to middle zone ($Dha^{-1}$ = 12.46; F = 4.35% and $Dha^{-1}$ = 2.12; F = 0.83%, respectively).

Several studies have demonstrated molecular and pharmacological aspects of *J. regia* (Oliveira *et al.* 2008; Wang *et al.* 2008), even there are horticulture studies but considering wider range of distribution no studies on wild population were found, at least not in Uttarakhand (Dhillon and Rana 2004; Aradhya *et al.* 2010).

*Q. leucotrichophora*, a climax species of cooler climate, is the most common broadleaf tree in the mid-elevational area of Uttarkashi which covers extensive areas that falls between the altitudinal ranges of 1500-2300m (Champion and Seth 1968; Singh and Singh 1987, 1992). It is one of the most preferred fodder and fuel-wood species and therefore, faces a threat of depleting forest cover under this species. A recent study in Uttarkashi revealed that mean tree density in the district is one of the highest density in entire state ($Dha^{-1}$ = 393individuals ± 218 SD) and regeneration is also in its peak as seedling density is the highest in the state ($Dha^{-1}$ = 793 individuals ± 623 SD). The study enumerated 4574 patches of *Q. leucotrichophora* of which 2408 are less than one ha in size whereas 27 patches are larger than 100ha (Singh and Rawat 2011). Previously, Thadani and Ashton (1995) stated that, the best regeneration establishment was observed in reserve and private forests, which had moderate levels of disturbance. It also mentioned that in protected areas due to complete canopy closure banj oak seedling does not established well but the high disturbance levels in village forests also discouraged the establishment. A study conducted in Askot WLS, showed very high density of species ($Dha^{-1}$ = 1100 trees) but suspected that due to heavy grazing pressure poor representation of recruitment class was observed (Dhar *et al.* 1997).

### 4.5 Conclusion

1. Eight of the 12 species of ethnobotanical significance species were also traded commercially. All species, except widely distributed EMPs, showed contiguous distribution within the surveyed area. Four species are rare and endangered with restricted distribution and very low population.
2. *Q. leucotrichophora, Z. armatum* and *B. aristata* are also under heavy pressure due to their use in daily life as well as owing to having cultural significance.
3. *J. regia, S. nudicaulis,* and *V. thapsus* may not necessarily face a high pressure of use but show restricted distribution.
4. *G. wallichianum* is locally important species but show wider distribution with good population, though it was not considered of high use value in many previous studies.
5. The EMPs with (with their common name and) highest density at various forest blocks are as below:

i. *Aconitum heterophyllum* (Atis) (Ganganani block, Taknaur Range, Uttarkashi FD)
ii. *Dactylorhiza hatagirea* (Hath Jari, Salam Panja) (Suki block, Gangotri Range, Uttarkashi FD)
iii. *Geranium wallichianum* (Ratanjyot, Laljari) (Harsil block, Gangotri Range, Uttarkashi FD)
iv. *Picrorhiza kurrooa* (Kutki, Karui) (Suki block, Gangotri Range, Uttarkashi FD)
v. *Rheum australe* (Dolu, Archa) (Harsil block, Gangotri Range, Uttarkashi FD)
vi. *Senecio nudicaulis* (Neel-Kanthi) (Dilasur block, Mukhem Range, Uttarkashi FD)
vii. *Verbascum thapsus* (Akulabir, Gidar-tamaku) (Kukreda block, Devta Range, Tons FD)
viii. *Viola pilosa* (Vanfsa) (Dichli block, Dharasu Range, Uttarkashi FD)
ix. *Berberis aristata* (Kingore, Kasmor) (Ranukigad block, Dunda Range, Uttarkashi FD)
x. *Zanthoxylum armatum* (Timroo, Tumbak) (Molda block, Mugarsanti Range, Upper Yamuna FD)
xi. *Juglans regia* (Akhrot) (Bhuki block, Taknaur Range, Uttarkashi FD)
xii. *Quercus leucotrichophora* (Banj) (Godar block, Naugaon Range, Upper Yamuna FD)

# Chapter 5:
# Habitat Specificity of High Value Ethnomedicinal Plants

# 5.0 HABITAT SPECIFICITY OF HIGH VALUE ETHNOMEDICINAL PLANTS

## 5.1 Introduction

Response of a species to a set of habitat variables such as mean annual temperature, solar radiation, precipitation and soil properties influences its distribution (Brown 1984). Habitat specificity, especially in case of rare species, is difficult to quantify because the environmental variables that limit distribution can only be identified confidently through experimental manipulation (Begon *et al.* 1996). Often establishing the correlations of species' distribution to these variables is more difficult than measuring range of abundance. This could be one of the potential reasons behind lack of habitat specificity studies in case of rare species (Lindenmayer and Burgman 2005). Globally populations of many plant species are declining owing to loss, degradation and fragmentation of suitable habitats (Colling and Matthies 2006; Dar *et al.* 2008). Upsurge in demand of MAPs globally has led to overexploitation of these MPs thereby threatening their wild population (Kala *et al.* 2006, Mulliken and Crofton 2008). Short growth period, poor soil and specific habitat requirement of several MAPs further restricts their distribution and abundance (Nautiyal *et al.* 2002; Joblonski 2004; Kala *et al.* 2006). In Himalaya, quantitative studies on micro-habitat preferences of MAPs are rather sparse (Kala 2005b). Commercially important MAPs which show restricted distribution **(Table 3.7 and 4.13)** have been studied more for their habitat specificity and distribution, for example, studies conducted by Kala *et al.* (1998); Uniyal *et al.* (2002a); Rawat (2005); Uniyal *et al.* (2006); Semwal *et al.* (2007). Of these studies, except Rawat (2005) which was at state level study carried out in alpine meadows of Uttarakhand, all other studies were local (area specific). Owing to small population size and habitat specific distribution of MAPs more local studies are required as such studies often provide with important data that complement regional or national studies (Kumar and Jain 2002). Such studies reveal the local environment and sometimes exceptions to the general trend that is believed or assumed (Joshi *et al.* 2013). For example, district-level research on medicinal and aromatic plant trade from Nepal to India showed that the trade may be more extensive than originally estimated through regional studies (Olsen and Helles 1997).

Therefore, in the current study an attempt was made to investigate the impact of various covariates on the presence and absence of EMPs in Uttarkashi district.

**Objective**

**To study the habitat specificity and distribution of selected ethnomedicinal plants in the district**

Two research questions were posed to achieve the above objective.

1. Which vegetation (habitat) types were preferred by selected EMPs?
2. Which environmental variables preferred more by EMPs?

To address the above research questions following methodology was used.

## 5.2 Methodology

### 5.2.1 Data collection

The sampling method was similar to one which was carried out to enumerate population status of EMPs therefore, more details about sampling methods can be found in previous chapter 4 (Section 4.3.2). The data set consists of presence/absence records for 12 EMPs. In case of herbaceous EMPs, occurrences in any of the four quadrats laid in cardinal direction, within one 10m radius plot, was considered for presence of that species. Hence, the numbers of plots for herbs were equal to that of trees and shrubs.

In addition to presence/absence data of species, environmental variables were recorded as well as extracted using ArcGIS tool (ver. 9.3). Environmental covariates included elevation, slope and aspect, influence the occurrence and abundance of various plants (Claridge *et al.* 1993; Stohlgren and Bachand 1997; Sharma and Baduni 2000; Kharkwal *et al.* 2005; Körner 2007). Aspect particularly influences the level of solar radiation a site receives and in turn helps regulate soil moisture status (Claridge *et al.* 2000). Furthermore, the slope measures compositional pattern diversity and landscape complexity (Scheiner 1992). Aspect was measured in degrees, using a compass, and for later statistical (Ivlev's Electivity Index) analyses, it was grouped into eight classes: N (337.5°-22.5°), NE (22.5°-67.5°), E (67.5°-112.5°), SE (112.5°-157.5°), S (157.5°-202.5°), SW (202.5°-247.5°), W (247.5°-292.5°) and NW (292.5°-337.5°). Variables were measured from a centre point of the biggest circular plot i.e., 10m radius plot. Ruggedness and degree of slope was generated by Digital Elevation Model (DEM; USGS 2004) using SAGA GIS (version 2.0.5; www.saga-gis.org; Cimmery

2010). **Slope** (in degrees) were grouped into four classes *viz.*, <5° = gentle; 5° to 15° = moderate; 15° to 30° = moderately steep; 30° to 50° = steep (Jeganathan and Chauniyal 2000).

Bioclimatic variables (e.g., BIOCLIM) which represent annual trends (e.g., mean annual temperature, annual precipitation) were used (Hijmans *et al.* 2005). Human footprint (human influence) data, for each surveyed plot, was extracted using ArcGIS software (ver. 9.3) evolved by Sanderson *et al.* (2002). In case of Uttarkashi, the value (z score) ranges from -0.97371 to 2.33782, where lowest footprint (influence) value denotes less human influences and so more intact (and less altered) habitat (Sanderson *et al.* 2002).

Micro-habitat study was carried out for four commercially important EMPs which also show restricted distribution within alpine zone (**Table 4.13;** Uniyal *et al.* 2002a). Plants respond to the harsh alpine environment with a high degree of specialization (Körner 1999). Therefore, only alpine zone was considered for micro-habitat study. In the study area, following vegetation types were considered for the analysis: Tall Forbs (TF), mixed herbaceous formations (MHF), matted shrubs (MS), *Danthonia* grasslands (DG), *Kobresia* sedge meadow (KSM), Cushionoid vegetation (CNV) and treeline gaps (TLG).

### 5.2.2 Data analysis

**5.2.2.1 Vegetation (habitat) types:** The widely varying climate, altitude and topography produce a wide range of vegetation and serve as habitats for diverse species. The analysis was conducted using PC-ORD (ver.4.34), to indicate how many different vegetation types existed within the survey area. Representation of high value MAPs in these clusters further indicates their specific association. The main method selected for grouping the data into vegetation (habitat) was hierarchical cluster analysis with the results being displayed as a dendrogram (McCune and Grace 2002). Distance was measure using Sørensen (Bray-Curtis) (McCune and Grace 2002; Perrin *et al.* 2006). Indicator Species Analysis (ISA; Dufrene and Legendre 1997) was used as an objective tool to determine at what level the dendrogram resulting from the hierarchical clustering should be cut, i.e. what is the optimal number of final groups. ISA produces percentage indicator values (IV) for species and works on the concept that for a predetermined grouping of samples, an ideal indicator species will be found exclusively within one group and will be found in all the samples in that group (Perrin *et al.* 2006). At any given level of clustering, species are assigned to the group for which their IV is maximal. Due to absence of tree species in transects (plots) laid in alpine meadows, such transects were not included in this analysis whereas, transects laid in miscellaneous forest (at lower altitudinal zone) were also not included in ISA, due to distinctive type of vegetation present within it. Therefore, out of total 135 transects, 113 transects were used for hierarchical cluster analysis and ISA.

#### 5.2.2.2 Habitat specificity

**Ivlev's Electivity Index:** Ivlev's (1961) index of electivity has been widely used as a means of computing preferences of habitats by a species to all available habitats in the sampled area (e.g. Armas *et al.* 2004; Liu *et al.* 2007; Jhala *et al.* 2009; Dohling and Sathyakumar 2011; Sankar *et al.* 2013). The purpose of the index is to characterize the electivity, or degree of selection, of a particular habitat/s by a particular species. The relationship is defined as,

$$\text{Ivlev's Electivity Index } (E) = \frac{U_i - A_i}{U_i + A_i}$$

where $E$ is the measure of electivity, $Ui$ the percent (or proportion) of occurrence (no. of plots) of species $i$ to all occurrences of that species in all habitats in sampled area (it's percent value) and $Ai$ the percent (or proportion) of all sampled plots within a particular habitat to all sampled plots in sampled area (it's percent value).

The index has a possible range of -1 to +1, with negative values indicating avoidance of species, zero indicating random selection from the environment, and positive values indicating active selection. In the present study, vegetation (habitat), defined after hierarchical cluster analysis and ISA, and the aspect classes (as mentioned above) were analysed using Ivlev's Electivity Index. Availability was determined from sampling numerous random points as suggested by Van Dyke (2008) following RME evolved by Rawat *et al.* 2004, explained in chapter 4 (Section 4.3.2). Each EMP species was considered as a sample for statistical analysis. A standard statistical method (Chi-square test) was performed to determine the strength of the selection of habitat and aspect (Van Dyke 2008).

**Relationship with other covariates**: Descriptive analysis was conducted using SPSS (ver.19.0; IBM Corp. Released 2010) to study the range of habitat characters (elevation, ruggedness, human influence, annual temperature and annual precipitation) favoured by species within its distribution area. Descriptive statistics conveys the important aspects of the distribution of data. It gives numerical and graphic procedures to summarize a collection of data in a clear and understandable way.

**5.2.2.3 Micro-habitat preference by alpine EMPs:** Mann-Whitney U test (Siegel 1956; Kosfeld *et al.* 2005; Zar 2010) was performed in R (ver. 3.0.0) to see the selection of slope and aspect by alpine EMPs. Selection of slope and aspect, by alpine EMPs, was computed based on their presence and absence locations within the alpine zones. The population status of these EMPs across various micro-habitats was shown in terms of density (D), frequency (F, %). CV was calculated and used as an index of dispersion these species across various micro-habitats. A chi-square test was performed to test the significance of the difference between micro-habitats where these EMPs occurred.

**5.3 Results**

**5.3.1 Vegetation (habitat) types:** The Hierarchical Cluster analysis segregated five clusters of vegetation (habitat) types (**Figure 5.1**) and they coincide with the forest types discussed in Chapter 2. First cluster formed of transects laid in Pine or Chirpine (*Pinus roxburghii*) and Pine mixed habitat, 2nd of Banj oak (*Quercus leucotrichophora*), 3rd formed of Deodar (*Cedrus deodara*)-Rai (*Picea smithiana*)-Blue Pine or Kail (*Pinus wallichiana*), 4th cluster was of Bhojpatra (*Betula utilis*)-Thuner (*Taxus wallichianum*) and last one of Morinda (*Abies spectabilis*)-Kharsu (*Quercus semecarpifolia*)-Moru (*Quercus floribunda*). Including Alpine and sub tropical scrub forest, which were not included in the Hierarchical Cluster analysis, total vegetation (habitat) in the study area becomes seven.

ISA indicated that the five groups of the cluster analysis were the most informative. Each group was named after the tree species that was present within the group; these names were simply intended to succinctly distinguish and describe the related vegetation data: no direct reference to other classification systems is implied. Their indicator values (and *p*-value) are given in **Table 5.1**. Sampled plots (#) in different vegetation (habitat) and in different aspects are given in **Table 5.2** and **Table 5.3**, which were used in calculating Ivlev's Electivity Index.

**Figure 5.1: Grouping of different vegetation (habitat) using ISA**

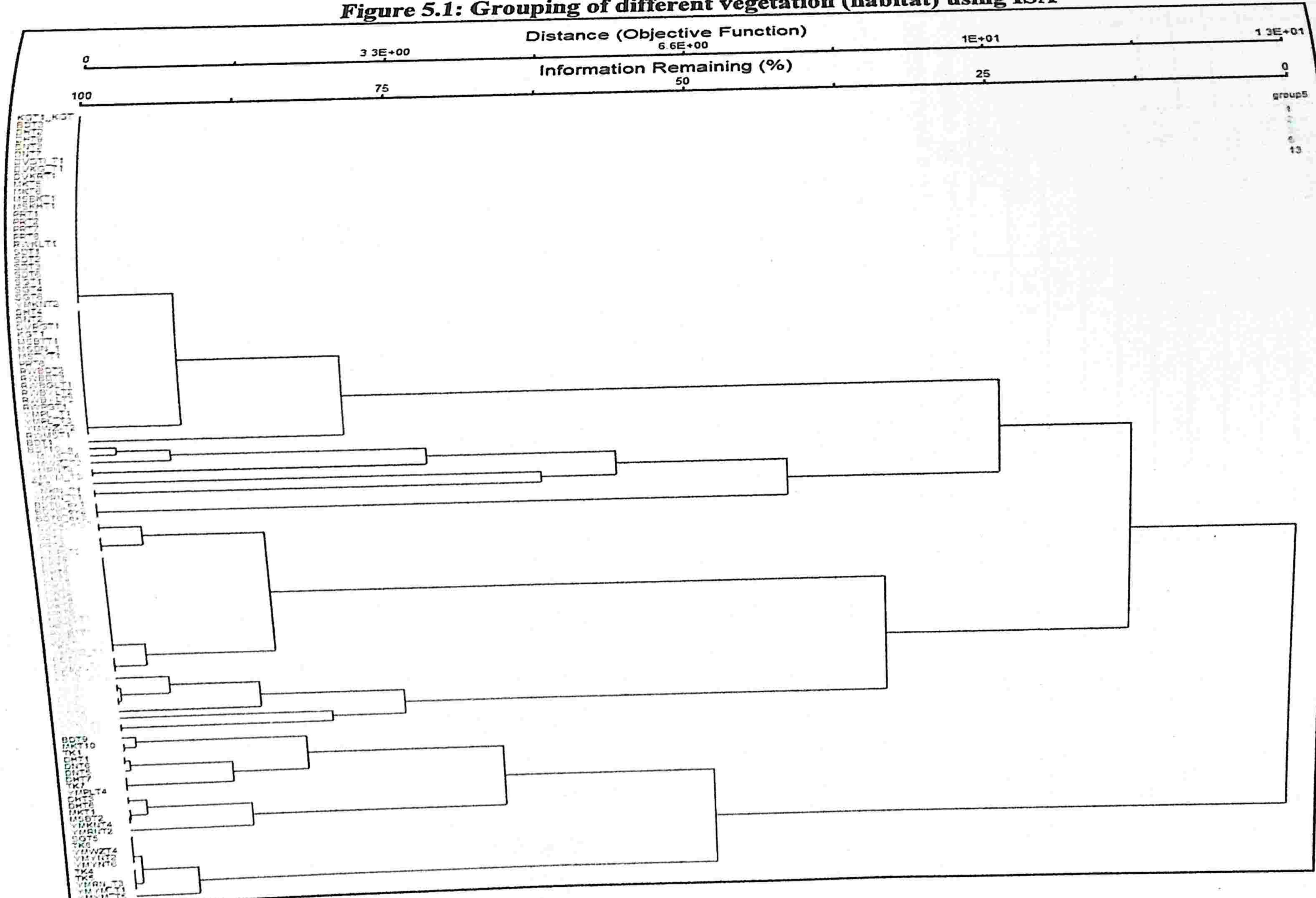


**Table 5.1: Indicator values of Indicator species**

| Cluster | Species | Indicator Value (IV) | Expected (E) | SD | p * |
|---|---|---|---|---|---|
| 1 | Chir Pine | 89.8 | 15 | 4.04 | 0.001 |
| 2 | Banj | 65.3 | 15.4 | 4.17 | 0.001 |
| 3 | Blue Pine | 60.6 | 8 | 3.95 | 0.001 |
| 3 | *Cedrus* | 71.2 | 8.2 | 3.91 | 0.001 |
| 3 | *Picea* | 31 | 8.9 | 4.1 | 0.004 |
| 4 | *Betula* | 36.4 | 5.7 | 3.34 | 0.001 |
| 4 | *Taxus* | 9.1 | 4.5 | 2.87 | 0.1992 |
| 5 | *Abies* | 56.3 | 9.6 | 4.26 | 0.001 |
| 5 | Kharsu | 34.2 | 8.8 | 4 | 0.001 |
| 5 | Moru | 56 | 8.7 | 4.1 | 0.001 |

* Proportion of randomized trials with indicator value equal to or exceeding the observed indicator value. p = (1 + number of runs >= observed)/(1 + number of randomized runs)

**Table 5.2: Vegetation (habitat) types present in Uttarkashi and plots laid in them**

| Vegetation (habitat) type | Abbreviation | Plots (#) |
|---|---|---|
| Kharsu oak –Fir mixed Forest | AKM | 428 |
| Alpine | AL | 258 |
| Birch/Fir Forest | BT | 54 |
| Subalpine conifer mixed Forest | CPBP | 278 |
| Sub-tropical scrub Forest (at LAZ; *Ougenia oojeinnesis, Lannea coromandelica, Bauhinia variegate, Mallotus philippensis, Sapium insigne* were sparsely observed) | MISL | 47 |
| Chirpine mixed Forest | PM | 859 |
| Banj Oak mixed Forest | QM | 700 |
| **Total** | | **2624** |

**Table 5.3: Sample plots (#) in different aspect**

| Aspect | Abbreviation | plots (#) |
|---|---|---|
| North | N | 455 |
| North-East | NE | 404 |
| East | E | 272 |
| South-East | SE | 231 |
| South | S | 324 |
| South-West | SW | 323 |
| West | W | 252 |
| North-West | NW | 363 |
| **Total** | | **2624** |

### 5.3.2 Habitat specificity:

**5.3.2.1 *Aconitum heterophyllum*** was confined to alpine areas of the study area. Ivlev's electivity Index showed that species did not occur in other vegetation types and this difference was significant (**Figure 5.2**). The average elevation, where species can be found was 3600m asl. The range of its distribution was 3300-4000m asl. There was distinct difference among the mean elevation, mean annual temperature and precipitation at presence and absence locations of the species (**Table 5.4**). Within its range of distribution, it was mainly found on SE to SW aspect and sparsely on N and NW aspect (**Figure 5.3**).

**Figure 5.2: Selection of vegetation (habitat) by *Aconitum heterophyllum* as indicated by Ivlev's Index**

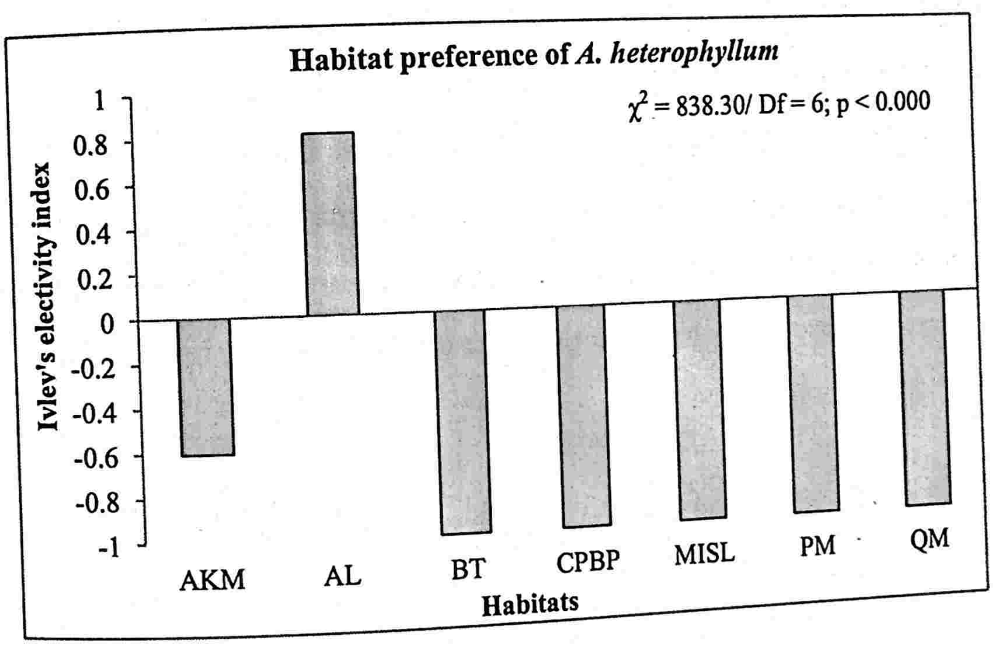



**Figure 5.3: Selection of aspect by *Aconitum heterophyllum* as indicated by Ivlev's Index**

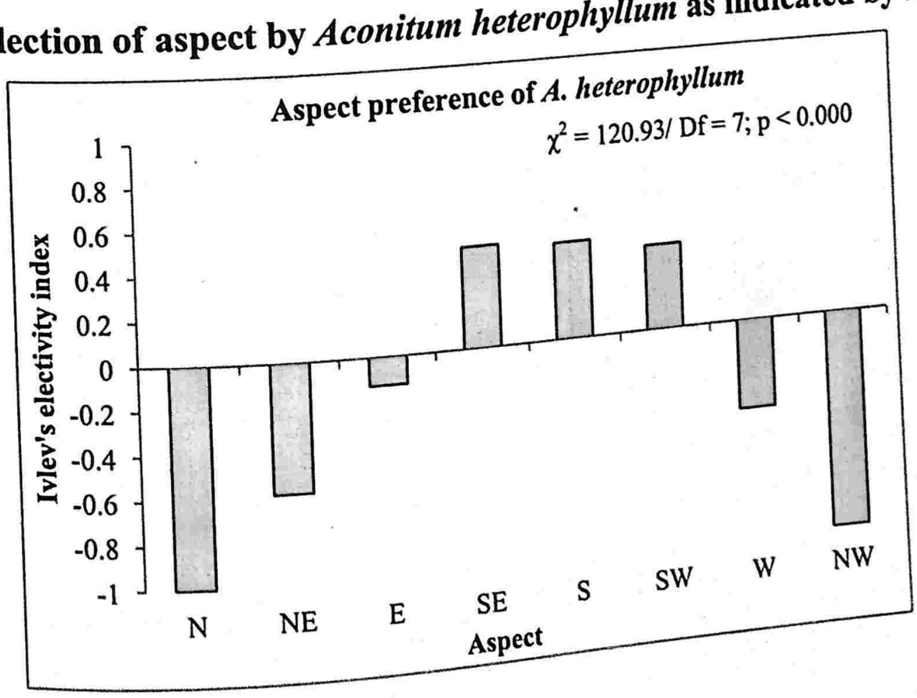


**Table 5.4: Environmental variables at presence and absence locations of *Aconitum heterophyllum* calculated using descriptive analysis**

| Vari-ables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 3332 | 4069 | **3688.64** | 3616.72 | 3766.28 | 1055 | 4552 | 2218.67 | 2193.23 | 2245.97 |
| R | 4.822 | 22.444 | 11.054 | 9.331 | 12.639 | 0.866 | 35.658 | 11.520 | 11.335 | 11.703 |
| HD | -0.974 | 0.682 | -0.305 | -0.528 | -0.049 | -0.974 | 2.338 | -0.305 | -0.328 | -0.282 |
| T | 4 | 8 | **4.96** | 4.56 | 5.40 | 0 | 20 | 12.99 | 12.83 | 13.13 |
| P | 1049 | 1292 | **1139.88** | 1119.12 | 1163.23 | 890 | 1937 | 1436.28 | 1427.78 | 1444.24 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

5.3.2.2 ***Dactylorhiza hatagirea*** preferred alpine as well as sub-alpine forest dominant of *Betula*, ranging from 2900m asl to 3900m asl, with average elevation of presence being 3500m asl. Temperature around 6°C and precipitation around 1100mm were preferred by species within its distribution range. More human influences, as result of various human activities, were observed near presence locations. At NE aspect it was randomly present but restricted to E, S, SE and SW aspect in ascending order of preference. **(Figure 5.4 and 5.5; Table 5.5)**

**Figure 5.4: Selection of vegetation (habitat) by *Dactylorhiza hatagirea* as indicated by Ivlev's Index**

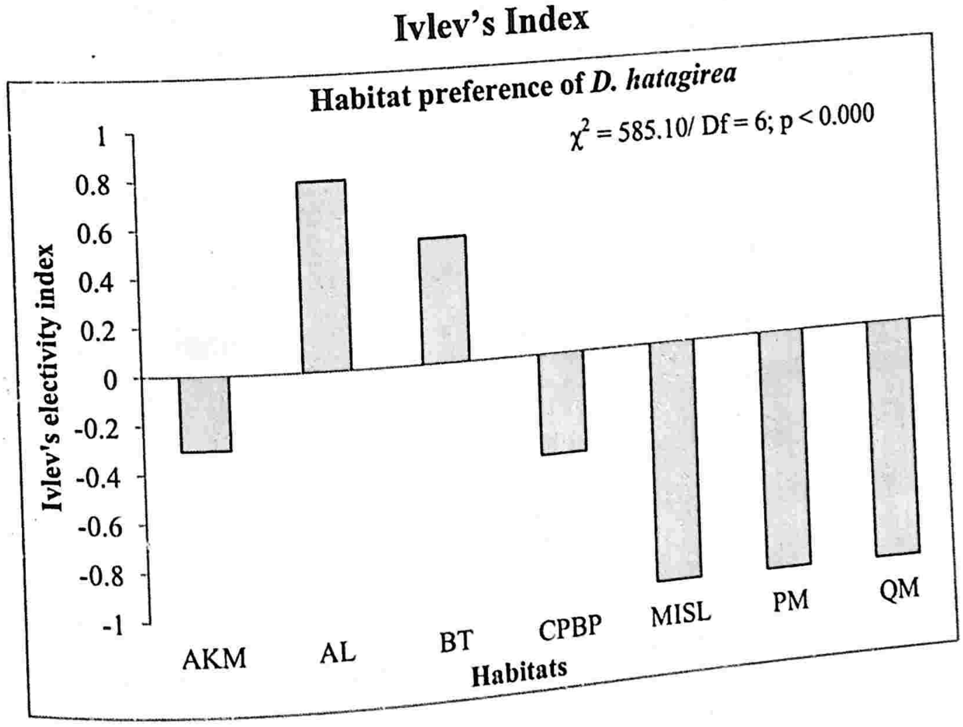


**Figure 5.5: Selection of aspect by *Dactylorhiza hatagirea* as indicated by Ivlev's Index**

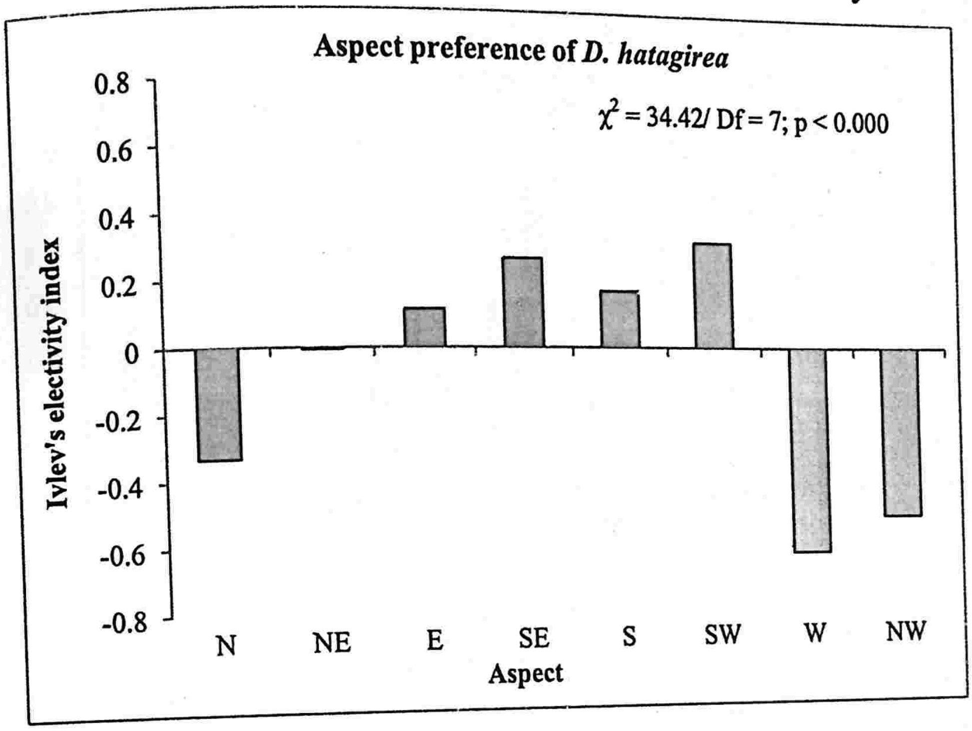



**Table 5.5: Environmental variables at present and absence locations of *Dactylorhiza hatagirea* calculated using descriptive analysis**

| Variables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 2931 | 3956 | **3502.26** | 3452.27 | 3550.23 | 1055 | 4552 | 2210.03 | 2184.43 | 2235.36 |
| R | 3.000 | 21.926 | 10.407 | 9.114 | 11.797 | 0.866 | 35.658 | 11.535 | 11.353 | 11.704 |
| HD | -0.823 | 0.908 | **0.010** | -0.167 | 0.165 | -0.974 | 2.338 | -0.311 | -0.334 | -0.287 |
| T | 4 | 10 | **6.22** | 5.78 | 6.65 | 0 | 20 | 13.03 | 12.89 | 13.18 |
| P | 1031 | 1317 | **1169.87** | 1145.96 | 1194.95 | 890 | 1937 | 1438.16 | 1430.46 | 1445.96 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

5.3.2.3 ***Geranium wallichianum*** were found distributed in four types of vegetation (habitat). Sub-alpine forests dominated by *Betula, Cedrus,* Blue Pine, *Picea* were the most preferred among them (**Figure 5.6**) High elevation, less temperature, high precipitation and less human disturbances were favoured by this species (**Table 5.6**). A widely distributed species was randomly occurring at N and NE aspects, but was more restricted to SE and NW aspects. There are fewer chances of it to occur on E, S and SW aspect (**Figure 5.7**). Due to wider distribution the chi-square test did not show any significant difference, especially for aspect.

**Figure 5.6: Selection of vegetation (habitat) by *Geranium wallichianum* as indicated by Ivlev's Index**

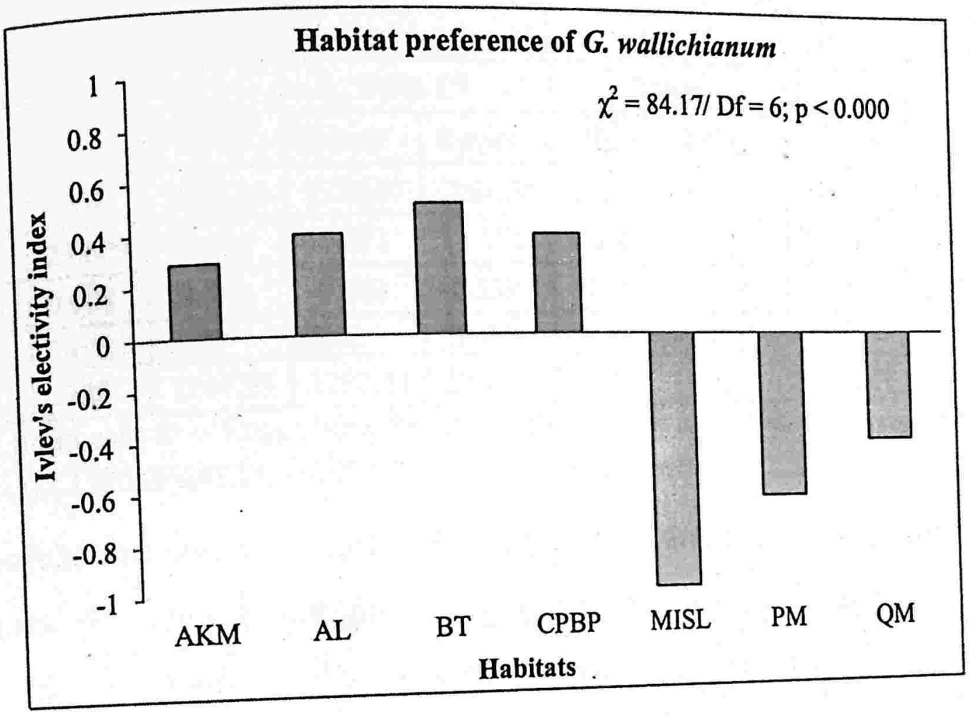



**Figure 5.7: Selection of aspect by *Geranium wallichianum* as indicated by Ivlev's Index**

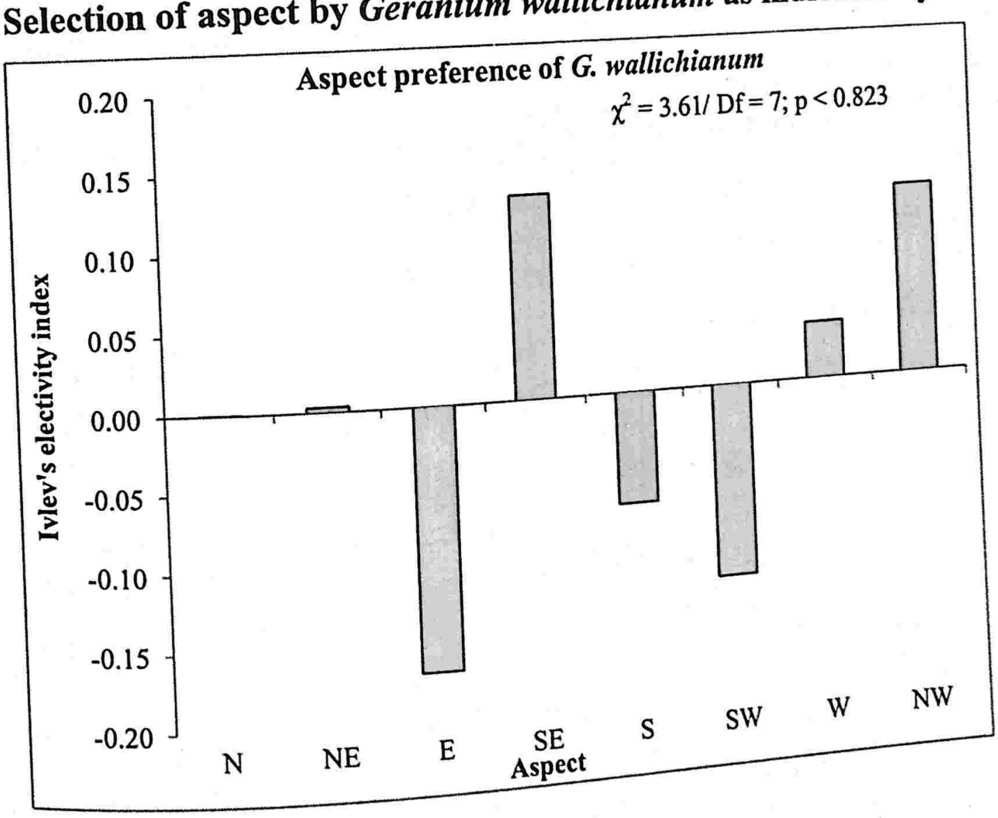


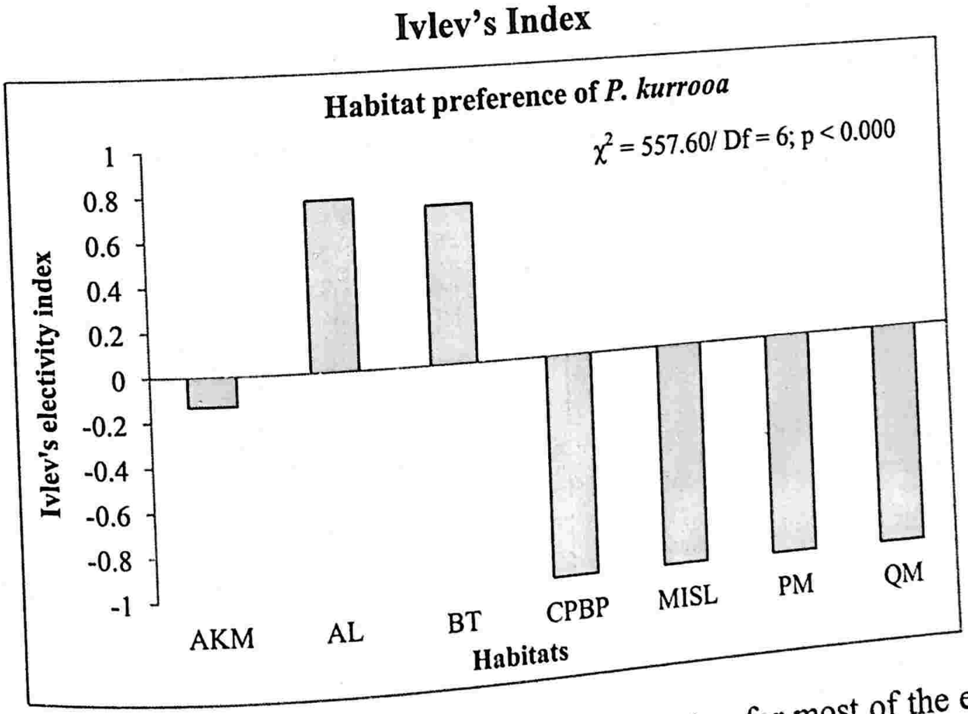
**Table 5.6: Environmental variables at presence and absence locations of *Geranium wallichianum* calculated using descriptive analysis**

| Vari-ables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 1302 | 4069 | **2830.31** | 2750.67 | 2908.36 | 1055 | 4552 | 2163.85 | 2135.46 | 2191.02 |
| R | 1.581 | 28.609 | 10.996 | 10.471 | 11.578 | 0.866 | 35.658 | 11.575 | 11.389 | 11.766 |
| HD | -0.974 | 0.908 | **-0.400** | -0.460 | -0.339 | -0.974 | 2.338 | -0.294 | -0.318 | -0.269 |
| T | 4 | 18 | 9.80 | 9.41 | 10.24 | 0 | 20 | 13.27 | 13.11 | 13.43 |
| P | 1039 | 1728 | 1244.93 | 1227.43 | 1262.76 | 890 | 1937 | 1455.17 | 1447.45 | 1463.58 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

5.3.2.4 ***Picrorhiza kurrooa*** was confined to alpine areas and sub-alpine forests dominated by *Betula* (**Figure 5.8**) and found preferring rocky patches in those forests (pers. obs.). Electivity Index also confirms that species has weak negative affinity towards sub-alpine forests dominated by *Abies* and Kharsu but showed strong negative affinity towards other vegetation (habitat) (**Figure 5.8**).

**Figure 5.8: Selection of vegetation (habitat) by *Picrorhiza kurrooa* as indicated by Ivlev's Index**




Its presence and absence locations showed great variation for most of the environmental covariates. Its mean elevation of distribution was around 3600m asl. It preferred cold climate (mean annual temperature 5°C), but less precipitation (mean annual 1100mm). It was restricted to SW and W aspects and almost did not occur on N, NE and E aspects

(**Figure 5.9**). There was visible difference in the mean annual temperature and precipitation of presence and absence locations and also more human influence due to various activities could be seen at the presence locations (**Table 5.7**).

**Figure 5.9: Selection of aspect by *Picrorhiza kurrooa* as indicated by Ivlev's Index**

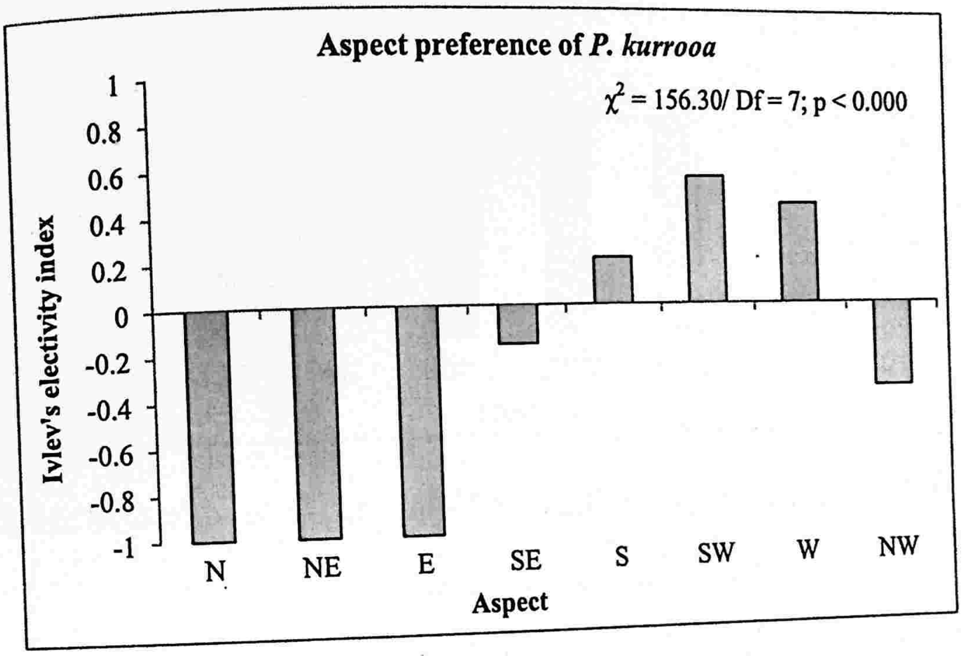



**Table 5.7: Environmental variables at presence and absence locations of *Picrorhiza kurrooa* calculated using descriptive analysis**

| Variables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 3153 | 3978 | **3637.31** | 3544.85 | 3716.92 | 1055 | 4552 | 2224.06 | 2196.66 | 2250.76 |
| R | 11.247 | 24.073 | **17.064** | 15.330 | 18.658 | 0.866 | 35.658 | 11.481 | 11.303 | 11.658 |
| HD | -0.823 | 0.682 | **0.061** | -0.202 | 0.343 | -0.974 | 2.338 | -0.308 | -0.329 | -0.285 |
| T | 3 | 8 | **5.63** | 4.88 | 6.44 | 0 | 20 | 12.95 | 12.81 | 13.10 |
| P | 1025 | 1174 | **1101.81** | 1086.69 | 1115.00 | 890 | 1937 | 1435.49 | 1427.72 | 1443.60 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

**5.3.2.5** ***Rheum australe*** was restricted to alpine areas, and mean elevation of distribution was 3600m asl (**Figure 5.10**). It preferred temperature around 6°C and precipitation around 1000mm. It was restricted to only S, SE and W aspect (**Figure 5.11**). Presence locations have more human influence and so more chances of habitat alteration due to ongoing human activities (**Table 5.8**).

**Figure 5.10: Selection of vegetation (habitat) by *Rheum australe* as indicated by Ivlev's Index**

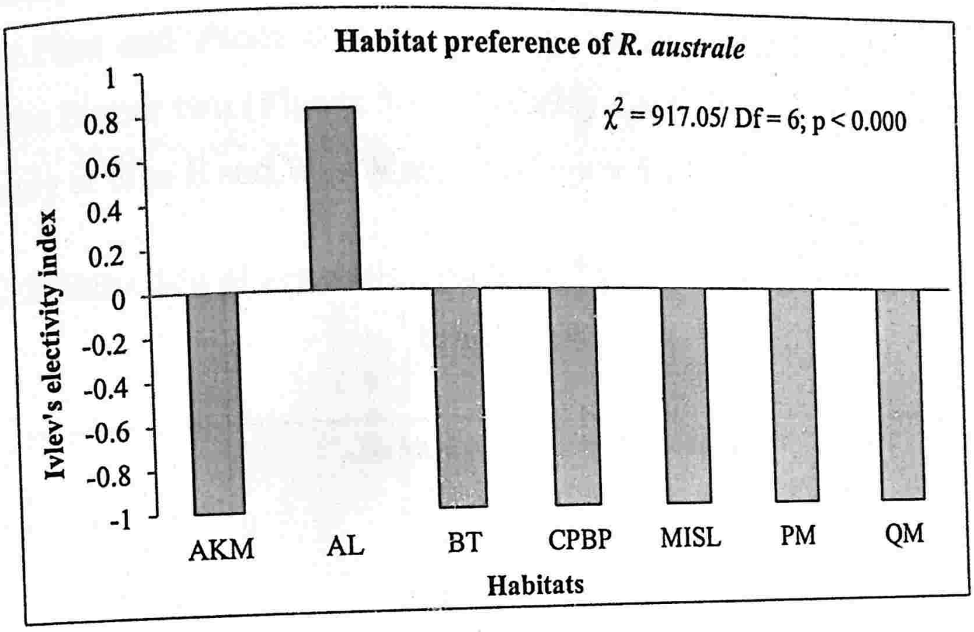



**Figure 5.11: Selection of aspect by *Rheum australe* as indicated by Ivlev's Index**

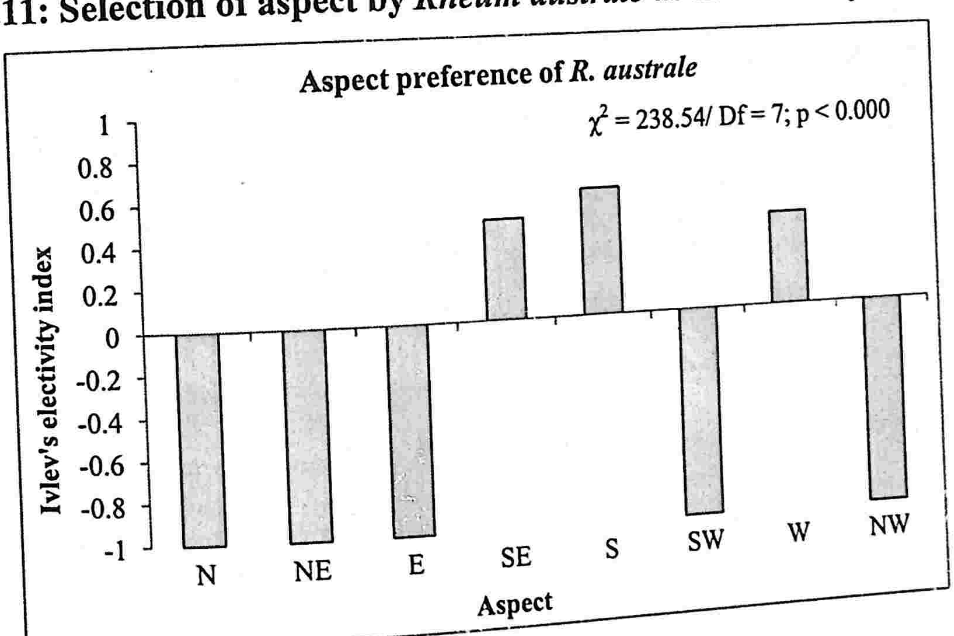



**Table 5.8: Environmental variables at presence and absence locations of *R. australe***

| Variables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 3548 | 3705 | **3621.50** | 3555.00 | 3688.00 | 1055 | 4552 | 2230.56 | 2204.88 | 2257.72 |
| R | 8.078 | 13.973 | 11.779 | 9.502 | 13.874 | 0.866 | 35.658 | 11.515 | 11.343 | 11.694 |
| HD | -0.823 | 0.682 | -0.071 | -0.823 | 0.682 | -0.974 | 2.338 | -.0306 | -.0329 | -0.284 |
| T | 4 | 8 | **6.00** | 4.00 | 8.00 | 0 | 20 | 12.92 | 12.76 | 13.07 |
| P | 1039 | 1112 | **1075.50** | 1039.00 | 1112.00 | 890 | 1937 | 1434.00 | 1426.56 | 1441.41 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

5.3.2.6 ***Senecio nudicaulis*** showed wider altitudinal distribution, preferring Pine mixed forest and sub-alpine forest dominated by *Abies*-Kharsu-Moru, equally. It was also found in *Cedrus*, Blue Pine and *Picea* dominated forest but such forests were not preferred as compared to the former two (**Figure 5.12**). Probably due to its wider distribution it appeared almost randomly at N to E and W-NW aspects (**Figure 5.13**).

**Figure 5.12: Selection of vegetation (habitat) by *Senecio nudicaulis* as indicated by Ivlev's Index**

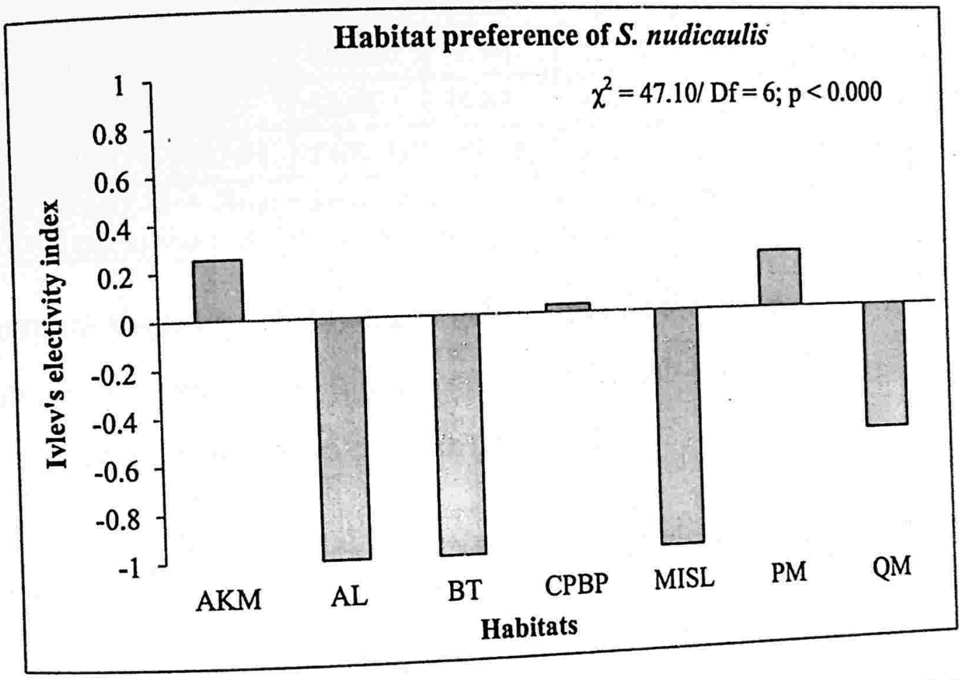
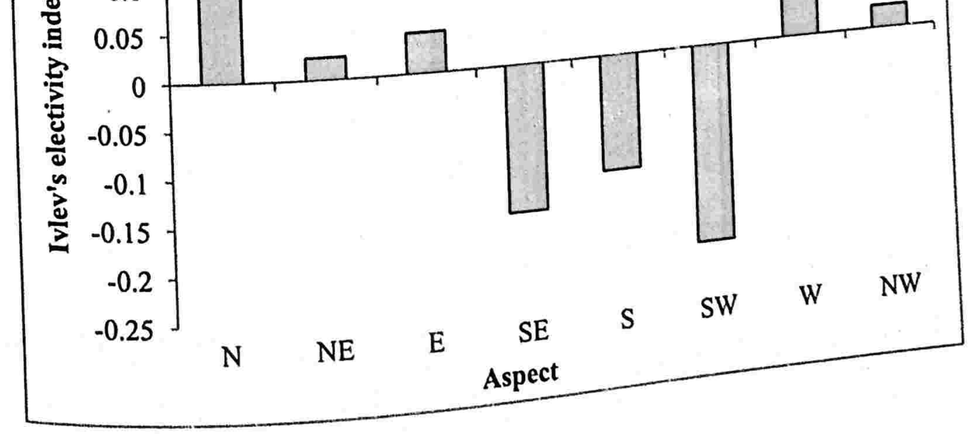



**Figure 5.13: Selection of aspect by *Senecio nudicaulis* as indicated by Ivlev's Index**



There was no significant difference observed between presence and absence locations, in context with other covariates though these areas are under relatively less human influences **(Table 5.9)**.

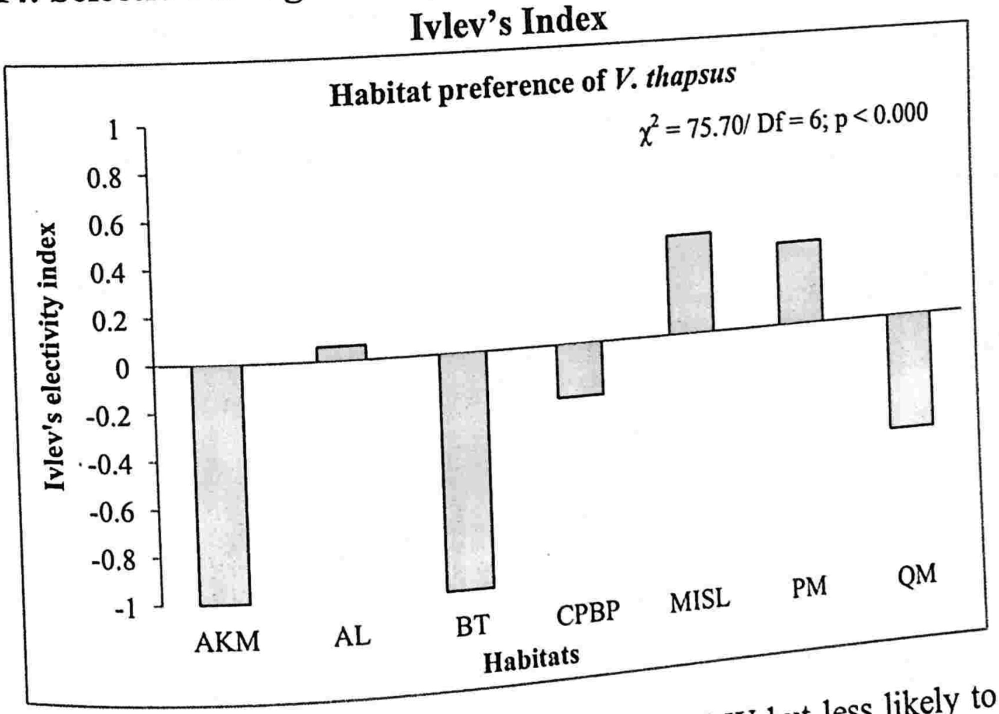
**Table 5.9: Environmental variables at presence and absence locations of *S. nudicaulis***

| Vari-ables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 1231 | 3252 | 2056.63 | 1896.51 | 2232.31 | 1055 | 4552 | 2236.94 | 2210.85 | 2263.30 |
| R | 3.606 | 22.023 | 11.551 | 10.614 | 12.567 | 0.866 | 35.658 | 11.515 | 11.348 | 11.703 |
| HD | -0.974 | 1.058 | -0.373 | -0.504 | -0.248 | -0.974 | 2.338 | -0.304 | -0.327 | -0.279 |
| T | 6 | 19 | 13.61 | 12.61 | 14.64 | 0 | 20 | 12.89 | 12.75 | 13.04 |
| P | 1081 | 1844 | 1467.84 | 1408.33 | 1524.08 | 890 | 1937 | 1432.62 | 1425.24 | 1440.51 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

5.3.2.7 ***Verbascum thapsus*** distributed largely in middle altitude zone, average elevation of it being 1800m asl and preferring higher extension of sub-tropical (miscellaneous) forest to lower temperate forests dominated by Pine **(Figure 5.14)**.

**Figure 5.14: Selection of vegetation (habitat) by *Verbascum thapsus* as indicated by Ivlev's Index**




It was restricted to SW aspect as well as to SE, S and W but less likely to occur on N aspect **(Figure 5.15)**. Besides these, there was no drastic difference in presence and absence locations though these areas were under relatively less human influences. **(Table 5.10)**

**Figure 5.15: Selection of aspect by *Verbascum thapsus* as indicated by Ivlev's Index**

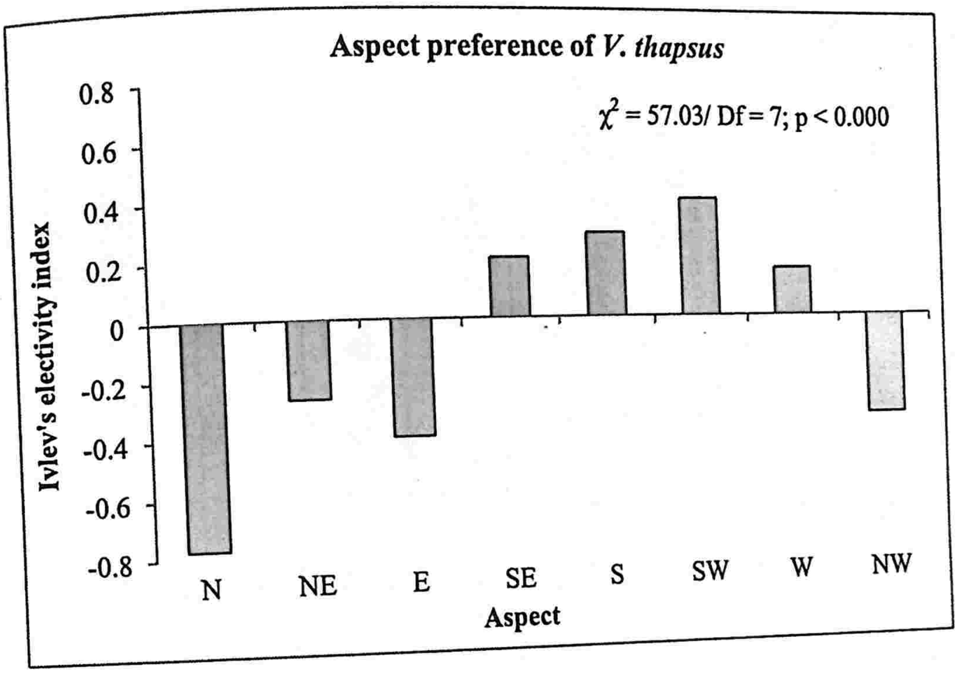



**Table 5.10: Environmental variables at presence and absence locations of *V. thapsus***

| Variables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 1251 | 3641 | **1866.27** | 1661.96 | 2085.15 | 1055 | 4552 | 2239.07 | 2212.70 | 2266.02 |
| R | 3.606 | 23.436 | 11.892 | 10.531 | 13.363 | 0.866 | 35.658 | 11.509 | 11.336 | 11.684 |
| HD | -0.974 | 0.456 | -0.325 | -0.474 | -0.181 | -0.974 | 2.338 | -0.305 | -0.329 | -0.282 |
| T | 7 | 19 | 15.42 | 14.36 | 16.49 | 0 | 20 | 12.87 | 12.72 | 13.02 |
| P | 1066 | 1863 | 1507.20 | 1441.38 | 1567.75 | 890 | 1937 | 1432.17 | 1424.12 | 1440.76 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

**5.3.2.8** A widely distributed ***Viola pilosa*** was found mostly in temperate forest dominated by Banj (*Quercus leucotrichophora*) as well as *Cedrus*, Blue Pine, *Picea*. It was found in less human influenced (less altered forests) areas. Probably due to wider distribution, no major differences were visible in other covariates. It randomly occurred in all aspects which is evident from chi-square test results. **(Figure 5.16 and 5.17; Table 5.11)**

**Figure 5.16: Selection of vegetation (habitat) by *Viola pilosa* as indicated by Ivlev's Index**

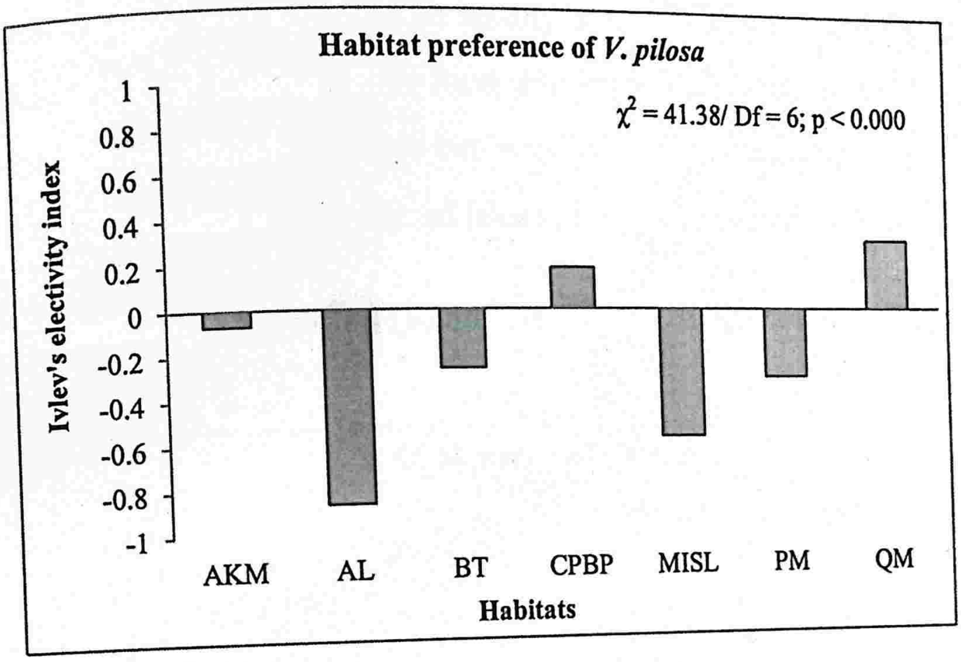



**Figure 5.17: Selection of aspect by *Viola pilosa* as indicated by Ivlev's Index**

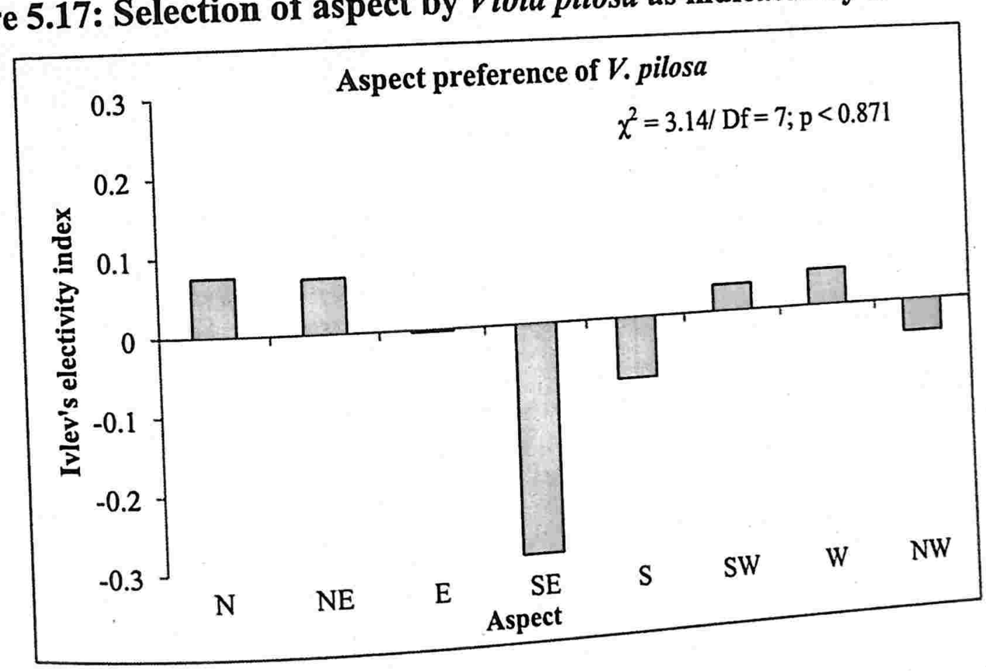



**Table 5.11: Environmental variables at presence and absence locations of *V. pilosa***

| Variables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 1202 | 3740 | 2125.89 | 2086.07 | 2164.79 | 1055 | 4552 | 2252.86 | 2220.35 | 2283.61 |
| R | 1.500 | 28.434 | 10.758 | 10.352 | 11.182 | 0.866 | 35.658 | 11.659 | 11.465 | 11.845 |
| HD | -0.974 | 2.338 | **-0.440** | -0.494 | -0.383 | -0.974 | 2.338 | -0.280 | -0.305 | -0.258 |
| T | 6 | 18 | 13.47 | 13.28 | 13.68 | 0 | 20 | 12.80 | 12.64 | 12.97 |
| P | 1089 | 1871 | 1497.65 | 1483.87 | 1511.80 | 890 | 1937 | 1421.33 | 1412.65 | 1429.96 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

5.3.2.9 ***Berberis aristata*** was confined to mostly temperate forest dominated by Banj and also forests dominated by *Cedrus*, Blue Pine, *Picea* (**Figure 5.18**). It was restricted to NE and E aspect of middle altitudinal zone but very less chances to occur on S to W aspects (**Figure 5.19**). It was present in less altered (due to human activities) areas (**Table 5.12**).

**Figure 5.18: Selection of vegetation (habitat) by *Berberis aristata* as indicated by Ivlev's Index**

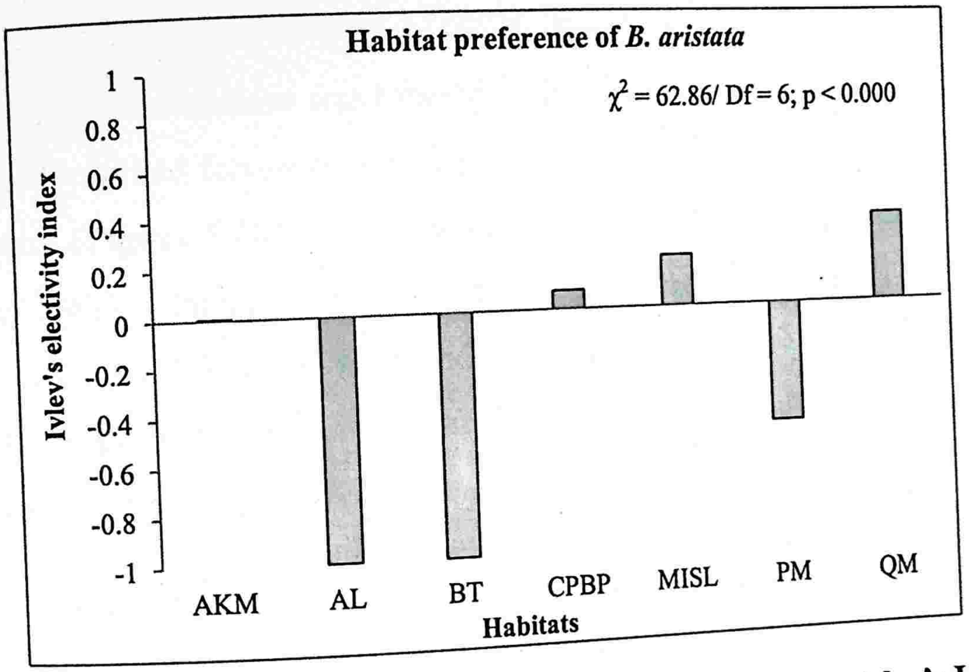



**Figure 5.19: Selection of aspect by *Berberis aristata* as indicated by Ivlev's Index**

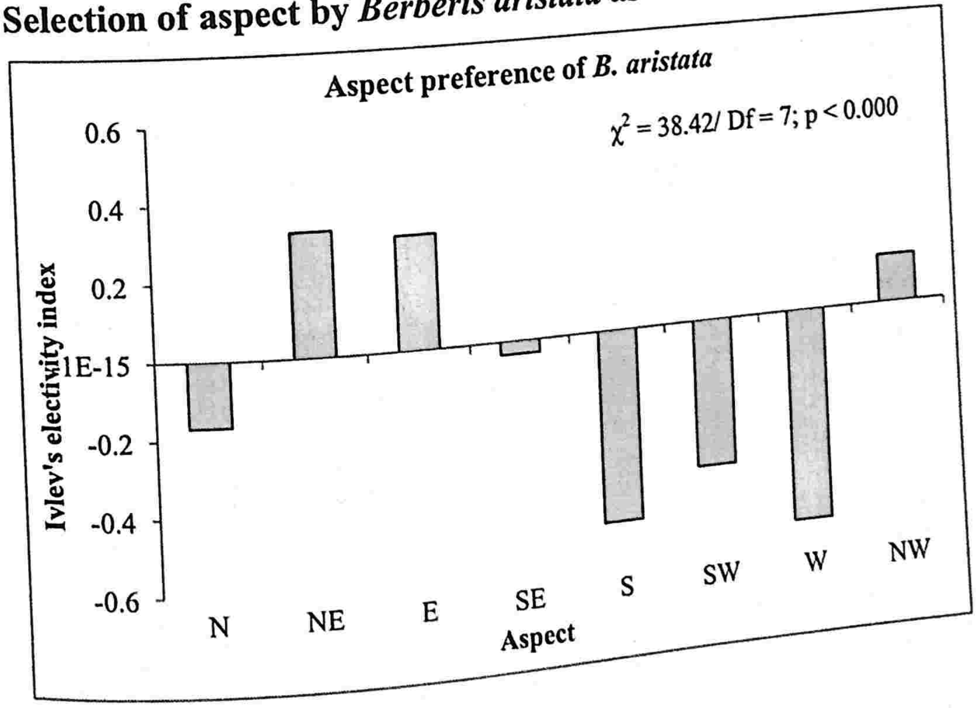


**Table 5.12: Environmental variables at presence and absence locations of *B. aristata***

| Vari-ables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 1277 | 3020 | 2202.21 | 2105.55 | 2289.86 | 1055 | 4552 | 2233.55 | 2204.64 | 2260.72 |
| R | 2.872 | 19.085 | 10.405 | 9.587 | 11.311 | 0.866 | 35.658 | 11.547 | 11.372 | 11.736 |
| HD | -0.974 | 1.284 | **-0.448** | -0.540 | -0.337 | -0.974 | 2.338 | -0.301 | -0.323 | -0.281 |
| T | 7 | 20 | 12.85 | 12.38 | 13.34 | 0 | 20 | 12.91 | 12.76 | 13.07 |
| P | 1110 | 1870 | 1534.23 | 1481.99 | 1586.69 | 890 | 1937 | 1430.57 | 1423.05 | 1438.73 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

**5.3.2.10 *Zanthoxylum armatum*** was found distributed in sub-tropical (miscellaneous) forest, temperate Pine forest and forests dominated by *Cedrus*, Blue Pine, *Picea*; but preferring sub-tropical the most **(Figure 5.20)**. It generally occurred in lower-middle altitude zone and was restricted on SW-W facing slope. It preferred higher temperature (*ca.* 16°C) with precipitation around 1600mm. It was randomly present on all aspects except on N aspect **(Figure 5.21)**. It preferred relatively less disturbed area. However present infrastructure developmental activities may harm this area **(Table 5.13)**.

**Figure 5.20: Selection of vegetation (habitat) by *Zanthoxylum armatum* as indicated by Ivlev's Index**

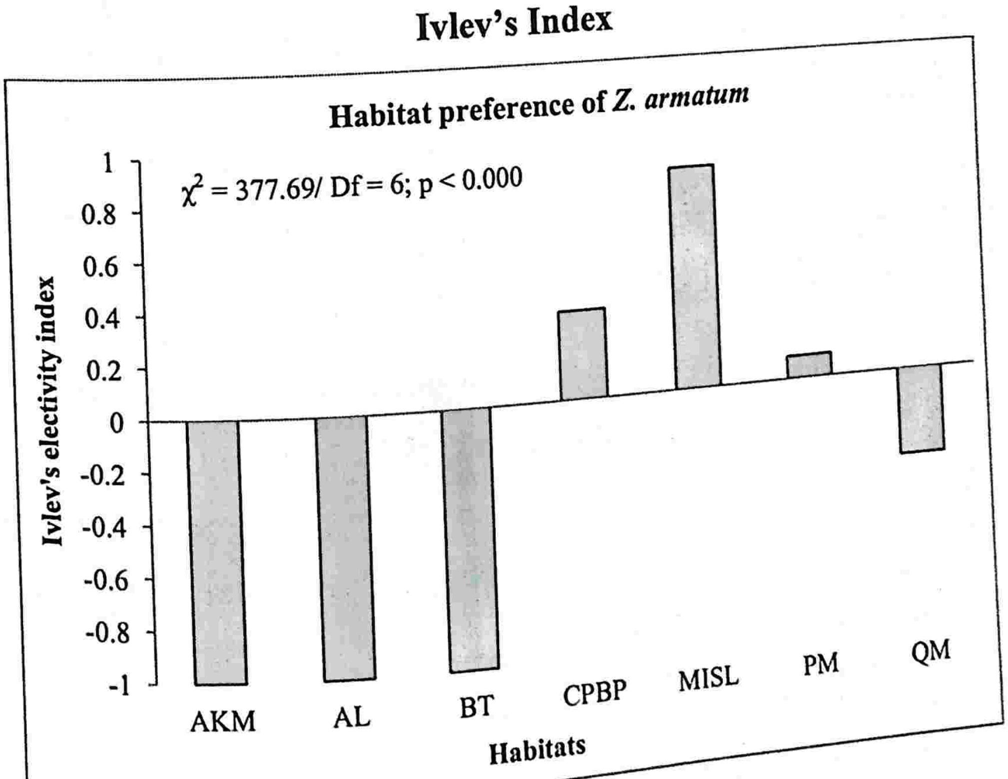


**Figure 5.21: Selection of aspect by *Zanthoxylum armatum* as indicated by Ivlev's Index**

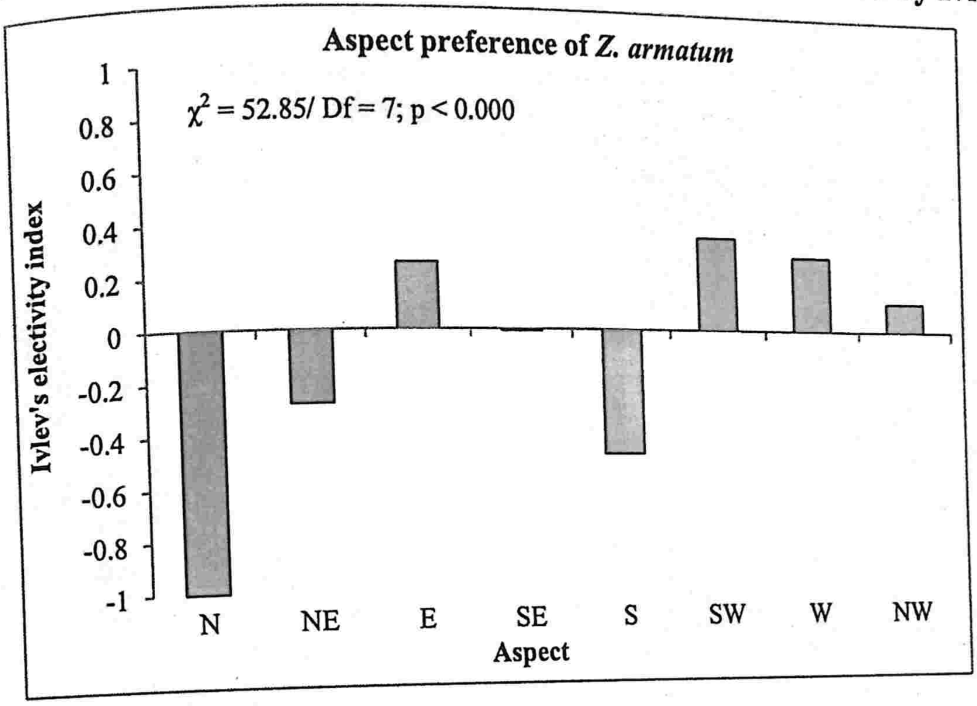



**Table 5.13: Environmental variables at presence and absence locations of *Zanthoxylum armatum***

| Vari-ables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 1213 | 2006 | **1589.61** | 1501.62 | 1680.24 | 1055 | 4552 | 2238.37 | 2212.63 | 2266.29 |
| R | 5.613 | 26.754 | 13.177 | 11.100 | 15.314 | 0.866 | 35.658 | 11.501 | 11.322 | 11.682 |
| HD | -0.974 | 0.908 | **-0.215** | -0.450 | 0.057 | -0.974 | 2.338 | -0.306 | -0.330 | -0.285 |
| T | 13 | 20 | **16.39** | 15.52 | 17.26 | 0 | 20 | 12.88 | 12.73 | 13.03 |
| P | 1368 | 1870 | 1628.00 | 1570.40 | 1690.74 | 890 | 1937 | 1431.74 | 1424.13 | 1439.36 |

E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

5.3.2.11 ***Juglans regia*** is distributed in temperate forests dominated by broadleaf as well as coniferous species (**Figure 5.22**). It was found at an average elevation of 2200m asl on NE, E, SE and S aspects (**Figure 5.23B; Table 5.14**). There was no significant difference between value of other covariates at present and absence locations though those forest areas seems under low human influence (**Table 5.14**).

**Figure 5.22: Selection of vegetation (habitat) by *Juglans regia* as indicated by Ivlev's Index**

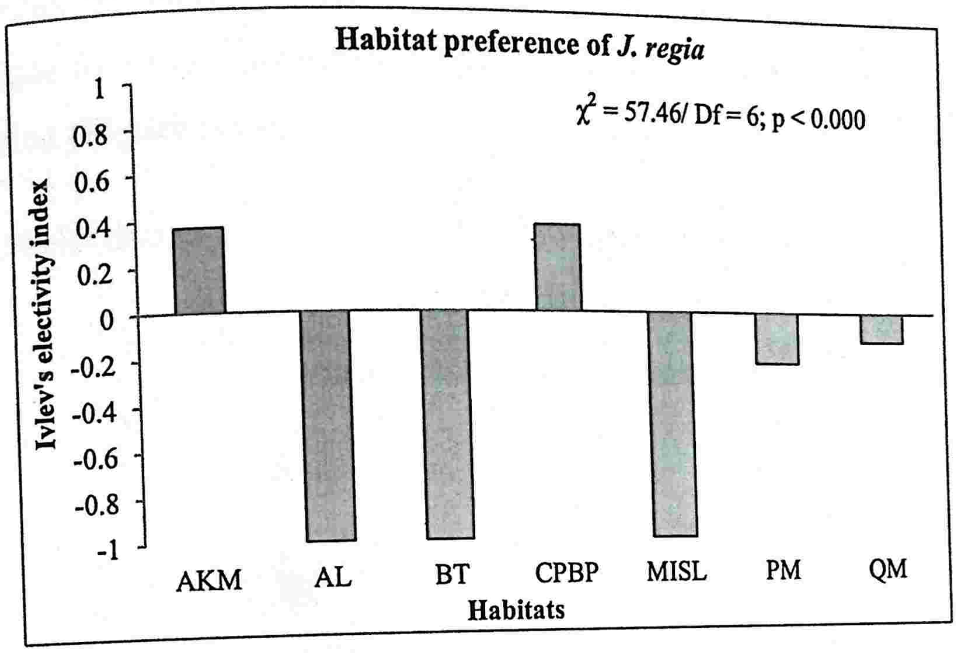



**Figure 5.23: Selection of aspect by *Juglans regia* as indicated by Ivlev's Index**

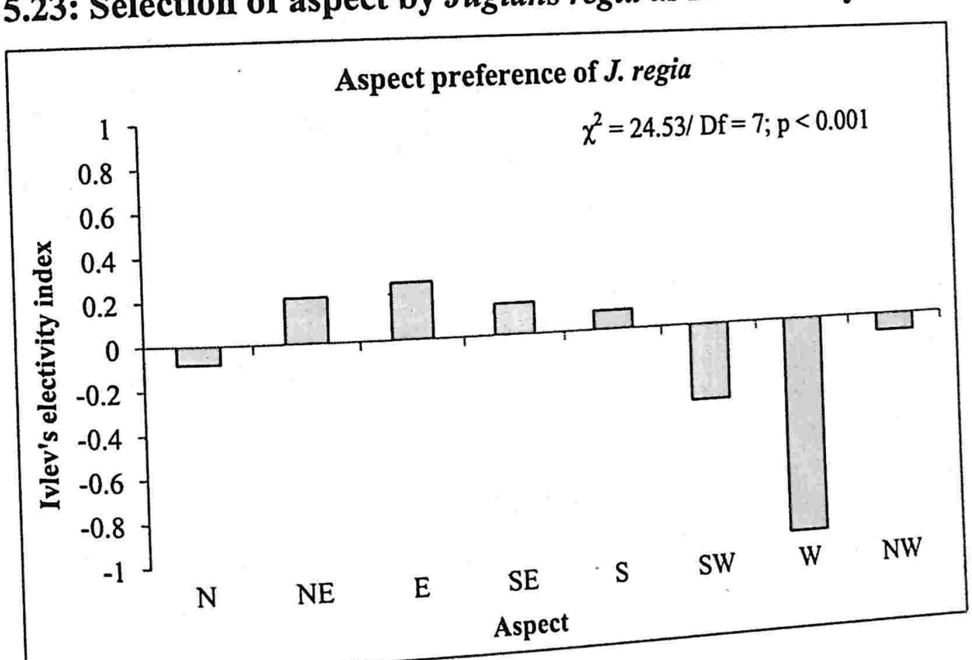



**Table 5.14: Environmental variables at presence and absence locations of *Juglans regia***

| Variables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 1436 | 2776 | 2237.74 | 2115.03 | 2350.51 | 1055 | 4552 | 2232.61 | 2206.59 | 2260.57 |
| R | 4.528 | 20.390 | 11.407 | 9.962 | 12.823 | 0.866 | 35.658 | 11.517 | 11.335 | 11.683 |
| HD | -0.974 | 2.338 | -0.374 | -0.664 | -0.026 | -0.974 | 2.338 | -0.304 | -0.327 | -0.282 |
| T | 8 | 17 | 12.56 | 11.79 | 13.32 | 0 | 20 | 12.91 | 12.77 | 13.06 |
| P | 1089 | 1607 | 1355.47 | 1312.09 | 1400.76 | 890 | 1937 | 1434.48 | 1426.46 | 1442.45 |
| E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original | | | | | | | | | | |

percent value); T = Temperature (in degree); P = Precipitation (in mm);

**5.3.2.12 *Quercus leucotrichophora*** is a climax species of lower-middle temperate forest forming a unique forest type by dominating it. Therefore, it was obvious to find this species in its own habitat **(Figure 5.24).**

**Figure 5.24: Selection of vegetation (habitat) by *Quercus leucotrichophora* as indicated by Ivlev's Index**

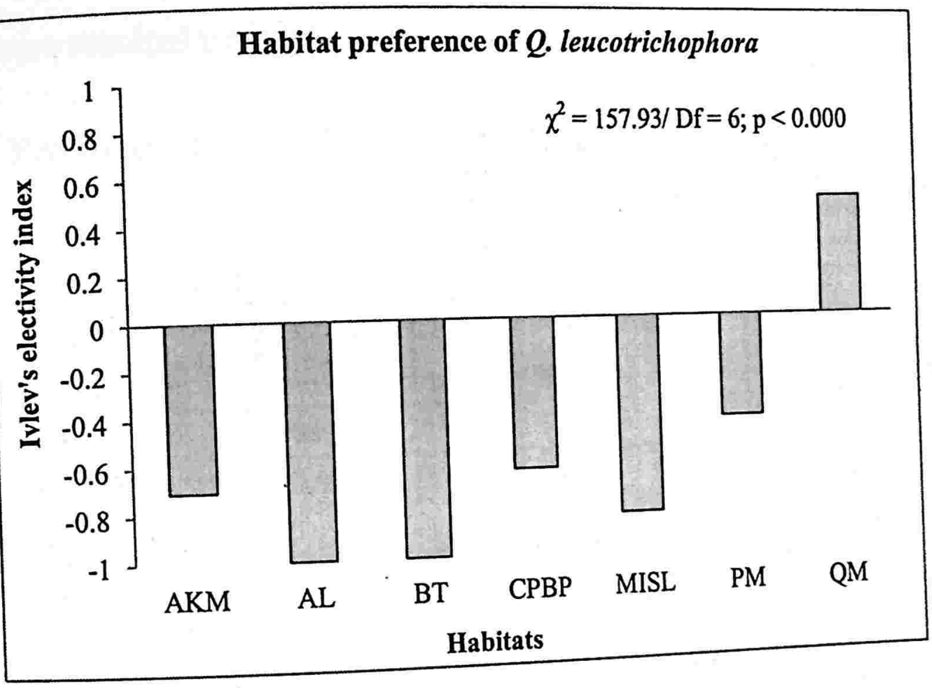
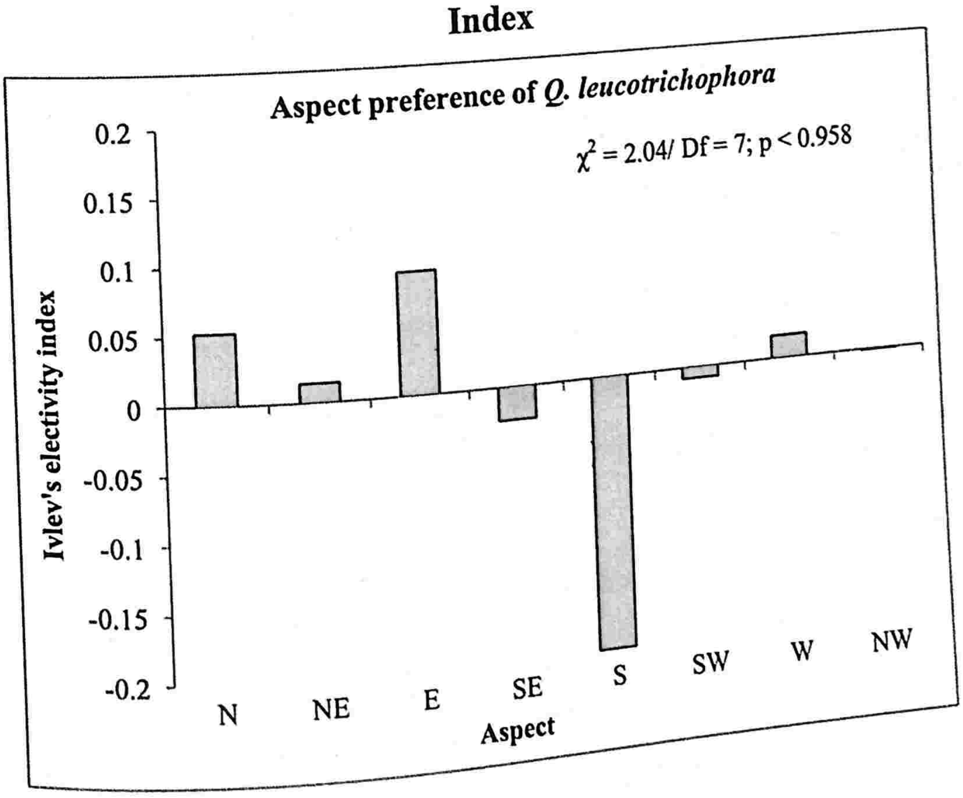



**Figure 5.25: Selection of aspect by *Quercus leucotrichophora* as indicated by Ivlev's Index**



Due to its wider distribution at altitudinal range of 1500m – 2500m asl, there were no significant differences noted in covariates at presence and absence location. But species dominates at average altitude of 2100m and prefers slightly heavy precipitation (**Table 5.15**). Despite Banj oak being under heavy pressure for fuel wood and fodder collection, human influence value has denoted less altered, areas. It may be due to its wider distribution. It was randomly distributed at almost every aspect with more chances of occurrence on east aspect and less on south aspect (**Figure 5.25**) but no significance difference were resulted owing to its wider distribution.

**Table 5.15: Environmental variables at presence and absence locations of *Quercus leucotrichophora***

| Variables | Presence | | | | | Absence | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Range | | Mean | 95% CI | | Range | | Mean | 95% CI | |
| | Min | Max | | Lower | Upper | Min | Max | | Lower | Upper |
| E | 1213 | 2536 | 2101.37 | 2085.41 | 2117.08 | 1055 | 4552 | 2275.39 | 2239.75 | 2310.57 |
| R | 1.732 | 26.958 | 11.268 | 10.948 | 11.607 | 0.866 | 35.658 | 11.596 | 11.387 | 11.803 |
| HD | -0.974 | 2.338 | **-0.424** | -0.456 | -0.388 | -0.974 | 2.338 | -0.267 | -0.295 | -0.238 |
| T | 11 | 20 | 13.62 | 13.52 | 13.71 | 0 | 20 | 12.68 | 12.49 | 12.88 |
| P | 1286 | 1904 | 1510.56 | 1500.34 | 1521.55 | 890 | 1937 | 1408.38 | 1398.78 | 1418.66 |

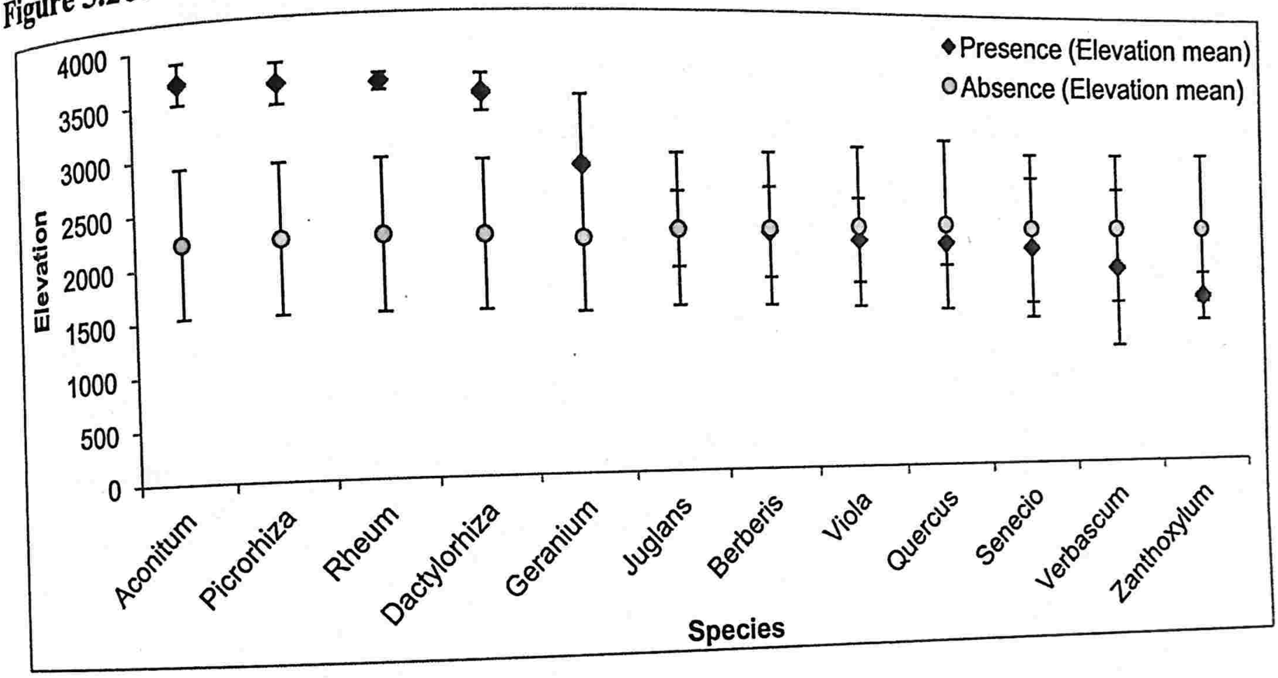
E = Elevation (in m asl); R = Ruggedness (is index); HD = Human influence (adjusted z score of original percent value); T = Temperature (in degree); P = Precipitation (in mm);

### 5.3.3 Interaction of species with covariates

It can be inferred, from above results that widely distributed species show less interaction and changes with almost all covariates though moderate variations in selecting vegetation (habitat) and aspect were observed with such species. All other covariates, excluding vegetation (habitat) and aspect which have already explained, show some change for at least one species in its (species') presence and absence locations but elevation and human influences were not only differed in presence and absence locations but also determined the distributions and vulnerability to human activities. Therefore, these two covariates have explained further.

There are four species, namely, *Aconitum heterophyllum*, *Dactylorhiza hatagirea*, *Picrorhiza kurrooa* and *Rheum australe*, which confined to the high altitude zone, i.e. above 3500m asl. *Geranium wallichianum* was confined to sub-alpine forests approximately at 2800m asl. *Berberis aristata*, *Juglans regia*, *Quercus leucotrichophora*, *Viola pilosa* and *Senecio* *nudicaulis* preferred altitudinal zone between 2000-2250m asl whereas, *Verbascum thapsus* and *Zanthoxylum armatum* represented sub-tropical zone by preferring altitudinal zone between 1500-1800m asl. **(Figure 5.26)**

**Figure 5.26: Ethnomedicinal plants found at different altitudinal gradient in Uttarkashi**




Human influence was another covariate that differed for presence and absence locations for many species. Higher value denotes high human influence and habitat alteration (destruction) due to human activities. Thus, it also denotes vulnerability of species found in such areas. *Picrorhiza kurrooa* was most vulnerable to human activities as it found in areas where human influence value (mean) is highest among surveyed locations. *Dactylorhiza hatagirea*, *Rheum australe*, *Zanthoxylum armatum* and *Aconitum heterophyllum* were the next to be affected by human influence. There was no major difference in human influence values at presence and absence locations of *Aconitum heterophyllum*. Areas where *Verbascum thapsus*, *Senecio nudicaulis*, *Juglans regia*, *Geranium wallichianum*, *Quercus leucotrichophora*, *Viola pilosa* and *Berberis aristata* were present recorded lower human influence.

**5.3.4 Micro-habitat Preference by alpine EMPs:**

Microhabitat study for four alpine EMPs was performed using occurrence data of EMPs against three variables namely, slope, aspect and the vegetation types.

**Slope:** Mann-Whitney U test indicated that in case of distribution of *A. heterophyllum* (Mann-Whitney test statistics (W) = 3514, $p < 0.05$) and *P. kurrooa* (W = 2493.5, $p < 0.000$)

slope plays critical role as values for presence locations significantly differ from absence locations. For other two species, *D. hatagirea* (W = 3941.5, $p = 0.563$) and *R. australe* (W = 603, $p = 0.324$), the difference between presence and absence location, for slope, was not so significant. The mean value of slope for *A. heterophyllum*, *D. hatagirea* and *R. australe* suggests that these species occurred in moderately steep slope whereas *P. kurrooa* occurred in steep slopes **(Table 5.16).**

**Aspect:** Mann-Whitney U test indicated that aspect plays important role in governing distribution of *P. kurrooa* as aspect values differ significantly between presence and absence locations (W = 2111, $p = 0.001$). For other three EMPs, aspect did not influence the distribution (*A. heterophyllum*, W = 2682.5, $p = 0.722$; *D. hatagirea*, W = 3389.5, $p = 0.393$, and *R. australe*, W = 506, $p = 0.784$). The mean value of aspect for these EMPs indicates that *A. heterophyllum* and *R. australe* occurred on south aspect, *D. hatagirea* occurred on south-east aspect whereas *P. kurrooa* occurred on south-west aspect **(Table 5.16).**

**Table 5.16: Mean and SD for slope and aspect at presence locations of alpine EMPs in Uttarkashi district**

| Variable | | Ah | Dh | Pk | Ra |
|---|---|---|---|---|---|
| Slope° | Mean ± SD | 25.38 ± 7.11 | 23.29 ± 7.57 | 32.28 ± 2.18 | 25.80 ± 2.99 |
| Aspect° | Mean ± SD | 177.93 ± 49.26 | 156.68 ± 76.56 | 232.49 ± 24.93 | 183.43 ± 49.33 |

Ah = *Aconitum heterophyllum;* Dh = *Dactylorhiza hatagirea;* Pk = *Picrorhiza kurrooa;* Ra = *Rheum australe*

**Habitat preference with respect to vegetation types:** There were seven different vegetation types identified within alpine zone of the study area. Of the seven, *Aconitum heterophyllum* and *Dactylorhiza hatagirea* occurred in six types of habitats whereas *Picrorhiza kurrooa* occurred in five habitats. *Rheum australe* occurred in only two types of habitat **(Table 5.17; Figure 5.27)**. This occurrence was found significant ($\chi^2 = 175.29$/ Df= 6; $p < 0.000$). Among the preferred habitats *A. heterophyllum* was found more in abundant in *Kobresia* sedge meadow (KSM) and disperse more evenly than other habitats. *D. hatagirea* was found more abundant in mixed herbaceous formation (MHF) but it was evenly dispersed in *Danthonia* grasslands (DG). Of the four EMPs, only *P. kurrooa* was occurred cushionoid vegetation

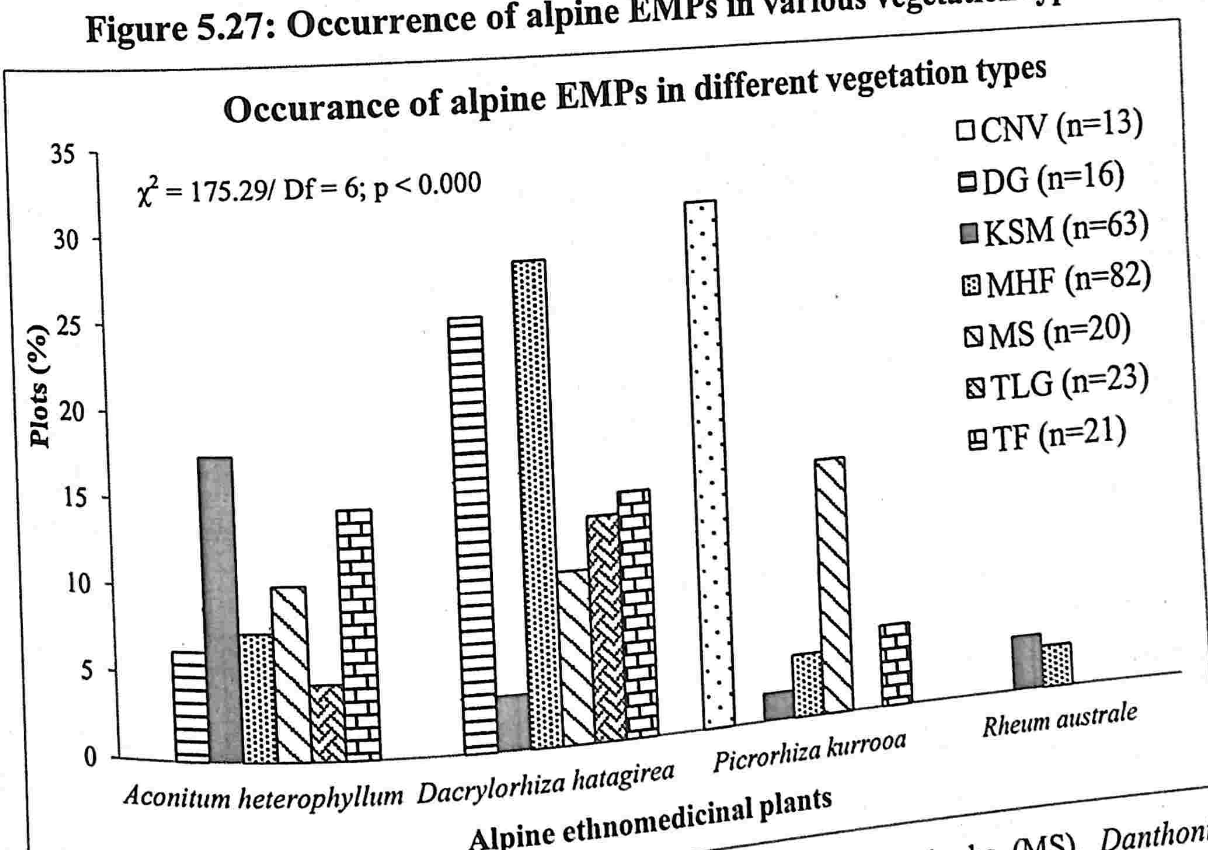
(CNV) where it was evenly dispersed. *R. australe* was patchily distributed in both habitats where it occurred.

**Table 5.17: Abundance and distribution of alpine EMPs across various vegetation types in Uttarkashi district**

| Vegetation type | Ah | | | Dh | | | Pk | | | Ra | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | D | F | CV | D | F | CV | D | F | CV | D | F | CV |
| CNV | - | - | - | - | - | - | 10.23 | 30.77 | 1.58 | - | - | - |
| DG | 0.13 | 6.25 | 4.00 | 0.75 | 25.00 | 1.98 | - | - | - | - | - | - |
| KSM | 1.67 | 17.46 | 2.89 | 0.08 | 3.17 | 5.68 | 0.02 | 1.59 | 7.94 | 0.19 | 3.17 | 6.24 |
| MHF | 0.46 | 7.32 | 4.63 | 1.33 | 28.05 | 2.25 | 0.94 | 3.66 | 5.88 | 0.07 | 2.44 | 6.72 |
| MS | 0.30 | 10.00 | 3.08 | 1.10 | 10.00 | 3.09 | 2.25 | 15.00 | 2.92 | - | - | - |
| TLG | 0.13 | 4.35 | 4.80 | 0.35 | 13.04 | 2.95 | - | - | - | - | - | - |
| TF | 0.67 | 14.29 | 2.86 | 0.62 | 14.29 | 2.96 | 0.43 | 4.76 | 4.58 | - | - | - |

Note: D = Density (individuals $m^{-2}$); F= Frequency (%); CV = Coefficient of variance; Ah = *Aconitum heterophyllum*; Dh = *Dactylorhiza hatagirea*; Pk = *Picrorhiza kurrooa*; Ra = *Rheum australe;* Tall Forbs (TF), mixed herbaceous formations (MHF), matted shrubs (MS), *Danthonia* grasslands (DG), *Kobresia* sedge meadow (KSM), Cushionoid vegetation (CNV); Treeline gaps (TLG)

**Figure 5.27: Occurrence of alpine EMPs in various vegetation types**




Tall Forbs (TF), mixed herbaceous formations (MHF), matted shrubs (MS), *Danthonia* grasslands (DG), *Kobresia* sedge meadow (KSM), Cushionoid vegetation (CNV); treeline gaps (TLG)

## 5.4 Discussions

The habitat selection indicates whether specific habitats are positively or negatively selected by a given species i.e., occupied more or less than expected based on the level of habitat availability (Manly *et al.* 2002; Carranza *et al.* 2011). However, "habitat selection" has rarely been used in context with plant ecology largely because plants are unable to move to a more hospitable location (Bazzaz 1991). To overcome their immobility plants possesses several mechanisms that improve their ability to reach appropriate habitats and have evolved several attributes that allow them to function in a changing local environment (Bazzaz 1991; Maina *et al.* 2002). These abilities, to survive, compete and reproduce successfully in different environments, determine the distributions of plant species which results in each species having its own distinctive distribution (Vázquez and Givnish 1998). Yet there are different stresses that limit a species at each extreme of its distribution. For example, physical stress usually determines the upper altitudinal limit of a species, while the lower altitudinal limit is determined by the stress of competition or predation, which intensifies as physical stress diminishes (Stachowicz 2001). Such physical stress, in case of *P. kurrooa* in parts of Uttarakhand, has made collectors to spend more time and cover long distances to collect same amount of *P. kurrooa* what they used to collect in the past (Awasthi and Uniyal 2003). The scenario for other high value EMPs is not different (Planning Commission 2000). Their rarity is also due to very small population, narrow range of distribution and habitat specificity (Samant *et al.* 1998; Dhar *et al.* 2000; Kala 2000). Alpine region supports various micro-habitats over a short distance (Rawat and Pangtey 1987b; Bathlott *et al.* 1996; Körner 1999). Almost all studies pertaining to their habitat has documented that these high value alpine EMPs showed restricted distribution with high collection pressure despite their low abundance and patchy distribution. In addition, many such studies identified various minuscule level habitats (such as, undulating meadow, moist rocks, steep slopes, scree slopes, eroded slopes, etc.) within the larger alpine area, where high value alpine EMPs are distributed (e.g., Kala *et al.* 1998; Uniyal *et al.* 2002a; Rawat 2005). Among the species that addressed in the current study, *Aconitum heterophyllum*, *Dactylorhiza hatagirea*, *Picrorhiza kurrooa* and *Rheum australe* were studied in most of the previous research that carried out on MAPs in western Himalaya e.g., Kumar and Rohatgi (1996); Kala *et al.* (1998); Uniyal *et al.* (2002a); Rawat (2005); Uniyal *et al.* (2006) and Semwal *et al.* (2007). The preference of altitudinal gradient and major Vegetation types, by these alpine EMPs, resulted in present study is in accordance with that of previous studies.

Since, these were very valuable plant species, most of the studies end up recommending their cultivation, so as to conserve them in the wild. But, no studies have so far discussed their relation with essential covariates, other than elevation and site preferences like special micro-habitat, in case of Uttarakhand. Nevertheless, few studies showed that the distribution of plant species in many parts of Himalayan region depend largely on altitude and climatic variables like temperature and rainfall, which determine the species richness (e.g., Carpenter 2005; Kharkwal *et al.* 2005). It is also strongly related to edaphic variable, in addition to altitude and rainfall, and but weakly to aspect and slope (Tambe and Rawat 2010). But these studies were general or more focused on climax species than MAPs and *Q. leucotrichophora* is one such climax species that is widely used for fuel-wood and fodder purpose (Thadani and Ashton 1995; Thadani 1999; Singh and Rawat 2011). In the present study, *B. aristata*, *P. kurrooa* and *Q. leucotrichophora*, showed variation in the ruggedness index of their presence and absence locations. Whereas *A. heterophyllum*, *J. regia*, *P. kurrooa*, *R. australe*, *V. thapsus* and *Z. armatum* showed strong response to the aspect analysis carried out using Ivlev's Electivity Index. Usually the Northern aspect, in northern hemisphere, receives low level of solar radiation (or direct sunlight) in turn helps regulate more soil moisture (Claridge *et al.* 2000). However, the same aspect, in northern hemisphere, receives more snow and takes more time to melt it due to low level of solar radiation (Dhanju 1983). According to FAO (1998) this forms ideal agro-climatic conditions for the cultivation of temperate crops, especially fruit crops. On the contrary to this, *A. heterophyllum*, *P. kurrooa*, *R. australe*, *V. thapsus* and *Z. armatum* were not found occurring on Northern aspect (**Figure 5.28**).

Thadani and Ashton (1995) stated that undisturbed forests restrict banj oak regeneration due to closed canopy structure. Open canopied banj oak forest patches with high seedling density also possessed threat due to human activity and livestock grazing. They further explained that lack of regeneration should not be interpreted as decline of banj forests, which was possibly erroneous. On the other hand, Singh and Rawat (2011) stated that increasing demand for fodder and fuel-wood, coupled with demand for agricultural land have degraded banj oak patches, especially, those on south facing gentle slopes within altitudinal range of 1200-2200m asl. The regeneration of banj oak in shaded areas was better than that of *P.*

*roxburghii*, due to its affinity towards shade and moisture but intolerance of *P. roxburghii* to shade (Thadani 1999). *P. roxburghii* has invaded many highly disturbed and altered banj oak habitats (in western Himalaya). Therefore it is considered a threat to regeneration of banj in such areas (Singh and Rawat 2011). *B. aristata*, in addition to medicinal properties, is also used for fuel-wood and fencing purposes and preferred open canopied area in Kharsu Oak forest, distributed upto 3400m asl (Tiwari 2011). *Verbascum thapsus,* in its native habitat (mostly temperate areas), is an early succession colonizer of disturbed dry and rocky sites and is able to survive under a broad range of environmental conditions (Williams *et al.* 1975; Semenza and Evans 1978; Reinartz 1984). It is considered as a weed in most of the North America (Parker *et al.* 2003). *J. regia*, due to demand for its nuts, was brought into cultivation as early as $4^{th}$ century BC. Hence, by now, various techniques are available for its cultivation (Akhalkatsi *et al.* 2012). Though this did not stop its wild harvest, (for nuts, medicines and wood) which has brought down its wild population to near threatened in its native range (Malhotra 2008; Ved and Goraya 2008). Other species which have very low or no commercial market, but are widely distributed in their ranges value fail to attract the researchers, for example, *G. wallichianum*, *S. nudicaulis,* *V. thapsus,* *V. pilosa* and *Z. armatum*

Interestingly, the human influence data expresses the relative human influence in every biome on the land's surface and where the human influence is highest, ecosystems will be most modified and species growing over there will be under the most pressure from human activity (Sanderson *et al.* 2002). In this context, human influence (footprint) value suggests that habitat of *P. kurrooa* is the most disturbed due to human activity. However, lower values of the index, though denotes less disturbed patches, it should not misinterpreted that *B. aristata* is not under threat. These values exhibits lowest and highest in reference with the district, consideration of nationwide or global range may increase the human influence value and so the threat level of these species.

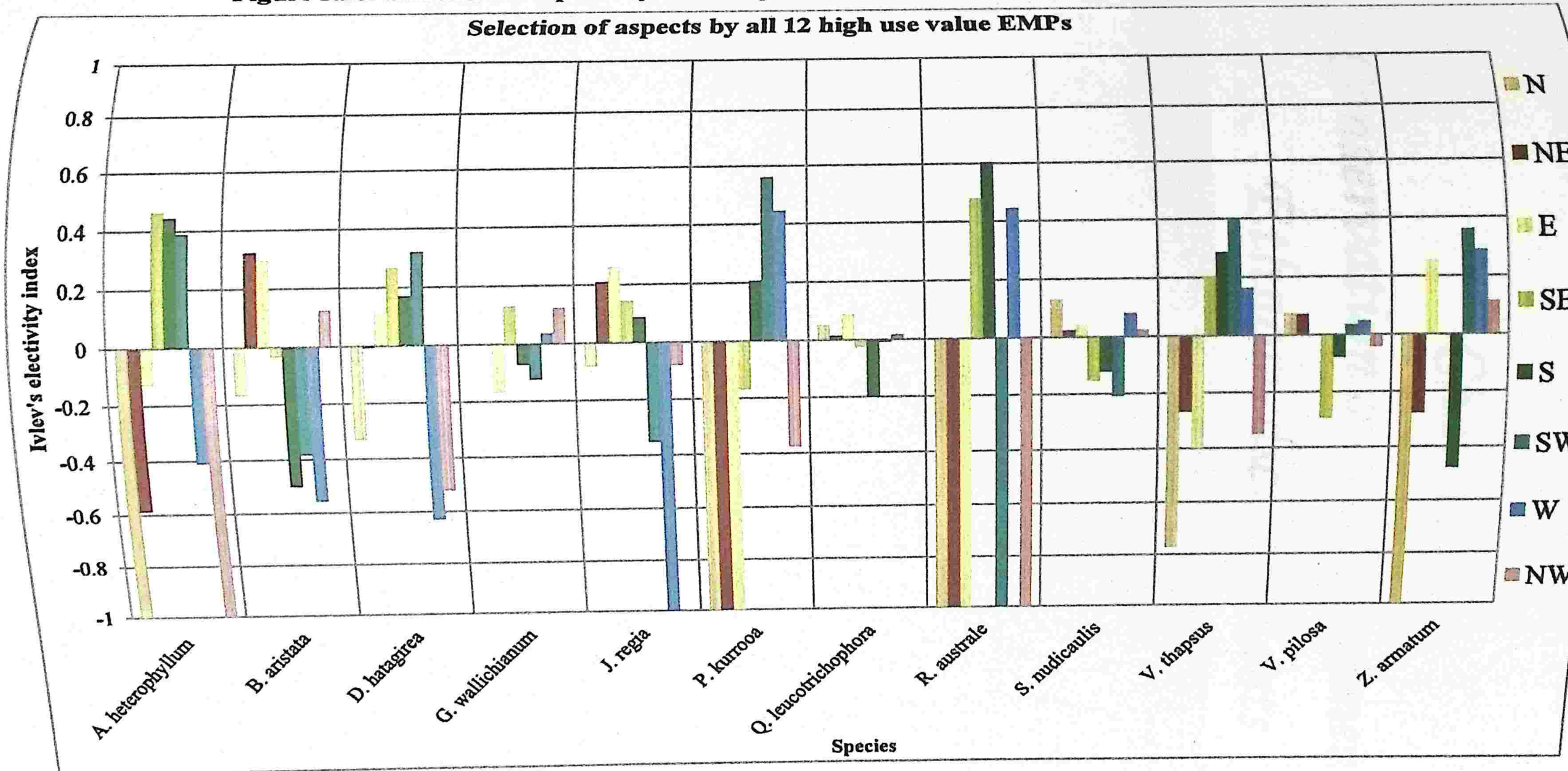
It is important to have information on exact requirement of the species to enhance the success of conservation and cultivation (*in-situ* or *ex-situ*). Previously it was believed that cultivated MAPs lack the essential medicinal properties and this fact has been scientifically proved. One of the source of medicinal properties present in plants are the secondary metabolites which plants need in their natural environments under particular conditions of stress and competition (Schippmann *et al.* 2002). Therefore, it is essential to provide similar environment to the species to produce the same secondary metabolites. The present study provides information on relation of seven essential covariates with that of EMPs to fill up the gap of information for (at least) these 12 commercially and locally important EMPs.

## 5.5 Conclusion

1. Distribution of *Quercus leucotrichophora, Geranium wallichianum, Viola pilosa* and *Berberis aristata* were less likely to restrict by any covariate used in the study and these were found widely distributed in the study area.

   *Aconitum heterophyllum* was restricted between southeast to southwest aspects, while *Picrorhiza kurrooa* was restricted on south to west aspects. *Rheum australe* was restricted to southeast to south and west aspects. *Verbascum thapsus* and *Zanthoxylum armatum* were not found on northern aspects.
2. *Picrorhiza kurrooa* was restricted to undulating terrain as evident from high degree of ruggedness through the descriptive analysis.
3. *Picrorhiza kurrooa* was found most vulnerable to human activities, followed by *Dactylorhiza hatagirea. Rheum australe, Zanthoxylum armatum* and *Aconitum heterophyllum.*
4. Micro-habitat study of alpine region for *Aconitum heterophyllum, Dactylorhiza hatagirea, Picrorhiza kurrooa* and *Rheum australe* revealed that *Aconitum heterophyllum* and *Picrorhiza kurrooa* show positive and significant response to slope. Only *Picrorhiza kurrooa* (presence and absence locations) showed significant difference with aspect.
5. Alpine landscape was classified into seven micro-habitats. *Aconitum heterophyllum* and *Dactylorhiza hatagirea* occurred in six types of habitats whereas *Picrorhiza kurrooa* occurred in five habitats. *Rheum australe* occurred in only two types of habitat.

*Figure 5.28: Selection of aspects by all 12 high use value EMPs based on Ivlev's electivity index*



# Chapter 6:
# Conservation and Management of Ethnomedicinal Plants

# 6.0 CONSERVATION AND MANAGEMENT OF ETHNOMEDICINAL PLANTS

## 6.1 Introduction

The depletion of TK can trigger the loss of biodiversity (Farooquee 1999). On the other hand, sustainable utilization of biodiversity is a complex issue that encompasses societal needs, ethical and cultural values, and economic status of communities (Chettri and Sharma 2009). Wynberg (2000) has stressed the need for economic returns to the local people but also warned against over-exploitation of high value species. The following quote is taken from him:

> *"Biodiversity, they argue, cannot be adequately conserved without economic return: through commercialisation, the biological riches of developing countries will be valued and will bring economic opportunities and much needed technology transfer and capacity building. In practice, however, commercialisation is transferring the control and development of biodiversity into the hands of largely corporations and institutes, and leaving little by way of return for communities on the ground".*

Therefore, involving local community in conservation efforts through access and benefit sharing (ABS) is the way forward. It is in line with one of the three objectives, of the CBD, on ABS that refers to the way in which genetic resources may be accessed, and benefits resulting from their use shared by users with countries that provide them. A supplementary agreement to the CBD, the Nagoya Protocol, also ensures benefit-sharing, of a genetic resources, with the providers even when genetic resources leaves the originating country. By doing this it creates incentives to conserve and sustainably use genetic resources, and therefore enhances the contribution of biodiversity to development and human well-being.

The conservation challenges today are more complex than ever before. Widespread threats such as drought, climate change and large-scale habitat fragmentation are complicating the efforts to plan and conduct conservation (Dunlop *et al.* 2012). These complex threats not only impact isolated places or individual species but also affect entire landscapes and multiple resources simultaneously (USFWS 2012). Of these, habitat loss is the one major reason for population decline and extinction of the species (Ehrlich 1995; Vitousek 1997; Fahrig 2001). Habitat loss and alteration were considered to be caused by human activities whereas upward shift of alpine plants considered due to climatic variations (Hughes 2000). In any case the loss is of biodiversity and if the species have narrow distribution range then the impact on the survival intensifies manifolds (Nautiyal *et al.* 2002). In addition, conservation measures, whether *in situ* or *ex situ,* have implications on local communities, public and private land owners and managers, entire industries and, of course, wild species (Schippmann *et al.* 2002). *In situ* conservation measures most of the time involve, protecting plants by according protection status to habitat like PAs and Reserves (Heywood and Dulloo 2005). Although many factors can be incorporated into reserve design and selection, diversity, rarity, naturalness, size and representativeness are the most widely used (Margules *et al.* 1988). Other considerations include island biogeography design principles of MacArthur and Wilson (1963 and 1967): (1) area effect - the larger the preserve, the greater the species richness (*i.e.*, species/area relationship) and the greater the chances of long-term viability of populations (more individuals); (2) isolation or distance effect - the less the distance between reserve units, the greater the opportunity for gene flow, colonization, and rescue effect (*e.g.*, Brown and Kodric-Brown 1977). In case of MAPs, identifying the conservation benefits and costs of the different production systems for MAP should help guide policies as to whether species' conservation should take place in nature or the nursery, or both (Bodeker *et al.* 1997). Medicinal plant production through cultivation, for example, can reduce the extent to which wild populations are harvested, but may also lead to environmental degradation, through changes in land-use patterns (Schippmann *et al.* 2002; Kala 2003). The cultivation can also result in loss of genetic diversity as well as loss of incentives to conserve wild populations. At local level cultivation of EMPs in farm was unsuccessful mainly because, some of the EMPs requires period of 2-2.5 years before harvesting, subject to favourable conditions (Mukhia 2004; NMPB 2008). So, the locals would avert risk by growing crops like wheat, rice, potatoes or tomatoes, which can be harvested annually. Additionally door-step collection is available for such agricultural produce (pers. obs.). Similar issues were identified by Alam and Belt (2009) while promoting cultivation of medicinal plants in the Himalayan region of India. Another important factor against cultivation of EMPs, especially in case of alpine EMPs, is that they are habitat specific and available land for cultivation is at lower altitude. It is also proved that cultivated EMPs in unfavourable conditions do not produce chemical constituents of required standard in terms of quality and so avoided by markets (Schippmann *et al.* 2002). So the participatory *in situ* conservation measures would be beneficial to overcome these problems and also to conserve gene pool of MAPs.

However, the practice of habitat conservation in India is quite old. In late 1920s, forest preservation plots were identified in the country for conservation of 'original vegetation' types through *in situ* conservation (Rawat 2005). However the efforts for conservation of MAPs in their native habitats have been initiated only during recent past. This type of conservation generally aims at protection of certain habitats with the desired plant populations. To fulfill this objective, the Forest Department, based on its Joint Forest Management (JFM) principles, develops medicinal plant conservatories in different agro-climatic zones. In India biodiversity can be conserved only with the co-operation of masses of people, many of whom still depend on it for their day-to-day sustenance (Gokhale *et al.* 2005). Involvement of local communities in protection and management of forests and thereby ensuring the ABS strengthens India's role in implementing objectives of CBD (NBAP 2008). A case study from Karnataka explains that the success of this model depend on the active and passive involvement of the locals and government staff (Ramakrishnappa 2002). Some of the successful examples of ecological and socio-economic benefits of community-based conservation are Mendha (Lekha) village (Maharashtra), Jardhargaon village and Makku *Van Panchayat* (Uttarakhand), Kolavipaalam (Kerala) where in communities not only protected forests but also practiced sustainable utilization of natural resources to ensure biodiversity conservation (Kothari 2006).

The concept of Medicinal Plant Conservation Areas (MPCAs), initiated in 1993, focused on conservation of prioritized wild MAPs in their natural habitat (FRLHT 2012). It involves establishment of a network of conservation areas and developmental areas similar to PAs. The FRLHT has been coordinating the establishment of this network in collaboration with the concerned state forest departments. In India, till now, 108 such MPCAs have been established across 12 states, of which, 21 MPCAs were developed in collaboration with state bodies and UNDP-GEF, in three states *viz.*, Uttarakhand, Arunachal Pradesh and Chhatisgarh. These 21 MPCAs covers *ca.* 200 hectares each, nested within larger 1500 hectares forest gene banks (FGBs) (FRLHT 2012; SMPB 2012). For Uttarakhand, *Aconitum heterophyllum*, *Arnebia benthamii*, *Picrorhiza kurrooa*, *Malaxis muscifera*, *Dactylorhiza hatagirea* and *Nardostachys grandiflora* are considered as Globally Significant Medicinal Plants (GSMPs) (SMPB 2012). Of the seven MPCAs declared in Uttarakhand, one is in Uttarkashi district – Kandara (FRLHT 2012; SMPB 2012). But, to enhance the conservation efforts, State Action Plan emphasizes on having MPCA along with medicinal plants development areas (MPDA) in each forest division, i.e., the (Kala *et al.* 2006). Uttarkashi district has three Forest Divisions, of which only one Uttarkashi Division has MPCA at Kandara. In case of Kandara, 250ha has been notified as MPCA and 1300ha area as medicinal plants developmental area (MPDA). Similar efforts would be desirable in other two FDs so as to have wider representation of species from different eco-climatic zones.

In general, this chapter gives the synthesis and conclusions based on the current status of traditional knowledge on the use of EMPs for curative purpose among local communities of the study area (Chapter 3), area specific population status and distribution of EMPs (Chapter 4), and habitat specificity (Chapter 5). It also provides strategies for conservation and management of high value EMPs and TK related to it based on the findings and observations.

**Objective: To evolve strategies for conservation and management of high value ethnomedicinal plants**

## 6.2 Methodology

Present status of TK and TK healers, in the district, and some of the legislations were consider for suggesting strategies for conservation of TK.

**Identification of potential site for establishment of MPCA and / or MPDA:**

For suggesting strategy for conservation of EMPs following methodology was used: Three altitudinal zones (*viz.* LAZ, MAZ and HAZ) were categorized based on the lowest and highest elevation of villages and different forest types present within that altitudinal zone (See Chapter 3, section 3.2.1). Use value (UV) Index for each species, separately in all three altitudinal zone, was calculated on the basis of responses from respondents, number of diseases cured and parts used (See Chapter 3, section 3.2.2.2). Top five species, from each altitudinal zone, were then selected on the basis of highest UVI and considered throughout the study. Occurrence of these 12 prioritized (high UVI) EMPs, in various forest blocks, was a major factor for selecting these forest blocks as potential sites for establishing MPCAs/MPDAs in order to conserve EMPs. Presence of other important MAPs (which did not occur in the plots or in high use value criteria) was also accounted in identification of the potential sites. Human influence data (Chapter 5.2) that describes disturbance caused by human activities at broader scale (Sanderson *et al.* 2002) as well as BIOCLIM data on precipitation and temperature (Hijmans *et al.* 2005) were also used while describing potential sites. Often administrative units of forests are determined by the human population. Hence areas with high human density had smaller administrative units while in case of low densities, these units covered larger area. Therefore, demarcation of compartments, which are smaller units than blocks, was also mentioned to get more realistic idea of an area (**Annexure IV**).

## 6.3 Strategies for conservation and management of high value ethnomedicinal plants

### 6.3.1 Use of Traditional Knowledge

One of the important steps towards the revitalization of traditional healthcare systems would be **identification of *vaidyas* and local traditional healers within various ethnic communities**. They can play a major role in conservation, management and awareness generation about depletion of EMPs and TK related to it. It was evident from the present study that there is a decline in the TK on herbal medicines among younger generation due to various reasons (Chapter 3).

The idea follows one of the Aichi targets (target#18) which expects the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, should be respected. This would be strengthened when national legislation, in line with international conventions are fully integrated and reflected in the implementation (www.cbd.int).

Therefore, it is recommended that *vaidyas* and traditional healer should be given an opportunity to register themselves with the authority, like Biodiversity Management Committee (BMC). In order to formalize local traditional healers and *vaidyas*, UKFD can issue identity cards in conjunction with the health department. Their knowledge on EMPs should be considered while carrying out *in situ* cultivation of EMPs. Since, their sustenance is depending on availability of EMPs, their active cooperation in conservation of EMPs can be expected. Also, they can be expected to accompany students, village heads in order to make them aware about EMPs found in their region. At same time, as suggested in National Biodiversity Action Plan (NBAP) 2008, cultivation of MAPs and other economically important plants can also be promoted through home herbal gardens, resident welfare associations in urban and semi-urban areas, village commons, etc.

### 6.3.2 Access and benefit sharing (ABS)

India, a signatory to Nagoya Protocol (2011), is bound by the article 21 of protocol (www.pib.nic.in; www.cbd.int). According to which, measures should be taken to raise awareness of the importance of genetic resources and traditional knowledge associated with it, and related access and benefit-sharing issues.

To bring these measures in reality India's Biological Diversity Act (2002) proposes to decentralize management of biodiversity by forming Biodiversity Management Committees (BMCs) at the level of Municipalities and Village Councils and allowing it to document biodiversity and associated knowledge within their jurisdiction in the form of People's Biodiversity Registers (PBR) (NBA 2013). However, given the tremendous variation from place to place in the distribution and uses of biodiversity, this provision has to be highly locality specific (Gokhale *et al.* 2005). Therefore, based on the observations of present study following practices can be promoted in Uttarkashi district:

For the purpose of effective management and sustainable use of MAPs, the existing *Van Panchayats* can be given additional responsibilities and re-designated as Biodiversity Management Committees (BMCs) for which provision exists in Biodiversity Act (2002). In this, stake holders (*Vaidyas*, Local traditional healers and also villagers) would become committee member by forming a user groups. A user group formed by these committee members will act as federal group to control conservation, development and harvest of MAPs. Major portion of the revenue collected would go to user groups whereas a small portion of it should go to UKFD, for the conservation purposes (e.g. Plantation etc.). The user groups should also cooperate UKFD by showing their involvement in **joint patrolling**, especially in alpine areas and also during fire season. This would help in ascertaining the instances of illegal collection and smuggling of EMPs and would help the UKFD, to cover more ground in available human resource.

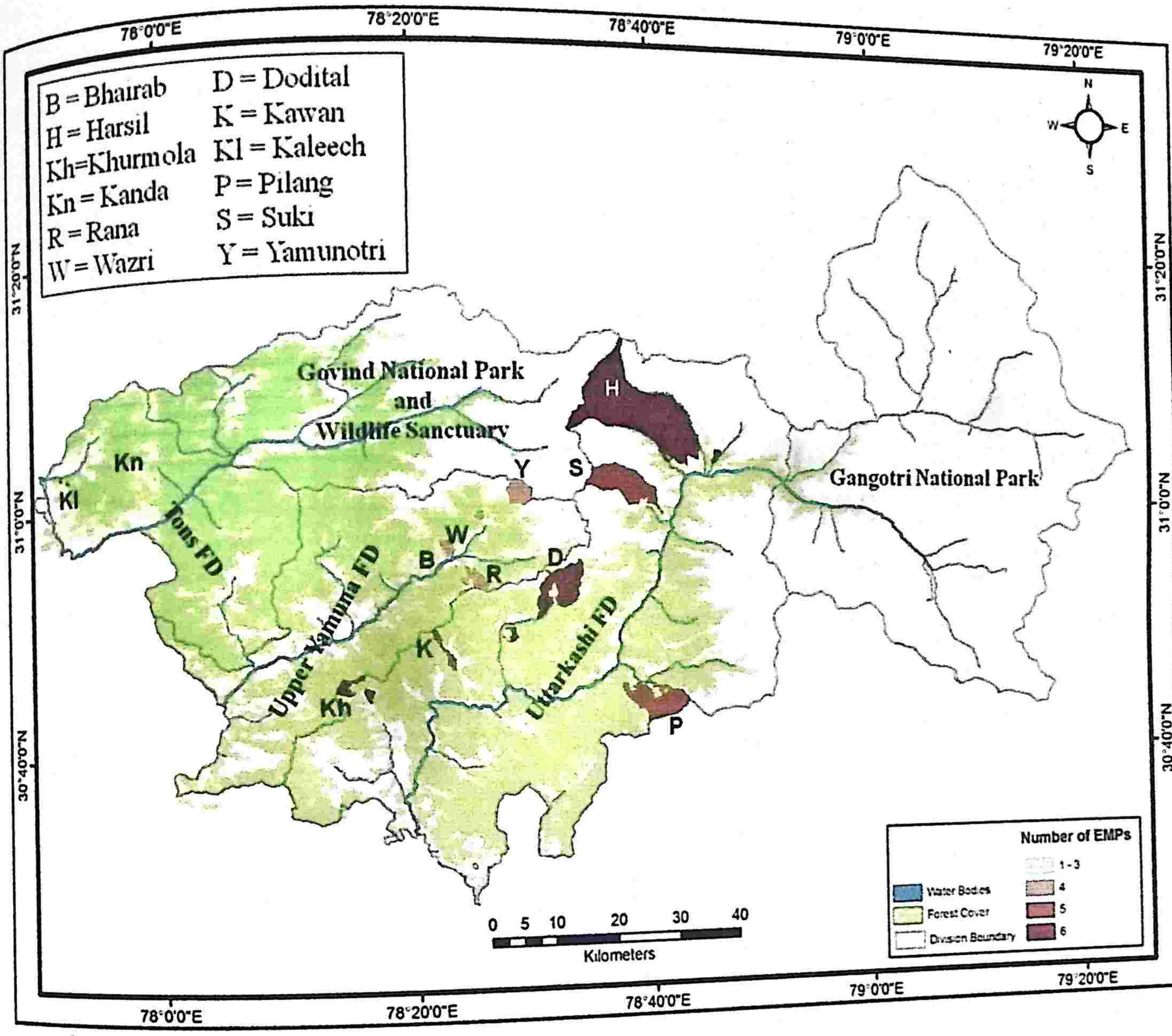
It was observed that the trade (demand) in developed countries drive the biodiversity threat in developing nations (Lenzen *et al.* 2012) and such demand leads to overexploitation of the species in demand. Overexploitation has been considered as another major threat, in addition to habitat destruction and fragmentation, faced by many species (Jablonski 2004; Munday 2004; MA 2005). Almost all EMPs that are traded, for medicinal value and cultural / religious importance, have been harvested from wild and most of the time in unsustainable way (Dhar *et al.* 2000; Kala 2003; Kala *et al.* 2004; Uniyal *et al.* 2002a, 2006, 2009). Harvest of (freely available) MAPs in waste land or on forest land by villagers can increased the dispute among villagers as it was observed in case of *Z. armatum* (Kala *et al.* 2005); but presence of middle man can worsen the situation by harvesting more and giving negligible return to villagers which observed in Mexico; the plant collectors, there, only received an average about 6% of the MAP's consumer price (Hersch-Martinez 1995). Thus, involving community, in conservation and management will multiply the success of conservation as well as will provide benefits to both, forest department and community, as it was seen in case of Mendha (Lekha) or Jardhargaon village. Locals can also be asked to use bunds, school compounds or fallow land around villages for EMPs plantation along with fodder and fuel wood plantation as suggested in NBAP (2008) and Sharma *et al.* (2009).

### 6.3.3 Identification of potential sites for establishment of MPCA and MPDA

Strategic goal (C, target 11) of Aichi Biodiversity Targets emphasizes on conserving habitat that are important in terms of biodiversity and ecosystem services (https://www.cbd.int/sp/targets/#GoalC). Additionally, the habitat specific conservation measures, rather than species centric efforts are the need of the hour (Allen *et al.* 2005). Multiple species' habitat conservation approach increases the 'biological value' of the area. It also provides protection to species that are under low pressure in an early stage (USFWS and NMFS 1996). It therefore, vindicate the idea of selection and protection of forest blocks for conservation of many useful EMPs.

In Uttarkashi district, within surveyed areas, total 12 blocks have been identified as potential areas for development of MPCA as well as MPDA which are rich in terms of availability of high value as well as other useful EMPs (**Figure 6.1; Table 6.1**).

**Figure 6.1: Forest Blocks (of Reserve Forests) that harbours highest number of EMPs in Uttarkashi district**




Representation of all three altitudinal gradient, *viz.*, LAZ, MAZ and HAZ was also considered while selection of the blocks. Six of these sites have potential to declare as MPCA as these sites show rich diversity and abundance of the EMPs. It was observed that most blocks (six) with high value EMPs were located in UFD (Table 6.1, Figure 6.1). These sites are different from already has existing MPCA and MPDA in Kandara region of UFD. In accordance with the State Action Plan, each Division needs to have MPCA surrounded by MPDA. So the blocks from TFD and UYFD could be considered on priority basis. These blocks include Kaleech and Kanda from TFD and Bhairab, Rana, Yamunotri and Wazri from UYFD respectively (Figure 6.1; Table 6.1). The surveyed areas i.e. transect locations (**Annexure IV**) would be preferred sites for establishing MPCAs and the surrounding area could be considered for MPDAs. The size of both MPCA and MPDA would be dependent on area of block and density and diversity of EMPs. The detail description of these sites is given below:

### 6.3.3.1 Areas of high potential for establishment of MPCA and / or MPDA

**Tons Forest Division:**

**Kaleech block (Kotigad Range):** Smallest block among the selected potential areas is represented by five EMPs. *G. wallichianum*, *J. regia*, *Q. leucotrichophora*, *V. thapsus* and *V. pilosa* were occurred in two transects that spread over two compartments. The elevational range of the block is from 1300-1950m asl. Dominant forest type in this block was Pine forest and elevation where most of these EMPs occurred was around 1500m asl. The surveyed area was prone to low human disturbances, probably owing to presence of Pine forest which receives less anthropogenic pressure due to less availability of fodder and fuel-wood species (Thadani and Ashton 1995). Annual (mean) temperature was 19°C whereas annual precipitation was 1616mm.

**Kanda block (Sandra Range):** This block harbours three EMPs, *viz.*, *G. wallichianum*, *J. regia* and *Q. leucotrichophora* that occurred in one transect that was spread over two compartments. Block's altitude ranges between 2190-2800m asl. Banj (*Q. leucotrichophora*) was dominant tree species where highest number of EMPs occurred, within surveyed area. Elevation there was *ca.* 2350m asl. Annual (mean) temperature was 12°C and precipitation was around 1300mm. Two different human disturbance patterns were observed within surveyed area.

**Upper Yamuna Forest Division:**

**Wazri block (Kuthnaur Range):** This block harbours three species, *viz.*, *D. hatagirea, G. wallichianum* and *Q. leucotrichophora* occurred in two different transects that were spread over two compartments. A very spars population of *A. hetrophyllum* (outside transects and sampled area) and *A. lethale* (*Mitha*) was also found in alpine meadows of Wazari. Altitude of the block was ranging from 1800m to 3600m. EMPs restricted to higher altitude were occurred at *ca.* 3500m asl where, *Abies*-Kharsu forest was dominant and annual (mean) temperature and precipitation were 9°C and 1130mm, respectively. Human disturbance was comparatively low. The alpine area of the block was approachable via village Kuthar and lower altitudinal area of the block was approached from village Wazri.

***Table 6.1:* Potential areas (forest blocks) in Uttarkashi district that can be established as MPCA/MPDA: block area; EMPs occurred in blocks and number of transects in which EMPs occurred**

| Division | Range | Beat | Block | Block area (ha) | Tr. (#) | Ah | Ba | Dh | Gw | Jr | Pk | Ql | Ra | Sn | Vt | Vp | Za | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Uttarkashi | Gangotri | Jaspur | Harsil | 13331.30 | 2 | + | | + | + | | + | | + | | + | | | 6 |
| Uttarkashi | Dharasu | Khurmola | Khurmola | 582.85 | 2 | | + | | | + | | + | | + | + | + | | 6 |
| Uttarkashi | Badahat | Dodital-I | Dodital | 3109.90 | 2 | + | | + | + | | + | + | | | | + | | 6 |
| Uttarkashi | Taknaur | Pilang-II | Pilang | 3121.18 | 3 | + | | + | + | + | | + | | | | | | 5 |
| Uttarkashi | Gangotri | Songad | Suki | 3552.45 | 2 | + | | + | + | | + | | + | | | | | 5 |
| Uttarkashi | Badahat | Kawan | Kawan | 441.36 | 1 | | + | | | | | + | | + | | + | + | 5 |
| Tons | Kotigard | Kaleech | Kaleech | 72.01 | 1 | | | | + | + | | + | | | + | + | | 5 |
| Upper Yamuna | Yamunotri | Durvil | Bhairab | 452.95 | 2 | + | + | + | + | | | | | | | | | 4 |
| Upper Yamuna | Yamunotri | Rana | Rana | 795.55 | 3 | | + | + | + | | | + | | | | | | 4 |
| Upper Yamuna | Yamunotri | Yamunotri | Yamunotri | 1144.24 | 2 | + | | + | + | | + | | | | | | | 4 |
| Upper Yamuna | Kuthnaur | Wazri | Wazri | 546.20 | 2 | | | + | + | | | + | | | | | | 3 |
| Tons | Sandra | Salla | Kanda | 117.24 | 1 | | | | + | + | | + | | | | | | 3 |

Tr. = Number of transect/s laid; Ah = *Aconitum heterophyllum*, Ba = *Berberis aristata*, Dh = *Dactylorhiza hatagirea*, Gw = *Geranium wallichianum*, Jr = *Juglans regia*, Pk = *Picrorhiza kurrooa*, Ql = *Quercus leucotrichophora*, Ra = *Rheum australe*, Sn = *Senecio nudicaulis*, Vt = *Verbascum thapsus*, Vp = *Viola pilosa*, Za = *Zanthoxylum armatum*

**Bhairab block (Yamunotri Range):** It can be considered for establishing MPCA and MPDA because it harbours four EMPs, *viz. A. heterophyllum, B. aristata, D. hatagirea* and *G. wallichianum* occurred in two transects present within single compartment. This block also harbours *Aconitum lethale, Aquilegia pubiflora, Caltha palustris, Nardostachys jatamansi, Picrorhiza kurrooa* (outside plots) and *Polygonatum* spp. and therefore has high potential for establishing conservation and development areas. Altitudinal gradient was ranging from 2000m to 3600m. The altitude where highest number of EMPs occurred was *ca.* 3500m asl. This area was dominated by *Abies*-Kharsu forest. The annual (mean) temperature and precipitation were 9-10°C and 1150mm, respectively. Human disturbance was comparatively low. The alpine area was approachable from Hanuman Chatti via village Kuthar.

**Rana block (Yamunotri Range):** It harbours four EMPs, *viz., B. aristata, D. hatagirea, G. wallichianum* and *Q. leucotrichophora* in three different transects spread across four compartments with each species representation each compartment. In addition, it also supported very sparse population of *Trillidium govanianum* and moderate population of *Jurinea dolomiaea* in alpine areas. Altitudinal gradient was ranging from 2000m to 3800m. Two forest types were present, where highest number of EMPs occurred, within this block, *viz. Abies*-Kharsu and *Betula*. Of these, the former represented altitudinal gradient of 2100m and 2900m asl, whereas, later represented higher altitudinal area (3200m asl) which was sub-alpine. Tree-line was formed by *Betula* in this zone. Surprisingly, human disturbance near *Betula* (sub-alpine area) forest was higher than that of at *Abies*-Kharsu area. Temperature ranged from 5°C at sub-alpine to 13°C near middle elvational, *Abies*-Kharsu forest and precipitation ranged from 1100mm to 1300mm. Alpine meadows were approachable from Hanuman Chatti, along Hanuman Ganga, via Pindki-Mades village. The alpine meadow extends to form boundary with Uttarkashi FD. Darva top, above Dodital lake (Badahat Range, Uttarkashi FD), was adjacent area.

**Yamunotri block (Yamunotri Range):** It harbours four EMPs, *viz. A. heterophyllum, D. hatagirea, G. wallichianum* and *P. kurrooa* in two transects laid in single compartment. It also had very sparse population of *Trillidium govanianum* as well as few more rare but important species such as, *Arnebia benthamii* in Compartment # 7, *Meconopsis aculeata, Rheum moorcroftianum* and *Rheum webbianum* in compartment # 7, 8 and 10. *Jurinea* *dolomiaea* was also common in alpine areas. Altitudinal gradient was ranging was from 2700m to 5400m. Highest number of EMPs were occurred in higher altitude area (alpine area) ranging between 3400-3900m asl. At few places, sampling was conducted in tree-line area which was dominated by *Abies*-Kharsu and *Betula*. Annual temperature at slightly lower elevation was 7°C while at higher elevation it was 4°C. Annual precipitation was 1100mm. The alpine meadows can be reached out from Janaki Chatti in two ways, one – via village Kharsali and another via Yamunotri shrine. In later case a 16km trek from Yamunotri proceeds upto Saptarshi Kund area, *en route* giving very scenic view of large, sometimes steepish Seema Bugyals that possessed many MPs. During the survey, traces of illegal (that too in month of July) harvest were observed in this area. The trek to alpine meadows via Kharsali was tougher than Yamunotri-Saptarshi. Grazing pressure was also more compare to alpine areas above Yamunotri shrine.

**Uttarkashi Forest Division:**

**Dodital block (Badahat Range):** It hosts very important six EMPs, *viz., A. heterophyllum, D. hatagirea, G. wallichianum, P. kurrooa, Q. leucotrichophora* and *V. pilosa* in two transects representing two compartments. In addition to these EMPs there were few more important MPs observed in the block, for example, *Polygonatum cirrhifolium* and *Nardostachys grandiflora* (**Plate 6.1A and B**), so, can be considered for conservation and development of these species. Presence of *Arnebia benthamii* was also shared by local staff but the area could not visit owing to heavy rains during survey visit. Altitudinal gradient ranges from 1650m to 3800m and the total trek is of 22km, from the end of motarable road at Sangam Chatti. This is one of the most beautiful places present in the Himalaya. Various types of forests are present in the route via village Aghoda, but larger area is covered under Banj oak forest and, towards the ridges, steep undulating meadows. Highest numbers of EMPs were occurred in two altitude zones (1) at 2000m (in Banj dominated area) and (2) at average of 3500m (alpine area). Through human footprint data, it revealed that alpine area was more prone to human disturbance than that of Banj oak forest that surveyed. This might be due to, presence of strands of Banj oak even after lopping for fuel-fodder collection whereas, alpine meadows face direct impact of which can be detected by remote sensing data. It is therefore more important to conserve both the habitat. Annual temperature ranges from 6°C to 16°C and precipitation from 1150mm to 1486mm at higher and lower sampled areas, respectively. Dodital Lake is situated at 3050m asl, amidst of high ranges that contributes water to the lake. Over flow of the water generates drainage of Assi Ganga, one of the small tributary of Bhagirathi. One of the best examples of ecotourism and forest department-people's joint participation has been set up over here by then Forester of Dodital. The only concern is the ecotourism should not put pressure on the vulnerable habitat that supports so many MPs. It has been proposed to declare as Conservation Reserve (pers. comm. Range Officer-Badahat) due to Golden trout fish present in Dodital (lake) but looking at diversity of MPs and other plant species as well as avian fauna, the early decision of notifying it under one of the protected area would benefit the habitat.

**Kawan block (Badahat Range):** This block harbours five EMPs, *viz. B. aristata, Q. leucotrichophora, S. nudicaulis, V. pilosa* and *Z. armatum* in single transect distributed across two compartments. The block was located between altitudinal gradient from 1600m to 3100m but altitudinal zone around 2000m asl harbours these EMPs. Annual temperature was 13°C while annual precipitation was around 1500mm. Human disturbance was low according to human footprint data.

**Khurmola block (Dharasu Range):** This block harbours six EMPs, *viz., B. aristata, J. regia, Q. leucotrichophora, S. nudicaulis, V. thapsus* and *V. pilosa* in two different transects spread in two compartments. A presence of *Lilium polyphyllum* **(Plate 6.1C)** was also observed in this block and it should be, therefore, considered for establishing conservation and development areas. Altitudinal gradient was ranging from 1600m to 2900m asl but these EMPs was occurred in sampling areas that represent low and middle altitudinal zones, around 1700m asl and 2300m asl, respectively. The former dominated by Pine forest whereas later dominated by Banj oak forest. Area experiences annual temperature, at lower region, of 16°C and precipitation *ca.* 1700mm whereas at higher altitude, temperature and precipitation was 11°C and 1400mm, respectively. According to human footprint data, human disturbance was low near Banj oak forest but higher at Pine forest. Similar observation about Banj oak forest was also recorded by Singh and Rawat (2011). It was not only one of the best Banj oak patches within district but also harboured some of the important MPs. It is situated at the junction of Uttarkashi and Upper Yamuna FD and thereby on the boundary of Yamuna and Bhagirathi valley, on the Dharasu-Badkot road. Owing to connecting route between

Yamunotri – Gangotri shrine, this road, experience heavy traffic during Char-Dham Yatra season, which in future can become cause of habitat fragmentation.

**Harsil block (Gangotri Range):** The largest block, among selected one, harbours six EMPs, namely, *A. heterophyllum, D. hatagirea, G. wallichianum, P. kurrooa, R. australe* and *V. thapsus* found in two transects laid in two compartments. It also harbours some very important MPs such as, *Dioscorea deltoidea, Polygonatum verticillatum, Allium humile, Anemone rivularis, Angelica glauca, Arnebia benthamii* and *Jurinea dolomiaea.* Overall, richness of MPs mark this block as one of the hotspots for MAPs in that area. Altitudinal gradient of the block was ranging between 2700-5900m asl but high diversity of EMPs were occurred in alpine areas ranged between 3300-3700m asl. Annual temperature ranged between 3-8°C and precipitation 1000-1100mm. Human disturbance ranged between low to medium. The alpine meadows were mostly located on the northern side of Bhagirathi River, towards the boundary of district. The block is flanked between two protected areas, Govind Pashu Vihar and Gangotri NP, but shared boundary only with the former. Two major valleys present in the block were, Sya gad (or Siya Gad) and Jalandari gad. The meadows are better known as Kyarkoti bugyal (**Plate 6.1D**). The Sya gad, through the high altitude passes, extends into Govind Pashu Vihar through Ruinsera Tal (lake). The Jalandari gad extends northwardly and ends up in Himachal Pradesh. Both the valleys have high grazing pressure, but alpine meadows of Jalandari harboured less MPs compared to alpine meadows in Sya valley. Presence of *Polygonum polystachyum* is an indication of eroded sites. Smythe (1938) stated that abandoned grazing and camping sites promotes growth of *Polygonum polystachyum* and *Impatiens sulcata* which permanently ruins the pastureland but Kala *et al.* (1998) reported several positive role of, mainly, *Polygonum polystachyum* such as, role in soil formation and enrichment due to accumulation high biomass, stabilization of slopes, role in forest succession by giving way to woody species, namely, *Lonicera myrtillus, Juniperus indica* and *Rhododendron anthopogon*. At a same time, the study also concluded that despite positive role played by this herb, its tendency to invade land and thereby suppression of many herbs cannot be neglected. So, its presence in Jaladari valley should be reason of concern.

**Suki block (Gangotri Range):** It harboured five EMPs, *viz., A. heterophyllum, D. hatagirea, G. wallichianum, P. kurrooa* and *R. australe* in two transects distributed across single compartment (# 3c). In general, altitudinal gradient of the block ranges from 3100m to 6200m. The rich diversity of EMPs occurred between altitude gradient ranged from 3500m asl to 3800m asl. The annual temperature of the place was between 5°C to 8°C and precipitation received annually, was 1100mm. Despite the claims from locals about saving this habitat, human footprint value was higher indicating medium disturbance (compared to other high altitude areas mentioned in this section). This may be due to the block's proximity to the National Highway between Rishikesh and Gangotri (NH 108). Block possessed one of the largest patches of *Taxus wallichiana*. Despite presence of individuals from both the sexes and fruit bearing individuals, of *T. wallichiana*, the regeneration was not observed under the patch. Another interesting observation was that village forest was extended till lower edge of alpine meadows (of Kandara bugyal) and therefore, presence of *A. heterophyllum*, was observed occurring in village forest. In the same block, 250ha area, belonging to compartment # 3b, has been notified as MPCA (and surrounding 1300ha area as MPDA) for conservation and development of *Aconitum heterophyllum* and *Arnebia benthamii*. But the block is more potential as it harbours *Aconitum ferox, Aconitum lethale, Allium carolinianum, Allium humile, Allium stracheyei, Anemone rivularis, Angelica archangelica, Jurinea dolomiaea, Meconopsis aculeata, Polygonatum multiflorum* and *Selinum tenuifolium,* in addition to above mentioned MPs. Therefore, after re-assessment, either attempt in increasing area of existing MPCA or marking one more MPCA within same MPDA will increase number of MAPs that requires protection.

**Pilang block (Taknaur Range):** Altitudinal gradient of the block was ranging from 1800m to 4100m. It harboured five EMPs, *viz., Aconitum heterophyllum, Dactylorhiza hatagirea, Geranium wallichianum, Juglans regia* and *Quercus leucotrichophora.* These EMPs were occurred in three transects distributed across three compartments. EMPs were occurred in areas having Banj oak dominated forest (at *ca.* 2000m asl), *Abies*-Kharsu dominated forest (2400-2800m asl) and in alpine areas (3400m asl). Grazing pressure was observed at the sites but human footprint value was low indicating low human disturbance. This could be reason of vastness of the alpine meadows that might be sharing the existed pressure and farness from the national highway (important road) and so human activities. The meadows that are in territory of Uttarkashi district can be reached from villages Malla (located on the NH 108, 3km before Bhatwari) via village Silla. The ridge area of Kush-kalyani and Kyarki (Kiarki)

Bugyals shares boundary between Uttarkashi and neighboring Tehri district. Kyarki bugyal opens up into Gangotri NP and Khatling glacier of Tehri district. Towards this end it possessed a religiously important area known as Sahastra Tal. Annual temperature was ranged from 5°C (at alpine area) to 13°C (near Banj oak forest) but precipitation was more over similar at all places, i.e., 1300-1400mm.

#### 6.3.3.2 Other potential areas rich in medicinal plants' diversity

Connectedness through landscape linkages and movement corridors is important because habitat fragmentation and isolation lead to extinction of local populations and are the most serious threats to biological diversity (Bolger *et al.* 1997). Therefore, in addition to 12 blocks selected, few more areas (blocks) which support good diversity of MPs have mentioned here. Though these blocks possessed good diversity of MPs, either due to low number of prioritized **EMPs,** as per the requirement of present study, or due to non occurrence of those MPs within sampling plots, these blocks did not find place in the list of potential MPCA/MPDA of previous section. Nevertheless, their importance does not fade out and can certainly be protected for species diversity present within them.

**Upper Yamuna Forest Division:**

**Kuthnor Range:** Kupra block harbours species like *Aquilegia pubiflora, Valeriana jatamansii* and *Paeonia emodi* whereas Pali block harbours *Paris polyphylla* (Compartment # 1), *Habenaria intermedia, Jurinea dolomiaea, Dactylorhiza hatagirea, Nardostachys jatamansi.*

**Mugarsanti Range:** Molda block harbours *Berberis asiatica* and *Zanthoxylum armatum.* Conservation of *Zanthoxylum armatum* can also be planned in Devrana block. *Datisca cannabina* and *Houttuynia cordata* were found in civil land within compartment # 3 of Devarana beat.

**Yamunotri Range:** Digdara block harbours species such as *Trillidium govanianum, Jurinea dolomiaea, Dactylorhiza hatagirea, Podophyllum hexandrum* **(Plate 6.1E)**, *Skimmia anquetilia* and *Taxus wallichiana* **(Plate 6.1F)**.

**Uttarkashi Forest Division:**

**Badahat Range:** Utraun block shows good population of *Cinnamomum tamala, Polygonatum verticillatum, Cissampelos pariera, Hedychium spicatum.*

**Taknaur Range:** Gangnani block is very important area as it harbours many MPs, such as, *Aconitum ferox, Aconitum heterophyllum, Caltha palustris, Dactylorhiza hatagirea, Picrorhiza kurrooa, Podophyllum hexandrum, Polygonatum verticillatum, Jurinea dolomiaea* and *Trilidium govanianum.* This block contains Gidara Bugyal (**Plate 6.1G**), which has high richness and diversity of MAPs, and therefore it was proposed for establishment of MPCA (Rawat 2005). On the way to Gidara from village Bhangeli, one of the best patches of *Taxus wallichiana* and *Podophyllum hexandrum* can be seen; further en-route to Gidara, on cliff areas presence of *P. kurrooa* was observed. *Megacarpaea polyandra* was also observed in the route. This area is dominated by mixed herbaceous formations and supports 14 MAPs (Rawat 2005).

### 6.3.4 *In situ* conservation of habitat specific ethnomedicinal plants

Some of the EMPs are more threatened than others because their distribution is restricted by one or two habitats. For example, *D. hatagirea* which is found in alpine area where it is confined to the marsh meadows only. Such species need more attention even during their *in situ* conservation. This could be in accordance with one of the objectives of NBAP (2008). On the other hand increased resource dependency on surrounding forests has affected the status of highly preferred species (Awasthi *et al.* 2003). For example, repeated onslaught of *Q. leucotrichophora* have led to its replacement by other species especially by pine which has become a common and ever increasing phenomenon (Singh *et al.* 1984; Singh 2008). Therefore, even such species and habitats also need attention. At a same time, in Uttarkashi, cultivation of EMPs for conservation of wild species is not a feasible option due to fragmented and marginal landholding with 3.3% area under agriculture (Awasthi 2001). Furthermore, cultivation would require conversion of forest land to agricultural, which will lead to depletion of forest cover.

Excessive tree felling for timber and fuel wood, establishment of cattle camps (creating artificial pastures), unplanned tourism and pilgrimage have caused a tremendous pressure on high altitude forests directly as well as indirectly by causing pollution in the area (Singh 2008).

### 6.3.5 Management of habitats

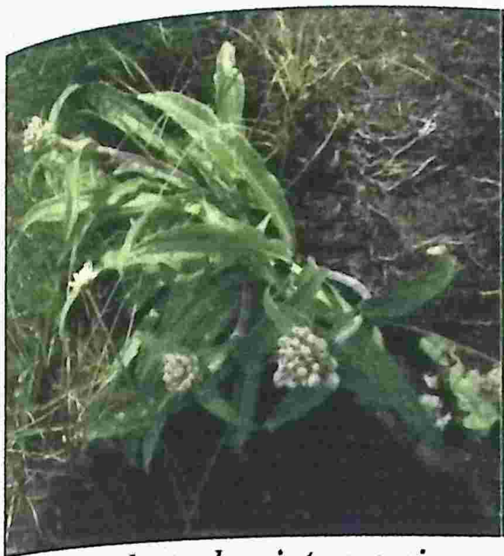
The constraints of difficult terrain, physiographic features, climatic variability in addition to natural calamities in the form of landslides, earthquakes and cloud bursts, etc., pose threats to the IHR (Agrawal 1999; USoE 2004). On the other hand ever increasing human population and its developmental needs of construction, mining, as well as requirements for food, fuel, and fodder have disturbed the region considerably (Agrawal 1999; Hogan and Gowaty 2012). This disturbance has led to a habitat destruction (Hogan and Gowaty 2012), which only we – humans can stop. Uttarkashi district is also facing similar consequences (USoE 2004; The Gazetteer of India 2012). But due to phyto-geographic, climatic and socio-economic variation within the district, the similar threats acts differently at different locations. The intensity of damage might be different across varied altitudinal gradient. For example, preference of fodder species varies depending upon presence of various fodder species at that altitudinal zone. *Q. leucotrichophora*, is one of the most preferred fodder species but it is usually distributed between 1500-2400m asl and therefore it is under heavy pressure within that limits only. Forest fire is major problem at LAZ but may not be in alpine meadows. Collection of timber, fuel-wood, NTFPs, lopping of trees and grazing have drastically altered the structure and composition of the protected forests (Marcot 1992). Regular camping within the forest, by shepherds and tourist, causes degradation of the habitat (Rawat 2005). Hence, while preparing management plans, these issues should also be considered. Even under heavy pressure for livelihood dependence, the reserve forests of Uttarkashi were found intact at most of the places. However, at few place, like Dayara *Bugyal* and Part of Kyarkoti *Bugyal* (Uttarkashi FD), signs of degradation or alteration of habitat was observed. At Dayara the degradation is because of the regular camping and overuse of pasture for tourism which was even observed by Rawat (2005), whereas at Kyarkoti, one of the slope was fully covered with *Polygonum polystachyum* (read more at **6.3.3.1/Uttarkashi FD/Harsil block**). MPDA, mainly surrounding area of MPCA, would functions as buffer area. In MPDAs, apart from protection of the existing bio-resources, introduction of other MAPs occurring in neighboring areas and cultivation at a large scale should be carried allowed. Sustainable harvest, with permission from and under the supervision of concerned authorities may be allowed. Local communities should be involve in such moves (as discussed earlier in this chapter) which would help avoid conflicts between local communities and Forest Department as suggested in report by WHO-WWF-IUCN (1993).

### 6.3.5.1 Medicinal Plant Nurseries

In Uttarkashi district, Forest Department has three MAPs nurseries, in addition to other forest nurseries which support annual plantation of mostly climax species. Of three nurseries, two are in Uttarkashi FD and one is in Tons FD. Nurseries present in Uttarkashi FD were at Harsil (2500m asl) and Songad (2300m asl), both supports MAPs found in sub-alpine and alpine region. Nursery at Harsil (**Plate 6.2A**) has large collection of *T. wallichiana* but mortality rate of these saplings were high when planted in forests (pers. comm. Mahendra Singh, Nursery in-charge cum gardener). Nursery at Jarmola in Tons FD is at 1700m asl (**Plate 6.2B**) where major plantation was of *Bergenia ciliata.* A few saplings of high altitude MPs such as *A. heterophyllum, Rheum* sp. were also observed. Such nurseries can help in multiplying the material but their mortality rate needed to reduce. However, most of the time (like in case of Jarmola nursery), high altitude MPs were brought from forest to plant in nursery (pers. comm.). This is inappropriate and not only damages material that has brought from the forest but also depletes the wild population.

**6.3.5.2 Role of Eco-sensitive zone (ESZ)**: In order to protect Bhagirathi river from negative impact of many developmental activities and population explosion, Government of India, has notified a part of Uttarkashi district as ESZ (Notification no. *S.O.2930(E), [18/12/2012] - River Bhagirathi from Gaumukh to Uttarkashi as Eco-sensitive Zone, Notification*; www.moef.nic.in). The said ESZ spans 4179.59 km$^2$ area of Bhagirathi drainage, starting from Gaumukh till Uttarkashi town covering *ca.* 100km distance from start to end along the banks of the river. On one hand it will prohibit certain developmental activities but on another hand, it will promote (i) Rain Water harvesting, (ii) Organic farming, (iii) Green technology, (iv) Walking tourism, (v) Micro hydel (hydroelectricity) projects for local use, (vi) Solar energy for local use and (vii) Local bio-resource based industry. The tourism activities have been permitted but should follow the Tourism Master Plan, prepared by the Department of Tourism of the Uttarakhand State Government. Therefore, this declaration will ultimately help in protection and management of biodiversity in some part of the district, but if interprets and implemented correctly.

**Plate 6.1**



A: *Nardostachys jatamansi*

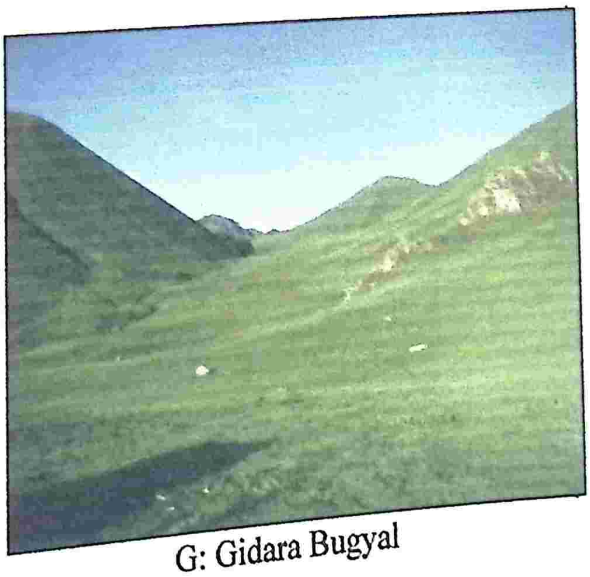
B: Suitable habitats for *N. jatamansi:* Dodital-Darva top

C: *Lilium polyphyllum*

D: Suitable habitats for *P. kurrooa* Kyarkoti (4500m), Syan gad-Harsil

E: *Podophyllum hexandrum*

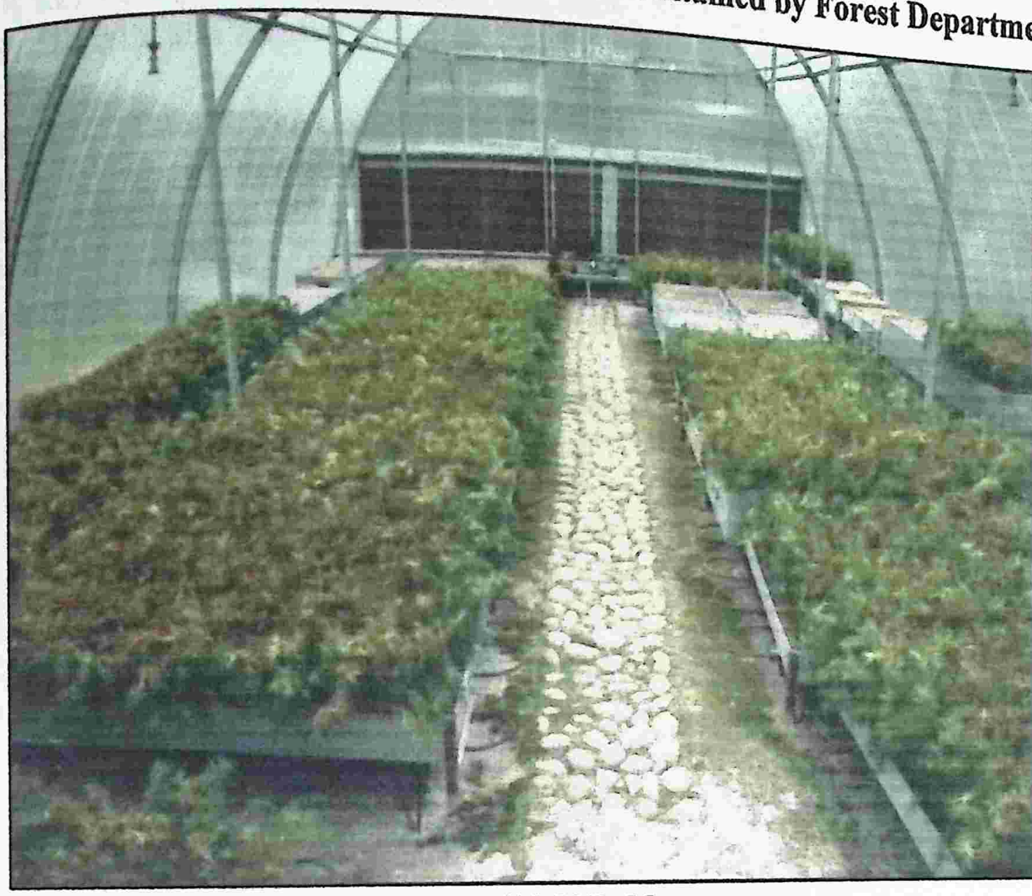
F: *Taxus wallichiana*



G: Gidara Bugyal

**Plate 6.2**

**Medicinal and aromatic plant nurseries maintained by Forest Department**



A: Harsil MAPs Nursery

B: Jarmola MAPs Nursery

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## Annexure I: Format of semi-structured questionnaire

Based on the objective (1), the questionnaire had the following questions:

1. Respondent's profile
   a. Age:
   b. Sex:
2. Whether respondent possessed any kind of TK on medicinal plants? **Y* / N**
3. Is this TK being practiced? **Y / N**
4. What is the source of their TK? **(Open ended)**
5. Whether TK is being passed on to next generation or to any one else? **Y / N**
6. Whether passed on TK is being used by their children? **Y / N**
7. Whether TK is eroding? **Y / N**
8. Why TK is eroding? **(Open ended)**

*If answer to the question number 2 is '**yes**' *i.e.* if respondent were using EMPs or they have an information about use of EMPs to cure any diseases then following questions were asked. These questions were mainly in descriptive form.

9. Which medicinal plant do they use frequently?
10. What is the common name of the plant?
11. Which part of the medicinal plant is used?
12. Which diseases this plant can cure?
13. Where is the plant collected from?
14. Are the plants being used for economic purpose?
15. If yes then whom do they sell these plants and at what price?

## *Annexure II: Ethnomedicinal plants (EMPs) of Uttarkashi district, with their common name, distribution range, useful parts and uses*

| Scientific Name | Family | Local Name/s | Habit | Geographic range (in m asl) and Distribution | Part Used | Uses (Literature review) | Diseases cured (present study) |
|---|---|---|---|---|---|---|---|
| *Acorus calamus* L. | Acoraceae | Bach, Baj Vacha (S) | Herb | upto 2200; North temperate hemisphere and tropical Asia. Throughout India, in marshes, | Wp | Worm killer, gastric troubles, menstrual disorders, improve lost voice, abdominal pain, inflammation, neck pain, asthma, jaundice, cough, cold, rheumatism, gout, stomach trouble, bitter tonic, bronchitis, lice killer, throat pain, carminative, emetic, spasmodic, stimulant, chronic diarrhoea, fever, stomachache, headache, malaria | Anti-helminthic |
| *Aconitum atrox* (Bruhl.) Mukherjee = *A. ferox* Wall. ex Ser. = *A. balfourii* Stapf | Ranunculaceae | Mitha (G, K) Vatsnabh (S) | Herb | 3400-3900; Himalaya | Rt | Sciatica, throat and internal inflamation, fever | Fever, Paralysis, Rheumatism, Snake-bite, Cough, Rheumatism |
| ***Aconitum heterophyllum* Wall.** | Ranunculaceae | Atis (G,K) Amrita (S) | Herb | 3300-4500; Himalaya | Rt | Roots aphrodisiac, tonic, diarrhea, Fever, rheumatism, gastric trouble, headache, intestinal pain, stomachic | Fever, headache, Stomachache, Typhoid, Cold, Health tonic, Jaundice, Gastric problem, Constipation |
| *Adhatoda vasica* Nees in Wallich | Acanthaceae | Baisingu, Baising (G); Vasika (S) | Shrub | upto 1500; Tropical Asia | Lv, Rt, Fl | Cough and cold, asthma, bronchitis, malaria, eczema, rheumatism, antiseptic, pulmonary infections, antispasmodic, fever, anthelmintic, joint dislocation, swelling | Cough |
| *Aesculus indica* (Wall. ex Camb.) Hook. | Sapindaceae | Pangar | Tree | 1500-2500 | Fr, Bk, Sd, Lv, Rt | Fistula, wounds, cracks, leucorrhoea, rheumatism, diarrhoea | Boils (Furuncle) |
| *Ajuga bracteosa* Wallich ex Benth. | Lamiaceae | Neelkanthi (G), Kadwipatti (H) | Herb | upto 2100 | Lv, Rt | jaundice, leucorrhoea, blood purifier, worm killer, malarial fever, tonic, stomachache, astringent, febrifuge, depurative, ear ache | coolant, Throat infection, Dysentry |

| Scientific Name | Family | Local Name/s | Habit | Geographic range (in m asl) and Distribution | Part Used | Uses (Literature review) | Diseases cured (present study) |
|---|---|---|---|---|---|---|---|
| *Anemone rivularis* Buch-Ham ex DC. | Ranunculaceae | Daipha (G) | Herb | 2100-3600 India | Rt | Headache, fever, eye diseases, cuts, wounds, burns, antidote to snake-bite, laxative | Boils (Furuncle) |
| *Angelica glauca* Edgew. | Apiaceae | Chora (G) | Herb | 3000-3800; Himalaya | Rt, Wp | Purgative, dysentery, menorrhoea, stomach complaint, vomiting, gastric complaints, bronchitis, constipation, whooping cough | Cough, cold, Gastric problem, Snake-bite, fever |
| *Arctium lappa* L. | Asteraceae | Nakli Kuth (H) | Herb | 2000-3600; Europe | Rt | Rheumatism, gastric complaints, gall stone, body weakness, fever, antiseptic | Fever |
| *Arnebia benthamii* (Don) Johnston | Fabaceae | Bal Jari; Balchhari (G) | Herb | 3300-4500 Himalaya | Rt | Hair tonic, fever, headache, cuts and wounds. | hair tonic |
| *Arisaema jacquemontii* Bl. | Araceae | Baankh (J) | Herb | 1000-3600 | Rt | Ringworm killer, skin diseases, snake-bite | Gastric problem |
| *Artemisia roxburghiana Bess.* | Asteraceae | Kunjaa, Chamur | Herb | 800-1200; Himalaya | Wp, Lv | Antipyretic, tonic, pimples, sores, eczema | breast feeding stop, Antihemorrhagic, Stomachache, Gastric problem, Anti-helminthic |
| *Asparagus filicinus* Buch.-Ham. ex D.Don | Liliaceae | Sharanoi, Kaunta, Jhirni, Kairu Satawar | Shrub | 800-2000 Himalaya; Afghan. | Rt, Lv | Abortifacient, used in dysuria, diabetes, dysentery, aphrodisiac, galactagogue, tonic, veterinary medicines | Brain tonic – Memory, Urogenital Disorders, coolant |
| *Astragalus candolleanus* Royle ex Benth. | Fabaceae | Rudravanti (H, S) | Herb | 3400-4500 - | Wp, Rt | leprosy, tuberculosis, bringing fertility to barren woman, tonic | Itching, Anti-helminthic |
| *Azadirachta indica* A.Juss. | Meliaceae | Neem (S) | Tree | upto 1000 | Sd, Bd, Lv, Fl, Fr, Bk | Diabetes, scabies, fever, skin diseases, scorpion sting, snake-bite, burns, smallpox, antiseptic, lice killer, spermicide, tooth tonic, blood purifier, bitter tonic, antiperiodic, boils, astringent, alterative, ulcer, ecezema, catarrhal infections, rheumatism, purgative, anthelmintic, bronchitis, tumors, cuts, dandruff, spyhilis, wounds, contraception, leprosy, diarrhoea, piles, inflammation, cholera, dyspepsia, jaundice, cancer | Itching, skin diseases |

| Scientific Name | Family | Local Name/s | Habit | Geographic range (in m asl) and Distribution | Part Used | Uses (Literature review) | Diseases cured (present study) |
|---|---|---|---|---|---|---|---|
| ***Berberis aristata* DC** | Berberidaceae | Kingore, Kasmor (G, H) Daru Haridra (S) | Shrub | 1800-3000; Oriental India | Fr, Rt | Eye diseases and in diarrhoea | Wounds, Health tonic, Eye disease, skin diseases |
| *Bergenia ciliata* (Hook. f. & Th.) Engler | Saxifragaceae | Ghee Pati, Silphar (G) | Herb | 1000-3000 Himalaya | Rt | Internal wounds, cutaneous disorders, febrifuge, digestive, tonic, substitute for Areca nut | Kidney stone, Stomachache, Dysentry with blood, Gastric problem |
| *Bergenia stracheyi* (Hook.f. & Th.) Engler | Saxifragaceae | Ghee Pati | Herb | 3600-5200 | Rt, Lv | kidney stones, sores, swelling, power tonic, cuts, boils, cold, cough, asthma, wounds, burns, diuretic, toothache, fever, stomachache, ulcer, gall stones | Kidney stone, Urogenital Disorders, coolant, Asthama |
| *Betula utilis* D.Don | Betulaceae | Bhoj Pat; Bhuj (G, K) | Tree | 2400-3000 | Re, Bk | wounds, burns, cuts, hysteria, jaundice, ear pain, asthma, cough, cold, internal injury, ulcerating sores, menstruation, spermicidal, antiseptic, carminative, intestinal worms | blunt trauma, Boils (Furuncle), |
| *Cannabis sativa* L. | Cannabinacaeae | Bhang Bhangra, Vijaya, Ganjika, Ajaya | Herb | 800-2000; Central Asia | Sd, Lv, Fl, Fr, Bk | Intoxication, narcotic, bronchitis, convulsion, cramps, epilepsy, dyspepsia, ear complaint, gonorrhoea, paralysis of tongue, skin disease, laxative, nervine stimulant | Stomachache, Burnt_cure |
| *Carissa spinarum* L. = *C. opaca* Stapf ex Haines | Apocynaceae | Jangli-Karounda, Karounda Karamadika | Shrub | upto 1200 | Lv, Rt, Bk | Fever, pain, sores, madness, epilepsy, dropsy | Wounds, Anticeptic, Eye disease |
| *Cedrus deodara* (Roxb. ex D.Don) G.Don | Pinaceae | Deodar Devdaru (S) | Tree* | 2000-3000 | Re, St, Bk | Scabies, boils, blisters, itching, worm killer, fever, dysentery, urinary disorders, rheumatism, piles, snake-bite, skin diseases, ulcer, anthelmintic, diaphoretic, carminative, pulmonary diseases, diarrhoea | Itching, skin diseases, Boils (Furuncle), Anticeptic |
| *Celtis australis* L. | Cannabaceae | Kharik | Tree | 700-1500 | Bk, Fr | pimples, leprosy, sprains, joint pain, amenorrhoea, colic | Burnt_cure |
| *Centella asiatica* (L.) Urban | Apiaceae | Bramhibuti Manduk Parni (S) | Herb | upto 2500; Tropical and Subtropical region | Wp | Blood purifier, tonic, diuretic, leprosy, syphilis, wounds, mental disorders, cooling, brain nourisher, improves memory | Spider-bite, coolant, Brain tonic – Memory, Constipation |

| Scientific Name | Family | Local Name/s | Habit | Geographic range (in m asl) and Distribution | Part Used | Uses (Literature review) | Diseases cured (present study) |
|---|---|---|---|---|---|---|---|
| *Cirsium wallichii* DC. | Asteraceae | Shyam Kanya (J), Kendeiya, Kandra | Herb | 1300-3000 | Rt | Dysentery, chest pain | coolant, Health tonic, Boils (Furuncle) |
| *Clinopodium umbrosum* (M. Bieb.) C. Koch | Lamiaceae | Birchee | Herb | upto 2000 | Wp, Lv | Astringent, carminative, blood purifier, gastric troubles | Antihemorrhagic |
| *Cynodon dactylon* (L.) Pers. | Poaceae | Dubla, Hari Doob Durva | Grass | upto 1800 | Lv | Vomiting, check bleeding, wounds, fever, internal injury, diuretic, dropsy, astringent, snake-bite, jaundice | Headache |
| *Cynoglossum viride* Eastw. = *C. occidentale* A.Gray | Boraginaceae | | Herb | | | | Piles_with blood, Boils (Furuncle), Burnt_cure |
| ***Dacrylorhiza hatagirea* (Don) Soo** | Orchidaceae | Hatha Jari; Salam Panja (G,K) | Herb | 2800-4000; Himalaya | Rt | Wounds, bone fracture, expectorant, astringent, tonic, general debility | Wounds, Bone Fracture, Cardiac diseases, Burnt_cure, Health tonic |
| *Datura metel* L. | Solanaceae | Dhatura Kanak, Dhustura | Herb | | Lv, Sd, Rt | Fistula, gum trouble, pyorrhoea, asthma, bodyache, bronchitis, skin diseases | Rheumatism, Earache, Boils (Furuncle) |
| *Debregeasia salicifolia* (D.Don) Rendle | Urticaceae | Syanru | Shrub | 1500-2400 | Bk | Bone fracture | blunt trauma, Bone Fracture, |
| *Dicliptera bupleuroides* Nees | Acanthaceae | Kuthhi, Kawgori | Herb | upto 2000 | Lv | Check bleeding, cough gastroenteritis | Antihemorrhagic |
| *Elatostema monandrum* (Buch.-Ham. ex D.Don) H.Hara | Urticaceae | | Herb | | | - | Fever |
| *Equisetum arvense* L. | Equisetaceae | | Herb* | | St | Bone fracture, diuretic, urinary troubles, bladder disorders | Bone Fracture |
| *Eupatorium adenophorum* Sprengel | Asteraceae | Kharna, Kala basing (G) | Shrub | upto 1000 | Lv | cuts, wounds | Antihemorrhagic |
| *Euphorbia pilosa* L. | Euphorbiaceae | Chuplya | Herb | | Rt | constipation | Dysentry |
| *Fagopyrum esculentum* (L.) Moench | Polygonaceae | Ougal | Herb | 2000-4000 | Rt, Lv, Fr, Sd | Rheumatic pain, typhoid, urinary disorders, fever, lung disorders, headache, anaemia, constipation, tonic | Boils (Furuncle) |

| Scientific Name | Family | Local Name/s | Habit | Geographic range (in m asl) and Distribution | Part Used | Uses (Literature review) | Diseases cured (present study) |
|---|---|---|---|---|---|---|---|
| *Ferula jaeschkeana* Vat. | Apiaceae | Thunak | Herb | 3400-4000 | Sd | Stomach disorders, digestive disorders, aborifacient, anti-implantation | Constipation, Rheumatism, Stomachache |
| *Ficus palmata* Forssk. | Moraceae | Beru, Bedhu, Bedu Anjira | Tree | upto 1800 | Lt, Fr | Boils, dysentery, sores, cuts, wounds, burns, digestion, constipation, stomachache, demulcent, laxative, lung diseases, bladder disorders, external pains, lumbago | Abortifacient, |
| *Galium rotundifolium* L. | Rubiaceae | Jharjharia | Herb | 1000-2500 | Wp | Bronchitis, throat sore, tonsil, wounds, colic, dyspepsia, jaundice | Itching, Spider-bite, Antihemorrhagic, Wounds, Boils (Furuncle) |
| *Geranium nepalense* Sweet | Geraniaceae | Phori, Syunli Ratanjyot | Herb | 1500-2900 | Rt, Wp, | Renal diseases, cuts, jaundice, toothache, ulcer, wounds, stomach disorders, fever, itching, eczema | sprain/cramp, Antihemorrhagic, Wounds, Burnt_cure |
| ***Geranium wallichianum* D.Don ex Sweet** | Geraniaceae | Ratanjyot, Laljari | Herb | upto 2500; Himalaya | Rt | Otorrhoea, opthalmia, hair growth, eye diseases, toothache | Boils (Furuncle), Throat infection, Mouth Ulcers, Dysentry with blood, Burnt_cure |
| *Girardinia diversifolia* (Link) Friis | Urticaceae | Kandeli-marsu, Dholan-kandeli | Herb | upto 2600 | Rt, Lv | Spermatorrhoea, gonorrhoea, hypertension, asthma, bronchitis, allergy | Boils (Furuncle) |
| *Hedychium spicatum* Ham. ex Sm. | Zingiberaceae | Bagldu, Ban-haldi, Kachor | Herb | 900-2000; Himalaya | Rh, Sd | Check vomiting, gastric troubles, blood purifier, eye diseases, bronhitis, asthma, abortifacient, tuberculosis, boils, throat troubles | Stomachache, Anti-helminthic, blunt trauma |
| *Hippophae salicifolia* D.Don | Elaeagnaceae | Bodyarl Chuk (J); Chuk, Amil | Shrub | 2000-3600; Himalaya | Fr, Fl, Bk | Cough, dandruff, cuts, ulcer, wounds | Consciousness |
| *Holoptelea integrifolia* (Roxb.) Planch. | Ulmaceae | Kanju-papri | Tree | upto 1000 | Bk | Leucoderma, scabies, skin diseases, rheumatism | Swelling_cure, skin diseases, Itching |
| ***Juglans regia* L.** | Juglandaceae | Akhrot | Tree | 800-2500 | Bk, Lv, Fr | Herpes, rheumatism, eczema, astringent, syphilis, tooth diseases, hair fall, scrofula, tonic, pyrorrhoea, toe sore, bone fracture, anthelmintic,, neurological disorders | skin diseases, Dental, Bone Fracture |

| Scientific Name | Family | Local Name/s | Habit | Geographic range (in m asl) and Distribution | Part Used | Uses (Literature review) | Diseases cured (present study) |
|---|---|---|---|---|---|---|---|
| *Lyonia ovalifolia* (Wall.) Drude | Iricaceae | Anyar, Aiyaar | Tree | 1000-3000 | Lv, Sd | Scabies, itching, skin diseases, wounds, boils, inflammation of eyes and face | skin diseases, |
| *Mallotus philippensis* Muell.-Arg. | Euphorbiaceae | Rohni, Sindur, | Tree | upto 1800; Tropical Asia and Australia | Fr, Sd, Rt | Anthelmintic, blisters, rheumatism, boils, dysentery, skin diseases, snake-bite, tonic for pregnant women, ulcer, vermifuge, constipation | Stomachache |
| *Megacarpaea polyandra* Benth. | Brassicaceae | Burmol; Moll (G); Rooki | Herb | 3500-4000 | Rt, Lv | Fever, stomachache, dysentery, intestinal injury, dyspepsia | Jaundice, Urogenital Disorders, coolant, fever |
| *Melia azedarach* L. | Meliaceae | Dainkan, Bakain Mahanimba | Tree | upto 1400 | Sd, Lv, Fl, Fr, Bk | Impotency, leprosy, boils, anthelmintic, diuretic, antiseptic, rheumatism, skin diseases, headache, alexiphramic, antilithic, abortifacient, scrofula, cuts, wounds | skin diseases, Itching |
| *Mentha arvensis* L. | Lamiaceae | Paudina | Herb | upto 2500 | Lv | Vomiting, indigestion | coolant, Dysentry, Vomiting_stop |
| *Micromeria biflora* (Buch.-Ham. ex D. Don) Benth. | Lamiaceae | Garur-buti, Jagan | Herb | upto 2000 | Wp, Lv | Ecezema, cold, gastroenteritis | Anti-helminthic |
| *Mukia maderaspatana* (L.) M.Roem. | Cucurbitaceae | Gulya, Ban-kakhri | Climber | upto 1000 | Fr, SD | Malarial fever, urinal disorders, vomiting | Boils (Furuncle) |
| *Murraya koenigii* (L.) Spreng. | Rutaceae | Gandela, Gani Krishnapatra | Shrub | upto 1500 | Lv, Rt, Bk | vomiting, cutaneous diseases, skin diseases, hyperdipsia, leucoderma, burning sensation, pruritus, hair tonic, leprosy, tonic, stomachache, stimulant, helminthasis, dyspepsia, scorpion sting, snake-bite | Urogenital Disorders (Nocturnal emmission) |
| *Origanum vulgare* L. | Lamiaceae | Ban Tulsi (G) | Herb | 1000-4000 | Lv, St, Wp | Whooping cough, bronchitis, influenza, fever, cold, toothache, earache, diarrhoea, colic, stimulant, tonic, menstrual complaints, rheumatism, hysteria, epilepsy | Anti-helminthic, Bone Fracture, Vomiting_stop, fever, Snake-bite, Dysentry, Cold, Cough |

| *Scientific Name* | *Family* | Local Name/s | Habit | Geographic range (in m asl) and Distribution | Part Used | Uses (Literature review) | Diseases cured (present study) |
|---|---|---|---|---|---|---|---|
| *Oxalis corniculata* (DC.) Raeusch | Oxalidaceae | Bhilmori Amlalonika | Herb | upto 1800 | Lt, Wp | cuts, wounds, swelling, insect bite, snake-bite, appetite, corns, dysentery, fever, jaundice, rickets, scurvey, stomachache, wart, diarrhoea, chest complaints, skin disease, cataract, conjunctivitis, tonic, gastrointestinal troubles | coolant, fever, Earache, Constipation |
| *Paeonia emodi* Wall. ex Royle | Paeoniaceae | Chandraya (G), Udsalap (H) | Herb | 1800-3600 | Rt, Fl, Rh. | Whooping cough, diarrhoea, dysentery, intestinal spasm, apetite, urinary diseases, cuts, ulcers, controlls maggots on animals | Fever |
| *Parnassia nubicola* Hook.f. | Celastraceae | Nir Bishi (G, J) | Herb | 3000-4000 | Rt | Snake-bite, antipoinsounous, wounds, boils, eye diseases, vomiting | Wounds, Boils (Furuncle), sprain/cramp |
| *Phyllanthus embelica* L. | Euphorbiaceae | Anwala Ambiki | Tree | upto 2000; Tropical Asia | Fr, Lv, Bk | bronchitis, asthma, cooling, burns, constipation, headache, stomach ache, dorpsy, madness, liver problems, diabetes, revive taste, dysentery. | Dandruff |
| *Phytolacca acinosa* Roxb. | Phytolaccaceae | Jagra, Jagrya | Herb | upto 2400 | Lv | Bodyache | Constipation |
| ***Picrorhiza kurrooa* Benth.** | Scrophulariaceae | Kutki, Karui (G,K) | Herb | 1500-3000 Himalaya | Rt, Rh | Fever, head ache, indigestion, abdominal pain, blood purifier, used to extract *Picrorhizin.* | Headache, Stomachache, Gastric problem, fever, Anti-helminthic, Cold, Constipation, Cough, |
| *Pinus roxburghii* Sargent | Pinaceae | Chir, Sarala | Tree* | 900-2500 | Re, Bk, Lv | Bronchial asthma, swelling, Bone fracture, sprain, urine trouble, boils, eye swelling, cuts, wounds, internal injury, heel crack, rheumatism, gonorrhoea, stimulant, stomachic, snake-bite, scorpion sting. Colic, joint pain | Scorpion-bite, Bone Fracture, blunt trauma |
| *Pinus wallichiana* A.B.Jacks. | Pinaceae | Kail, Chilla, Chir, Dhurasala | Tree* | 2000-3200 | Re, Bk | Bone fracture, headache, waist pain, internal injury, heel crack, skin diseases, pimple, ulcers, rheumatism, gonorrhoea, unconsciousness | Bone Fracture |

| ***Scientific Name*** | **Family** | **Local Name/s** | **Habit** | **Geographic range (in m asl) and Distribution** | **Part Used** | **Uses (Literature review)** | **Diseases cured (present study)** |
|---|---|---|---|---|---|---|---|
| *Plantago major* L. | Plantaginaceae | Lahuriya (G) | Herb | 1500-3000 | Sd, Lv | Liver tonic, dysentary, intestinal injury, cuts, wounds, skin diseases, burns, abortion, fever, gastric | Bone Fracture, Snake-bite, Spider-bite, Antihemorrhagic, Earache, Constipation |
| *Polygonatum cirrhifolium* (Wall.) Royle | Liliaceae | Khakan, Medha, Mahamedha Maida | Herb | 1600-3600; Himalaya, Boreal Asia | Rt, | Blood purifier, cuts and wounds, aphrodisiac | Urogenital Disorders |
| *Potentilla fulgens* Wall. ex Hook.f. | Rosaceae | Bajradanti | Herb | 2700-4300 | Lv, Rt | Dysentary, toothache, burns, wounds, stomach disorder, aphthae, urinary disorders, tiger bite | Dental, Stomachache |
| *Prinsipia utilis* Royle | Rosaceae | Bhainkal | Shrub | 1500-2500 | Sd, Oil, Rt, Fr | Stomach trouble, diarrhoea, burns, rheumatism, cuts, wounds, bodyache, skin diseases, giddiness | Eye diesease |
| *Prunus persica* (L.) Stokes | Rosaceae | Aaru, Aruka | Tree | upto 2400 | Sd, Fl, St, Lv, Bk, Fr | Eczema, tooth diseases, wounds, antiseptic, headache, scabies, cough, cold, urinary troubles, diuretic, purgative, stomachic, demulcent, antiscorbutic, ascaricide, antihelminthic | Dental |
| *Prunus cerasoides* Buch.-Ham. ex D. Don | Rosaceae | Panyyan Padmaka | Tree | upto 2400 | Bk | Wounds, cuts, burns, cough, fever, diarrhoes, body swelling, muscular pain, injury | Alopecia areata , Bone Fracture |
| *Prunus armeniaca* L. | Rosaceae | Chullu, Khurmani, Cuaru | Tree | upto 2500 | Sd, Fr | Rheumatic pain, fever, bodyache, laxative | Health tonic, coolant, Achne, Burnt_cure |
| *Prunella vulgaris* L. | Lamiaceae | Phulari (G) | Herb | 2000-4000 | Wp | Gastric and breathing troubles, rheumatism, paralysis, cerebral tonic | Urogenital Disorders |
| ***Quercus leucotrichophora* A. Camus** | Fagaceae | Banj | Tree | 800-2400 | Bk, Sd, Lv, Gu | Bronchial asthma, stomachache, snake-bite, urinary trouble, scabies, skin diseases, digestive disorders, gonorrhoea, diuretic, astringent, diarrhoea, fever, dyspepsia | Scorpion-bite, Gastric problem, Constipation, fever, Cough |
| *Reinwardtia indica* Dumort. | Linaceae | Pyoli, Basant | Herb | upto 2400 | Wp, St, Lv | Wounds, paralysis, infection | Antihemorrhagic, Wounds |
| ***Rheum australe* Don** | Polygonaceae | Dolu (J); Archa (G) | Herb | 2700-4000; Himalaya | Rt, Lv | Roots and rhizome purgative, tooth powder, dysentery, fever, internal injury, bone fracture, indigestion, general debility, purgative, astringent | Boils (Furuncle), headache, blunt trauma |

| ***Scientific Name*** | ***Family*** | **Local Name/s** | **Habit** | **Geographic range (in m asl) and Distribution** | **Part Used** | **Uses (Literature review)** | **Diseases cured (present study)** |
|---|---|---|---|---|---|---|---|
| *Rhododendron arboreum* Sm. | Ericaceae | Burans (G), Kurvak | Tree | 1100-2200 | Lv, Fl, Bk | Dysentery, fever, headache, rheumatism, wounds, indigestion, mental retardation, respiratory diseases | Piles_with blood |
| *Rhododendron campanulatum* Don | Ericaceae | Ratpa (J), Simru (G) | Shrub | 3000-4300 | Lv, Fl, Rt | Boils, cough, cold, headache, rheumatism, sciatica, wounds, skin diseases, syphilis, tonic, digestive disorders, chronic fever | Cough, Asthama |
| *Rhus punjabensis* J.L. Stewart ex Brandis | Anacardiaceae | Almor | Tree | 1500-2100 | Lv | Reported as medicinal plant | Consciousness |
| *Rubus niveus* Thunb. | Rosaceae | Kala-hisalu (G), Katharhawale, Kalahisar | Shrub | 1000-2500 | Lv, Fr, Rt | Fever, dismenorrhoea, snake-bite, stomachache, astringent | Throat infection, coolant |
| *Rumex nepalensis* Sprengel | Polygonaceae | Khatura, Amlya, Pahari Palak (H) | Herb | 1200-4300 | Lv, Rt | Insect bit, urinary, renal, colic, stomach trouble, purgative, boils, cooling, diuretic, scurvy, swelling, dysmenorrhoea, burns, intestinal disorders, venereal diseases, tonic | Itching, Wounds, headache, Boils (Furuncle), Anticeptic, skin diseases |
| *Saussurea costus* (Falc.) Lipsch. | Asteraceae | Kut, Kusttah, Agada, Amaya, Apya | Herb | 3000-4000 | Lv, Rt | Jaundice, tooth ache, gastric pain, stomachache, fever, asthma, dysentry, rheumatism, skin diseases, bronchitis, cough | Fever, Rheumatism |
| *Saussurea gossypiphora* D.Don | Asteraceae | Phen Kamal (G) | Herb | 3500-4800 | Wp | Reported as medicinal plant | Menorrhagia, Antihemorrhagic, Wounds, leucorrhoea |
| *Saussurea obvallata* (DC) Edgew. | Asteraceae | Kaul Kaphoo, Brahma Kamal (G, K) | Herb | 4000-5600 | Lv, Rt, Fl | leucoderma, cuts, bruises, urinary trouble, boils, bone fracture, wounds, cough, cold, hydrocele, reproductive disorders, digestive disorders | Gastric problem, lactogenic, Rheumatism, Urogenital Disorders |
| ***Senecio nudicaulis*** **Buch.-Ham. ex D.Don** | Asteraceae | Neel-Kanthi | Herb | upto 1500 | Lv, Rt | Sores, skin diseases, colic, fever | Throat infection, Urogenital Disorders, leucorrhoea, Piles_with blood, coolant, Boils (Furuncle), fever, Burnt_cure, Rheumatism |

| Scientific Name | Family | Local Name/s | Habit | Geographic range (in m asl) and Distribution | Part Used | Uses (Literature review) | Diseases cured (present study) |
|---|---|---|---|---|---|---|---|
| *Solanum anguivi* Lam. = *S. indicum* L. | Solanaceae | Kantkari, Banbhatta, Katang Akhranta, Vrihati | Herb | upto 1500 | Fr, Lv | Jaundice, Cough, asthma, fever, colic, skin diseases | Abortifacient |
| *Solanum americanum* Mill. = *S. nigrum* L. | Solanaceae | | Herb | | | | Jaundice, Boils (Furuncle), |
| *Stephania glabra* (Roxb.) Miers | Menispermaceae | Gindaru, Ganjaroo, Gadanjaad Raj-pattha | Climber | upto 2200 | Lv, Rt, | Colic pain, fever, dysentry, headache, bodyache, eye trouble, pulmonary tuberculosis, asthma | Snake-bite |
| *Swertia chirayita* (Roxb. ex Fleming) Karsten | Gentianaceae | Chiraita, Kirat | Herb | 1200-3500; Himalaya | Wp | febrifuge, stimulant, blood purifier, cooling | Pneumonia, Typhoid, fever, Cough |
| *Symplocos paniculata* Miq. | Symplocaceae | Lodh Lodhra | Tree | | Bk | Astringent, diarrhoea, check abortion | Alopecia areata |
| *Cinnamomum tamala* Nees | Lauraceae | Tejpatta, Dalchini | Tree | upto 2000; Himalaya | Bk | Dispepsia, throat irritation, heart trouble | Headache, fever |
| *Taxus wallichiana* Zucco | Taxaceae | Thuner (G); Lwait (J) | Tree* | 2400-3800 Temperate Boreal Region | Lv, Bk | Tumors, Cancer, bark is used for preparation of tea of medicinal value. | Cold, Swelling cure, Cough |
| *Thalictrum foliolosum*DC | Ranunculaceae | Mimiri | Herb | 1200-2500 Himalaya | Rt | Diuretic, purgative, used in opthalmia, colic and fever | Wounds, Eye disease |
| *Tinospora cordifolia* Merr. | Menispermaceae | Giloy (G), Athervel | Climber | upto 1000 Oriental India | St, Lv, Wp | Diphtheria, dysentery, fever, aphrodisiac, asthma, antipyretic, headache, cough, bone fracture, jaundice, malaria, pulmonary tuberculosis, bronchitis, skin diseases, tonic. | Piles with blood, Uro-genital Disorders |
| *Ulmus wallichiana* Planchon | Ulmaceae | Chamarmora Hemar, Kitmara | Tree | 1000-1800 | Bk | Bone fracture | Bone Fracture, |
| *Urtica parviflora* Roxb. | Urticaceae | Kandali, Kandiya, Kandari, Sisun, Suin | Herb | | Sd, Lv, Inf, Rt, Wp | Dysmenorrhoea, sprains, fever, rheumatism, dog bite, wounds, kidney disorders, post natal tonic, throat pain, tonic, astringent, skin diseases, hair tonic, bone fracture, jaundice, haematuria, nephritis, joint pain | Headache, Menstrual Disorder, Earache, appendix problem, Dental |

| Scientific Name | Family | Local Name/s | Habit | Geographic range (in m asl) and Distribution | Part Used | Uses (Literature review) | Diseases cured (present study) |
|---|---|---|---|---|---|---|---|
| *Valeriana jatamansii* Jones | Valerianaceae | Samewa (G, K), Mushkabala | Herb | 2000-3000; Himalaya | Rt, Lv, | Mental disorders, hysteria, urinary complaints, epilepsy, aphrodisiac, insecticide, incense | Anti-helminthic, |
| ***Verbascum thapsus* L.** | Scrophulariaceae | Gidar-tamaku, Akulabir, bantaial, Jakhmvir | Herb | upto 2500 | Sd, Lv, Inf, Rt, Wp | Bronchial asthma, cold, conjuctivitis, snake-bite, skin disease, cough | Fever, Eye disease, Boils (Furuncle) |
| ***Viola pilosa* Blume = *V. serpens* Wall.** | Violaceae | Kauru, Vanfsa | Herb | upto 1500 | Lv, Rt, Fl | Antipyretic, biliousness, cold, cough, fever, diaphoretic, lung diseases, purgative, headache, jaundice, malaria, emetic, throat cancer | Itching, Antihemorrhagic, Wounds, Boils (Furuncle), fever, Cold, Cough, coolant |
| *Withania somnifera* (L.) Dunal | Solanaceae | Asgandh, Aswagandha | Herb | upto 1200 | Lv, Rt, Sd | Leucoderma, scrofula, insomnia, fever, urinary disorders, chest complaints, cold, rheumatism, dropsy | Rheumatism, Constipation |
| ***Zanthoxylum armatum* DC** | Rutaceae | Timroo, Timur Andhaka, Tumbak | Shrub | 1000-2000; Himalaya China | Fr, St, Bk, Sd | Stomach ache, piles, fever, cholera, cough, itching, eczema, snake-bite, tonic, small-pox, indigestion. | Gastric problem, Constipation, Dental, antacid, Antiseptic |
| *Zizyphus mauritiana* Lam. | Rhamnaceae | Ber, Ajapriya, Badra | Tree | | Lv, Fr, Rt, St, Bk | Throat infection, dysentry, headache, indigestion, rheumatism, cough, cold, wounds, eye diseases, diarrohea, cholera, colic, blood purifier, sores, spleen ulcer, fever, stomachache | Boils (Furuncle) |

Wp=Whole plant; Rt=Root; St=Stem; Fl=Flower; Lv=Leaves; Bk=Bark; Fr=Fruit; Lt=Latex; Sd=Seed; Rh=Rhizome, St=stem, Gu=Gum, Re=resin, Inf=Inflorescence.
Note: Species mention in **bold** have been considered as high use valued EMPs for present study

# Annexure III

## Use values and current trend of usage of ethnomedicinal plants of Uttarkashi district

| Scientific Name | Practice | Information | UV-LAZ | UV-MAZ | UV-HAZ |
|---|---|---|---|---|---|
| *Acorus calamus* L. | - | + | - | | 5.010 |
| *Aconitum atrox* (Bruhl.) Mukhetjee = *A. ferox* Wall. ex Ser. = *A. balfourii* Stapf | - | + | - | 5.020 | 9.109 |
| ***Aconitum heterophyllum* Wall.** | + | + | **7.182** | **8.667** | **11.933** |
| *Adhatoda vasica* Nees in Wallich | + | + | 3.136 | - | - |
| *Aesculus indica* (Wall. ex Camb.) Hook. | - | + | - | - | 3.016 |
| *Ageratum adenophorum* syn. *Eupatorium adenophorum* Sprengel | + | + | 3.045 | 3.059 | - |
| *Ajuga bracteosa* Wallich ex Benth. | - | + | 3.045 | 4.039 | 8.031 |
| *Anemone rivularis* Buch-Ham ex DC. | - | + | - | - | 7.047 |
| *Angelica glauca* Edgew. | + | + | 6.182 | 6.157 | 9.130 |
| *Arnebia benthamii* (Don) Johnston | + | + | 5.091 | - | 5.047 |
| *Arisaema jacquemontii* BI. | - | + | - | - | 5.036 |
| *Artemisia roxburghiana Bess.* | + | + | 4.273 | 3.020 | 4.041 |
| *Asparagus filicinus*Buch.-Ham. ex D.Don | + | + | 6.045 | 3.020 | - |
| *Astragalus candolleanus* Royle ex Benth. | + | - | - | - | 6.005 |
| *Azadirachta indica* A. Juss. | - | + | 4.045 | - | - |
| ***Berberis aristata* DC** | + | + | 5.455 | **7.529** | 6.326 |
| *Bergenia ciliata* (Hook. f. & Th.) Engler | + | + | 6.136 | 5.059 | 7.062 |
| *Bergenia stracheyi* (Hook.f. & Th.) Engler | + | + | - | - | 10.062 |
| *Betula utilis* D.Don | - | + | - | - | 4.052 |
| *Cannabis sativa* L. | - | + | - | 3.020 | 5.005 |
| *Carissa spinarum* L. = *C. opaca* Stapf ex Haines | - | + | 7.091 | - | - |
| *Cedrus deodara* (Roxb. ex D.Don) G.Don | - | + | - | 3.059 | 9.073 |
| *Celtis australis* L. | + | + | 3.136 | - | - |
| *Centella asiatica* (L.) Urban | + | + | 5.182 | 5.039 | 3.005 |
| *Cirsium wallichii* DC. | - | + | - | 5.020 | 6.021 |
| *Clinopodium umbrosum* (M. Bieb.) C. Koch | - | + | - | 3.020 | - |
| *Cynodon dactylon* (L.) Pers. | - | + | 3.091 | - | - |
| *Cynoglossum viride* Eastw. = *C. occidentale* A.Gray | - | + | 6.091 | 5.039 | - |
| ***Dacrylorhiza hatagirea* (Don) Soo** | + | + | 5.136 | **8.431** | 8.648 |
| *Datura metel*L. | + | + | - | 6.039 | 5.005 |
| *Debregeasia salicifolia* (D.Don) Rendle | + | + | 6.227 | - | - |
| *Dicliptera bupleuroides* Nees | - | + | 3.045 | - | - |
| *Elatostema monandrum* (Buch.-Ham. ex D.Don) H.Hara | - | + | - | - | 3.005 |
| *Equisetum arvense* L. | + | + | 3.091 | - | - |
| *Euphorbia pilosa* L. | - | + | - | - | 5.005 |

Annexure III

| Scientific Name | Practice | Information | UV-LAZ | UV-MAZ | UV-HAZ |
|---|---|---|---|---|---|
| *Fagopyrum esculentum*(L.) Moench | - | + | - | - | 3.016 |
| *Ferula jaeschkeana* Vat. | - | + | - | - | 5.047 |
| *Ficus palmata* Forssk. | - | + | - | - | 3.036 |
| *Galium rotundifolium* L. | - | + | - | - | 7.036 |
| *Geranium nepalense* Sweet | + | + | - | 3.059 | 10.067 |
| ***Geranium wallichianum*D.Don ex Sweet** | + | + | - | 6.059 | **11.078** |
| *Girardinia diversifolia* (Link) Friis | - | + | - | - | 6.016 |
| *Hedychium spicatum* Ham. ex Sm. | + | + | 6.091 | 5.020 | - |
| *Hippophae salicifolia* D.Don | - | + | - | - | 3.021 |
| *Holoptelea integrifolia* (Roxb.) Planch. | - | + | 5.045 | - | - |
| ***Juglans regia* L.** | - | + | - | 4.059 | **11.041** |
| *Lyonia ovalifolia* (Wall.) Drude | + | - | - | 7.020 | - |
| *Mallotus philippensis* Muell.-Arg. | + | + | 3.136 | - | - |
| *Megacarpaea polyandra* Benth. | + | + | - | - | 9.036 |
| *Melia azedarach* L. | - | + | 4.045 | - | - |
| *Mentha arvensis* L. | + | + | 5.136 | 4.098 | 5.026 |
| *Micromeria biflora* (Buch.-Ham. ex D. Don) Benth. | - | + | 3.091 | - | - |
| *Mukia maderaspatana* (L.) M.Roem. | - | + | - | - | 5.005 |
| *Murraya koenigii* (L.) Spreng. | - | + | 3.045 | - | - |
| *Origanum vulgare* L. | + | + | 4.136 | 3.059 | 9.067 |
| *Oxalis corniculata* (DC.) Raeusch | + | + | 3.136 | 3.020 | 5.026 |
| *Paeonia emodi* Wall. ex Royle | - | + | - | - | 5.005 |
| *Parnassia nubicola* Hook.f. | + | + | 6.136 | 5.020 | 5.041 |
| *Phyllanthus embelica* L. | - | + | 3.091 | - | - |
| *Phytolacca acinosa* Roxb. | - | + | - | - | 3.005 |
| ***Picrorhiza kurrooa* Benth.** | + | + | 6.364 | **10.627** | **11.860** |
| *Pinus roxburghii* Sargent | + | + | 6.136 | - | - |
| *Pinus wallichiana* A.B.Jacks. | - | + | - | - | 3.021 |
| *Plantago major* L. | + | + | - | 3.020 | 7.031 |
| *Polygonatum cirrhifolium* (Wall.) Royle | + | - | - | - | 5.005 |
| *Potentilla fulgens* Wall. ex Hook.f. | + | + | - | 5.020 | 6.005 |
| *Prinsipia utilis* Royle | - | + | 3.045 | - | 3.010 |
| *Prunus persica* (L.) Stokes | - | + | - | - | 4.016 |
| *Prunus cerasoides* Buch.-Ham. ex D. Don | - | + | 4.091 | - | 3.005 |
| *Prunus armeniaca* L. | - | + | - | - | 6.083 |
| *Prunella vulgaris* L. | - | + | - | - | 5.005 |
| ***Quercus leucotrichophora* A. Camus** | + | + | **7.136** | - | 4.005 |
| *Reinwardtia indica* Dumort. | - | + | - | 4.039 | - |
| ***Rheum australe* Don** | + | + | **7.364** | 5.373 | 7.503 |

**Annexure III**

| **Scientific Name** | **Practice** | **Information** | **UV-LAZ** | **UV-MAZ** | **UV-HAZ** |
|---|---|---|---|---|---|
| *Rhododendron arboreum* Sm. | - | + | - | 3.020 | - |
| *Rhododendron campanulatum* Don | - | + | - | - | 4.036 |
| *Rhus punjabensis* J.L. Stewart ex Brandis | - | + | - | - | 3.005 |
| *Rubus niveus* Thunb. | - | + | - | 7.020 | - |
| *Rumex nepalensis* Sprengel | - | + | - | 7.039 | 9.088 |
| *Saussurea costus* (Falc.) Lipsch. | + | + | - | - | 6.010 |
| *Saussurea gossypiphora* D.Don | - | + | 4.045 | - | 10.031 |
| *Arctium lappa* L. | - | + | - | - | 5.031 |
| *Saussurea obvallata* (DC) Edgew. | - | + | - | - | 8.057 |
| ***Senecio nudicaulis* Buch.-Ham. ex D.Don** | + | + | 4.182 | **13.157** | 6.005 |
| *Solanum anguivi* Lam. = *S. indicum* L. | + | + | 5.091 | - | 5.005 |
| *Solanum americanum* Mill. = *S. nigrum* L. | - | + | 7.045 | - | 3.016 |
| *Stephania glabra* (Roxb.) Miers | - | + | - | 5.020 | - |
| *Swertia chirayita* (Roxb. ex Fleming) Karsten | + | + | 4.091 | 5.059 | 3.010 |
| *Symplocos paniculata* Miq. | - | + | - | - | 3.005 |
| *Cinnamomum tamala* Nees | + | - | - | 4.020 | - |
| *Taxus wallichiana* Zucco | - | + | 3.045 | - | 5.062 |
| *Thalictrum foliolosum*DC | + | + | - | 6.039 | - |
| *Tinospora cordifolia* Merr. | - | + | 5.091 | - | - |
| *Ulmus wallichiana* Planchon | - | + | 3.045 | - | 4.005 |
| *Urtica parviflora* Roxb. | + | + | - | 7.039 | 6.026 |
| *Valeriana jatamansii* Jones | + | - | - | - | 3.005 |
| ***Verbascum thapsus* L.** | + | + | **8.136** | 6.039 | 5.016 |
| ***Viola pilosa* Blume = *V. serpens* Wall.** | + | + | 6.273 | 7.098 | **11.016** |
| *Withania somnifera* (L.) Dunal | + | - | - | 6.020 | - |
| ***Zanthoxylum armatum* DC** | + | + | **13.409** | 7.235 | 4.010 |
| *Zizyphus mauritiana* Lam. | - | + | 3.045 | - | - |

Note: Species mention in **bold** have been considered as high use valued EMPs for present study

**_Annexure IV: Potential areas of Uttarkashi district (blocks and compartments of three forest divisions) that harbours EMPs._**

| Forest Division | Range | Beat | Block | Comp | Ah | Ba | Dh | Gw | Jr | Pk | Ql | Ra | Sn | Vt | Vp | Za | GPS locations of transects | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | N | E |
| Upper Yamuna | Yamunotri | Durvil | Bhairab | 1 | + | + | + | + | | | | | | | | | St | 30.95006 | 78.38256 |
| | | | | | | | | | | | | | | | | | En | 30.94408 | 78.38742 |
| | | | | | | | | | | | | | | | | | St | 30.95150 | 78.36539 |
| | | | | | | | | | | | | | | | | | En | 30.95144 | 78.37217 |
| Uttarkashi | Badahat | Dodital-I | Dodital | 4b | + | | + | + | | + | | | | | | | St | 30.90047 | 78.53003 |
| | | | | | | | | | | | | | | | | | En | 30.90964 | 78.53572 |
| Uttarkashi | Badahat | Seku-I | Dodital | 1a | | | | | | | + | | | | + | | St | 30.83336 | 78.45675 |
| | | | | | | | | | | | | | | | | | En | 30.84989 | 78.47086 |
| Uttarkashi | Gangotri | Bagori | Harsil | 10b | + | | | | | + | | | | | | | St | 31.08964 | 78.66900 |
| | | | | | | | | | | | | | | | | | En | 31.08911 | 78.66814 |
| Uttarkashi | Gangotri | Jaspur | Harsil | 7b | | | + | + | | | | + | | + | | | St | 31.07781 | 78.73419 |
| | | | | | | | | | | | | | | | | | En | 31.08364 | 78.72817 |
| Tons | Kotigard | Kaleech | Kaleech | 5 | | | | | | | + | | | + | | | St | 31.02322 | 77.82075 |
| | | | | | | | | | | | | | | | | | En | 31.02417 | 77.82578 |
| | | | | 8 | | | | + | + | | | | | | + | | single transect laid in compartments 5 and 8 | | |
| Tons | Sandra | Salla | Kanda | 1 | | | | | + | | | | | | | | St | 31.03817 | 77.96436 |
| | | | | | | | | | | | | | | | | | En | 31.02917 | 77.96447 |
| | | | | 2 | | | | + | | | + | | | | | | single transect laid in compartments 1 and 2 | | |
| Uttarkashi | Badahat | Kawan | Kawan | 2 | | + | | | | | + | | | | + | | St | 30.79686 | 78.38028 |
| | | | | | | | | | | | | | | | | | En | 30.78961 | 78.38228 |
| | | | | 3b | | | | | | | | | + | | | + | single transect laid in compartments 2 and 3b | | |

| Forest Division | Range | Beat | Block | Comp | Ah | Ba | Dh | Gw | Jr | Pk | Ql | Ra | Sn | Vt | Vp | Za | GPS locations of transects | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | N | E |
| Uttarkashi | Dharasu | Khur-mola | Khur-mola | 4 | | | | | | | | | + | + | | | St | 30.75075 | 78.26611 |
| | | | | | | | | | | | | | | | | | En | 30.74631 | 78.27228 |
| | | | | 6b | | + | | | + | | + | | | | + | | St | 30.76697 | 78.24181 |
| | | | | | | | | | | | | | | | | | En | 30.76331 | 78.23431 |
| Uttarkashi | Taknaur | Pilang-I | Pilang | 1e | | | | | | | + | | | | | | St | 30.75792 | 78.65628 |
| | | | | | | | | | | | | | | | | | En | 30.75886 | 78.64742 |
| | | Pilang-I | Pilang | 2d | + | | + | | | | | | | | | | St | 30.71632 | 78.66512 |
| | | | | | | | | | | | | | | | | | En | 30.72450 | 78.64533 |
| | | Pilang-II | Pilang | 1c | | | | + | + | | | | | | | | St | 30.74311 | 78.63025 |
| | | | | | | | | | | | | | | | | | En | 30.75644 | 78.63100 |
| Upper Yamuna | Yamunotri | Rana | Rana | 1c | | | | | | | + | | | | | | St | 30.91647 | 78.37036 |
| | | | | | | | | | | | | | | | | | En | 30.91147 | 78.36961 |
| | | | | 2a | | | | + | | | | | | | | | St | 30.90950 | 78.41381 |
| | | | | | | | | | | | | | | | | | En | 30.90303 | 78.41567 |
| | | | | 4b | | + | | | | | | | | | | | single transect laid in compartments 2a and 4b | | |
| | | | | 5a | | | + | | | | | | | | | | St | 30.89011 | 78.42267 |
| | | | | | | | | | | | | | | | | | En | 30.88678 | 78.43256 |
| Uttarkashi | Gangotri | Songad | Suki | 3c | + | | + | + | | + | | + | | | | | St | 31.00169 | 78.67408 |
| | | | | | | | | | | | | | | | | | En | 31.10825 | 78.67353 |
| | | | | | | | | | | | | | | | | | St | 31.00689 | 78.66969 |
| | | | | | | | | | | | | | | | | | En | 30.99914 | 78.67461 |
| Upper Yamuna | Kuthnaur | Wazri | Wazri | 3 | | | | | | | + | | | | | | St | 30.91439 | 78.32353 |
| | | | | | | | | | | | | | | | | | En | 30.91342 | 78.32869 |
| | | | | 12 | | | + | + | | | | | | | | | St | 30.95150 | 78.36539 |
| | | | | | | | | | | | | | | | | | En | 30.95144 | 78.37217 |

| **Forest Division** | **Range** | **Beat** | **Block** | **Comp** | Ah | Ba | Dh | Gw | Jr | Pk | Ql | Ra | Sn | Vt | Vp | Za | GPS locations of transects | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | N | E |
| Upper Yamuna | Yamunotri | Yamunotri | Yamunotri | 8 | + | | + | + | | + | | | | | | | St | 31.00428 | 78.46853 |
| | | | | | | | | | | | | | | | | | En | 31.00972 | 78.46772 |
| | | | | | | | | | | | | | | | | | St | 31.00147 | 78.46881 |
| | | | | | | | | | | | | | | | | | En | 31.99883 | 78.46578 |

Ah = Aconitum heterophyllum; Ba = *Berberis aristata*; Dh = *Dactylorhiza hatagirea*; Gw = *Geranium wallichianum*; Jr = *Juglans regia*; Pk = *Picrorhiza kurrooa*; Ql = *Quercus leucotrichophora*; Ra = *Rheum australe*; Sn = *Senecio nudicaulis*; Vt = *Verbascum thapsus*; Vp = *Viola pilosa*; Za = *Zanthoxylum armatum*; St = Start point of transect; En = End point of transect; Comp = Compartment