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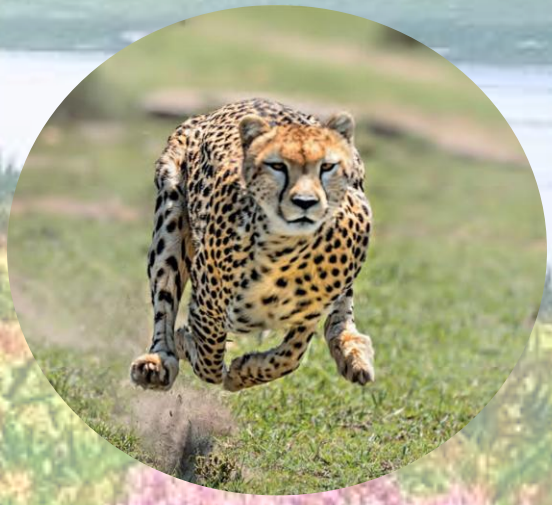
**State Name:** Jammu and Kashmir
**Common Name:** Common rhododendron
**Scientific Name:** *Rhododendron ponticum*

# ENVIS Bulletin
# Himalayan Ecology

## Vol. 30, 2022
## Special Issue on

- **Lifestyle for Environment**
- **Special Report on Reintroduction of Cheetah**
- **Himalayan Ecology and Environment**

**State Name:** Himachal Pradesh
**Common Name:** Pink rhododendron
**Scientific Name:** *Rhododendron campanulatum*



**Common Name:** Cheetah
**Scientific Name:** *Acinonyx Jubatus*

**State Name:** Uttarakhand
**Common Name:** Brahma Kamal
**Scientific Name:** *Saussurea obvallata*

**ENVIS CENTRE ON HIMALAYAN ECOLOGY**
**G.B. Pant National Institute of Himalayan Environment**
**(An Autonomous Institute of Ministry of Environment, Forest and Climate Change, Government of India) Kosi-Katarmal, Almora-263 643, Uttarakhand, India**

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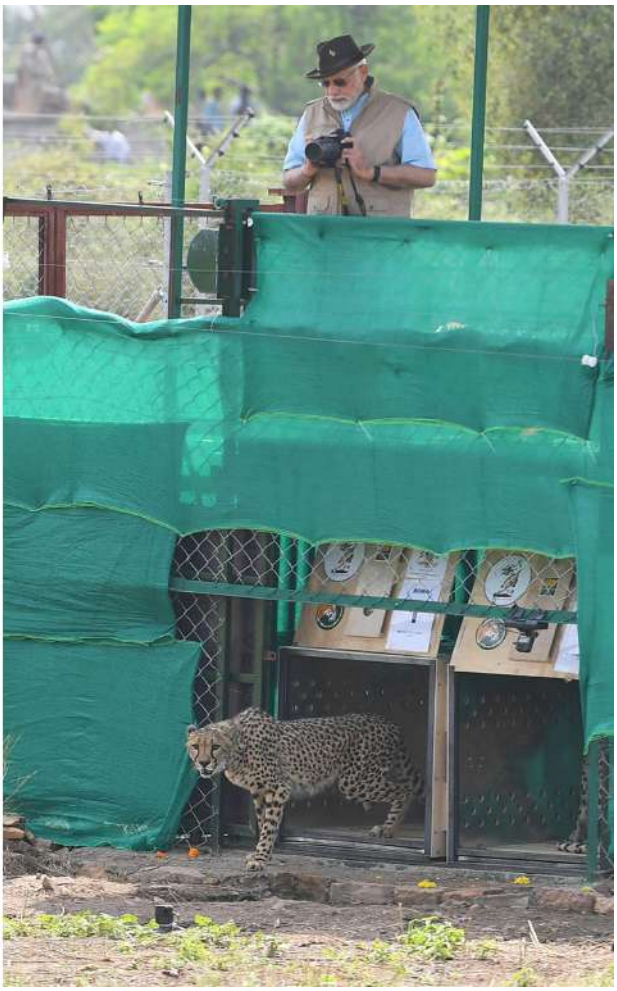
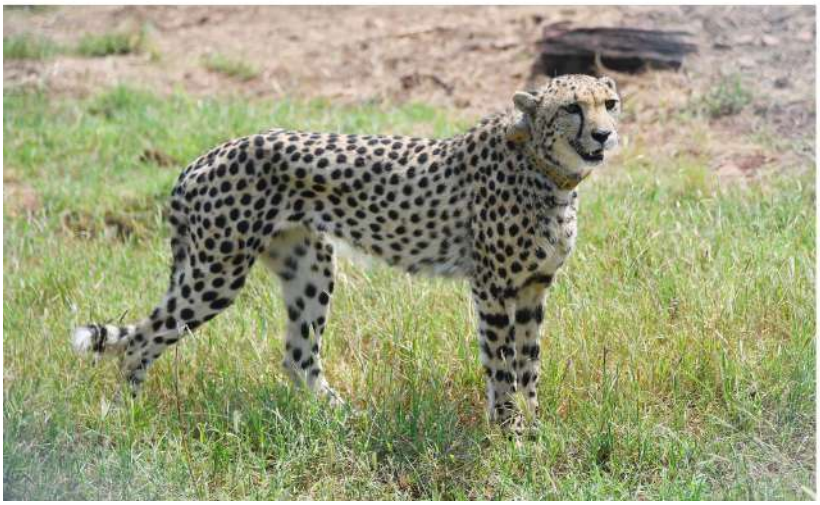
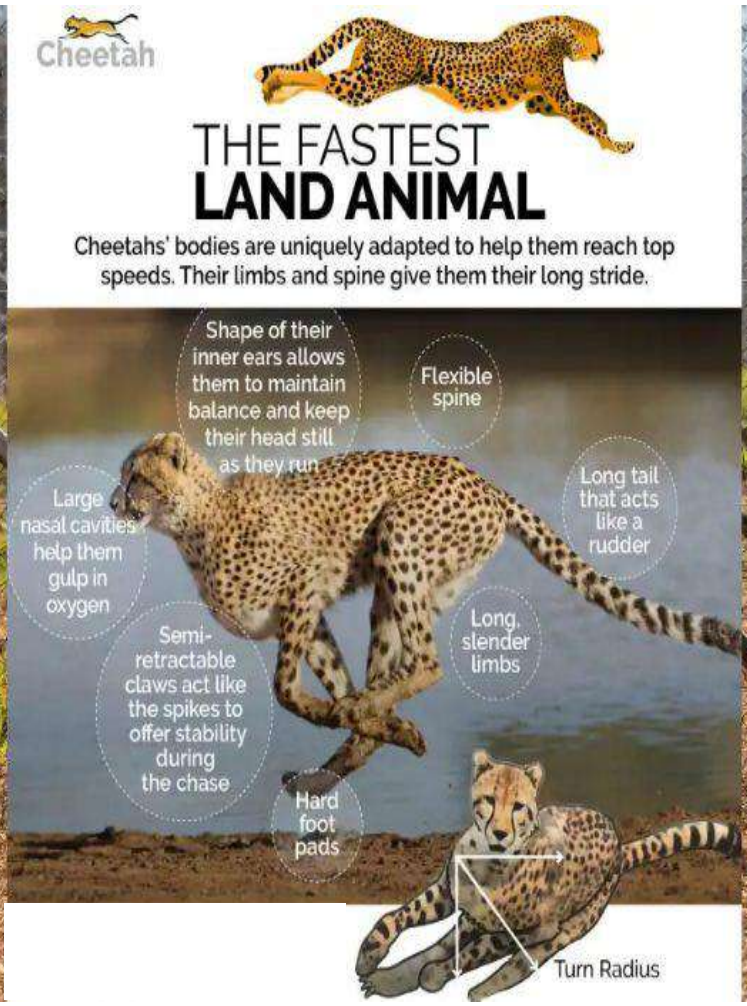







*Acknowledgment: Image PMO India and News18 Creative*

# From the Editor's Desk

A global initiative on "*Lifestyle for Environment*" was launched by the Prime Minister, Narendra Modiji on 5th June 2022. The idea was introduced during the 26th UN Climate Change Conference of Parties, COP-26 held in Glasgow in 2021. Mission LiFE (Lifestyle for Environment) was launched in India at the "Statue of Unity" in Gujarat in October 22. LiFE mission is a public movement to imbibe the spirit of "Pro Planet People" in the world. Prime Minister advocated for the basic principle of "Lifestyle of the planet, for the planet and by the planet". He also emphasized that reduce, reuse and recycle concept has been known and practiced by Indians from centuries.

It is a pleasure on the part of the ENVIS team to bring out the volume 30 of ENVIS Bulletin on Himalayan Ecology with an entire section dedicated to sustainable lifestyle and practices in the Indian Himalayan region (IHR). We received more than twenty articles on the theme "Lifestyle for Environment". Articles were received from almost all states of Indian Himalayan region covering Jammu, Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam and Arunachal Pradesh. The articles cover wide range of topics from conservation and domestication of valuable plants, to grain storage techniques. Sustainable traditional agricultural practices of Himachal Pradesh and Uttarakhand are also described. Traditional waste management, irrigation system, climate resilient lifestyle practiced across IHR are highlighted in the articles.

The ENVIS team was part of the great fanfare and publicity of reintroduction of Cheetahs back to India. The team has presented a special report on the same in section 2 of the Bulletin.

Section 3 of the Bulletin covers regular articles on Himalayan Ecology and Environment. Eight articles have been featured in this section. The topics covered are Bio-prospecting of economically and medicinally important plants and crops. The last three articles cover ecology and importance of hot springs of Arunachal Pradesh to spring flow study of Pauri Garhwal. Description of impact of riverine water quality of Tawi river of Jammu and Kashmir on agricultural practices brings to the end of this exceptionally long collection of short articles that showcase the lifestyle of IHR and inspires us to revisit our traditional lifestyle and save the planet for our future generation.

The cover and back page of Bulletin has been enriched by depicting the state flowers of Indian Himalayan region and reminding all to respect and conserve them.

Wishing all Season's Greetings on the festive season and enjoy the articles sitting in the soothing Autumn sun.

We have tried our best to bring out the Bulletin in the best possible manner in a very short period. Your valuable suggestions to improve the Bulletin are always welcome.

**Paromita Ghosh**
**ENVIS Coordinator & Executive Editor**

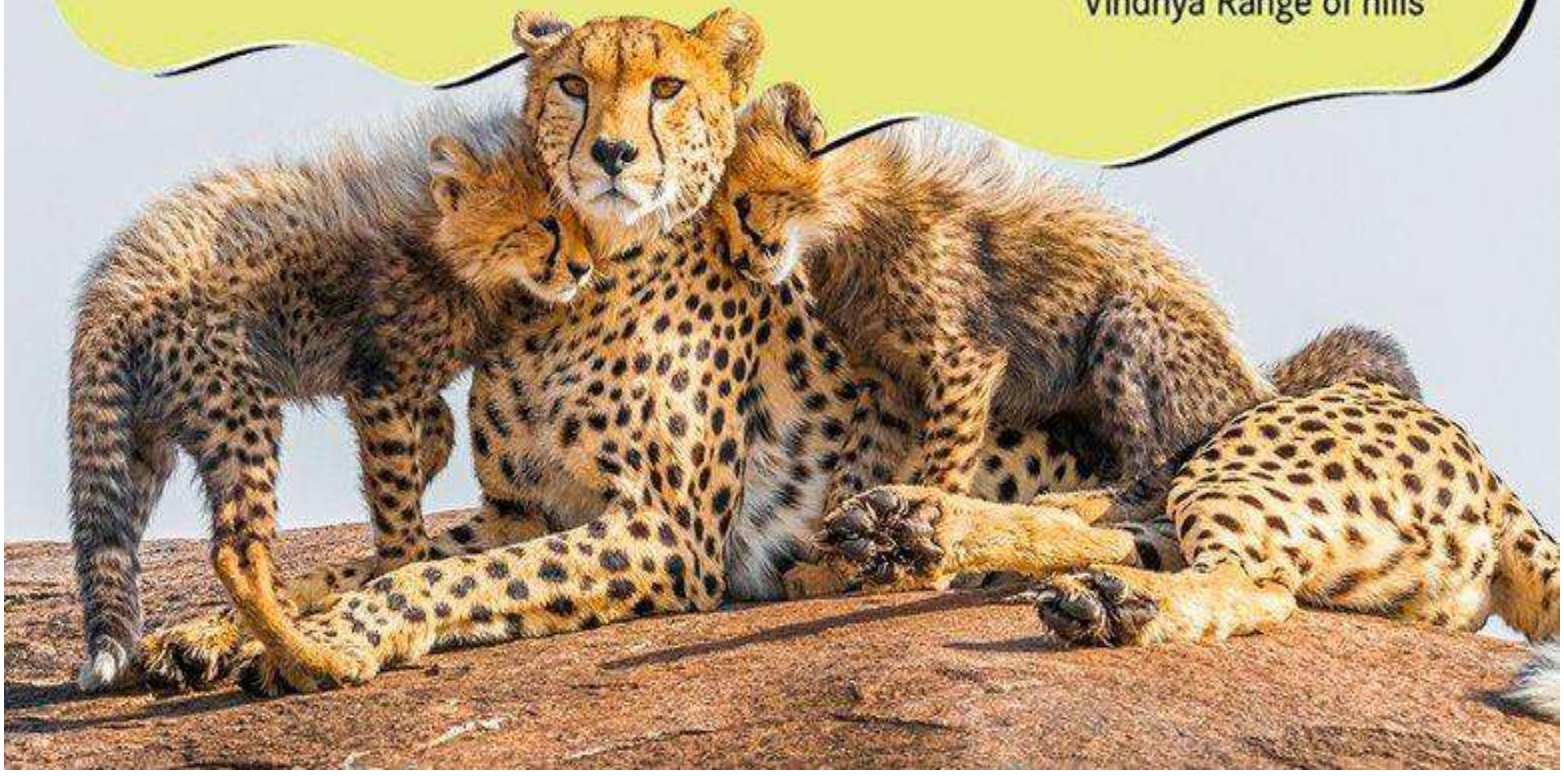
# THE HOMES FOR CHEETAH IN INDIA

Three potential wildlife sanctuaries that would support cheetah population


**Kuno-Palpur**
Area: 344.686km²
Part of Kathiawar-Gir dry deciduous forests

**Shahgarh**
Area: About 4,000km²
A fenced region close to India-Pakistan border

**Nauradehi**
Area: 1,197km²
Spreads over the southern area of Vindhya Range of hills



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# Section- I

# Lifestyle for Environment

# GERMPLASM CONSERVATION AND DOMESTICATION OF KALA ZEERA (*BUNIUM PERSICUM*) TOWARDS LIVELIHOOD SECURITY OF TRIBAL FARMERS OF GUREZ

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## RATIONALE

Gurez is one of the most important kala zeera growing areas in the UT of Jammu and Kashmir, which harbours various sub-populations within its forest pockets possessing significant genetic variability for this crop. This genetic variability has been observed in the form of land races that exist in higher reaches of Gurez valley. In the recent past continuous unscientific and ruthless exploitation of this crop by locals of these areas for immediate financial gains has led to low productivity and genetic erosion of this crop. The drastic reduction in area under the crop has further aggravated the situation. If this situation is not taken care of, the crop area may soon become drastically reduced which may, ultimately, lead to heavy economic losses. By far, the forest areas of Gurez contribute maximum to the zeera production of the UT and as such judicious domestication of this crop in this area for commercial cultivation is expected to contribute significantly. Further the efficient utilization of the genetic resources available in this crop species in Gurez for breeding through establishment of a Kala zeera germplasm bank can contribute in enhancement of its production and productivity in the area. SKUAST-Kashmir under NMHS funded project has been training local farmers regarding scientific cultivation of zeera on one hand and simultaneously working on selection of high yielding promising accessions, their multiplication and distribution to tribal community to boost zeera farming in Gurez. Efforts are also on way to restrict zeera adulteration, its branding as organic zeera, and establishment of farmers' cooperatives and e-marketing of zeera that will boost the zeera cultivation in Gurez, improve its marketing and provide more livelihood opportunities to tribal farmers of Gurez.

## SURVEY AND ESTABLISHMENT OF KALA ZEERA GERMPLASM ACCESSIONS

Extensive survey (Fig. 1) of Kala zeera growing areas (hills & terrains) viz., Nayal, Chorwan, Chuntiwari, Khandyal, Markoot, Dawar, Wanpora & Koragbal etc villages of Gurez valley was conducted during years 2019-20 and 2020-21 with the help of project staff and local collaborating partners viz., Department of Agriculture and Department of Forestry, Gurez. In total around 3500 kala zeera germplasm accessions were collected from different villages and terrains of Gurez valley during years 2019-20 and 2020-21, respectively. Out of which

around 930 accessions were established at Mountain Agriculture Research & Extension Station, SKUAST-K, Dawar, Gurez. The morphological characterization of Kala zeera germplasm led to the establishment of 252 diverse accessions. This diverse core set of 252 entries constitute Kala zeera germplasm bank at Mountain Agriculture Research and Extension Station (MAR&ES), SKUAST-K, Gurez.

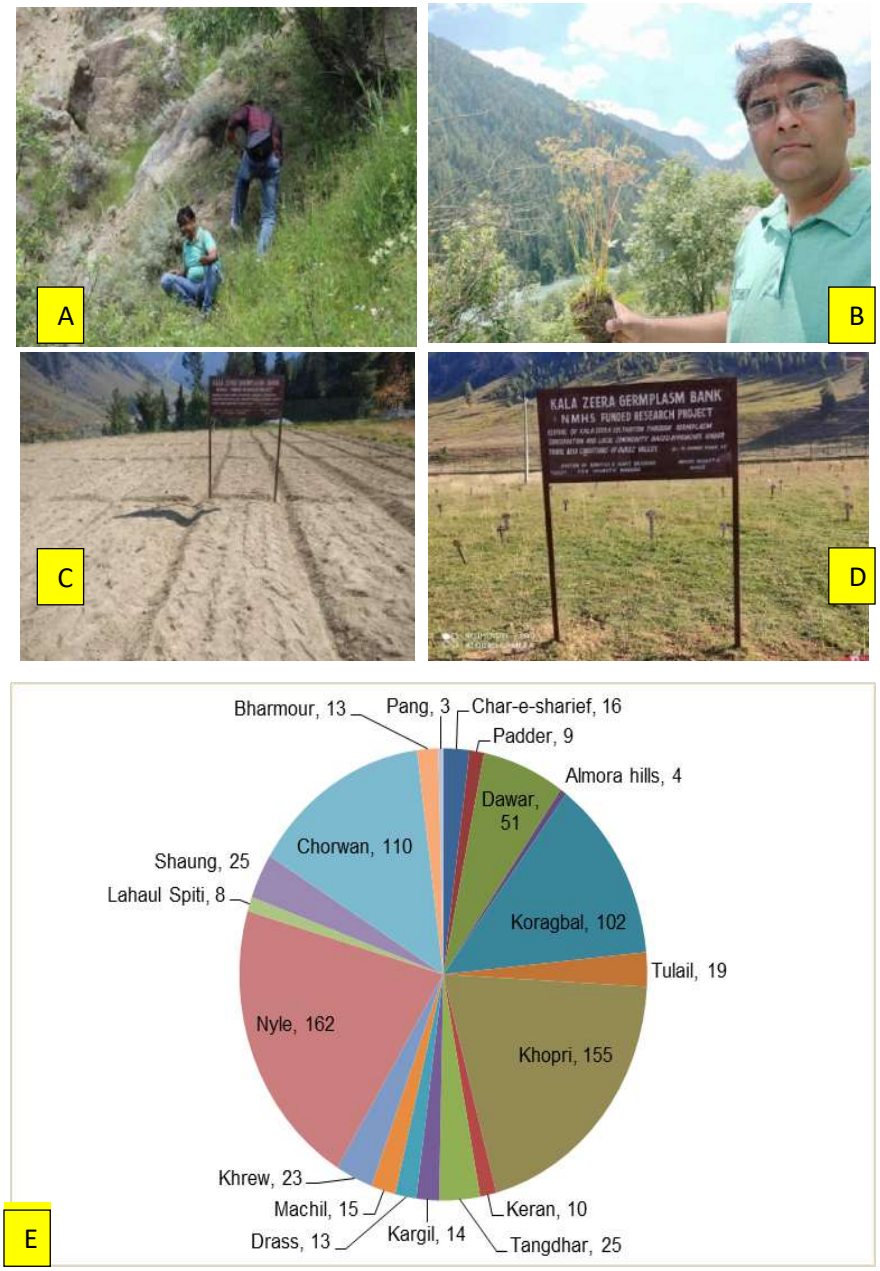


**Fig. 1.** (A-B) Exploration visits of north-western Himalayan regions (C-D) Layout of Kala zeera trials at MAR&ES SKUAST-K Gurez (E) Germplasm accessions collected from different Kala zeera growing areas during exploration visits

## FARMERS' AWARENESS CAMPS AND TRAINING PROGRAMMES

Overexploitation of this spice has resulted in a substantial decline in its production in Jammu & Kashmir. The farmers lift the immature seeds for the immediate benefits resulting in the restriction of its propagation (Khan *et al.*, 2022). This has resulted in the depletion of this commercially and medicinally significant spice plant in its native habitats at an alarming rate. The efforts were made to educate the people of Gurez regarding the importance of conservation, therapeutic values and economic benefits of kala zeera. Apart from our University efforts (Fig. 2) we also involved local bodies and news agencies to make the conservation of kala zeera (stop lifting of immature zeera) a word in the village.

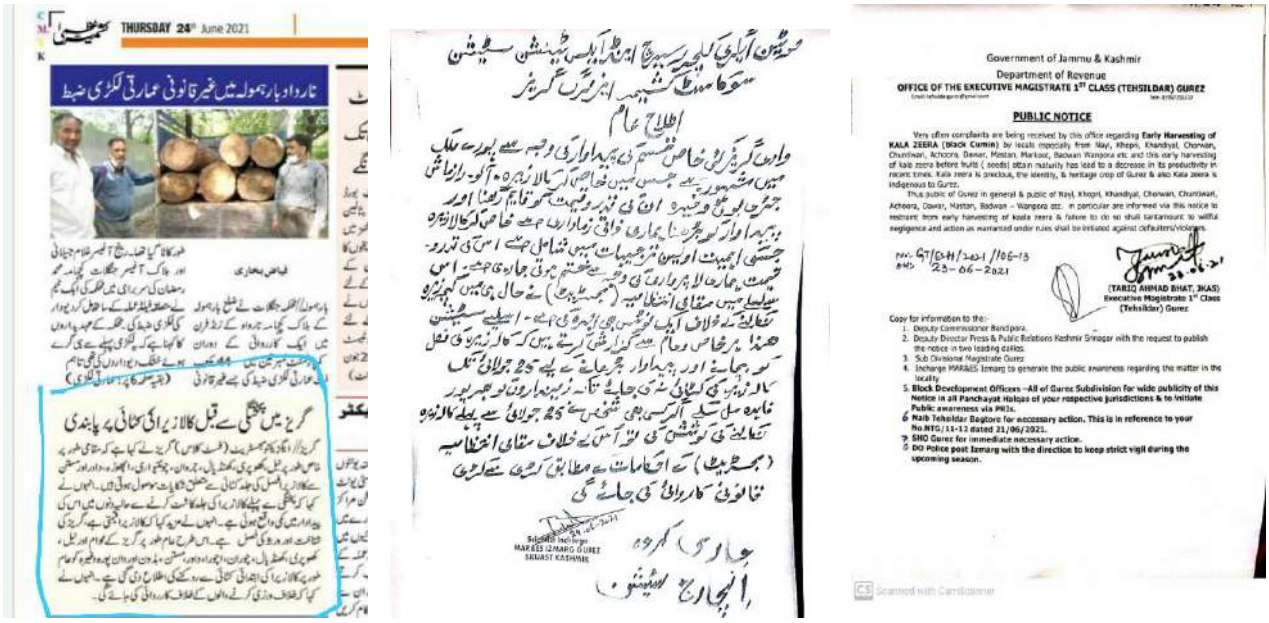


**Fig. 2.** Awareness regarding conservation of Kala zeera through local bodies and news agencies.

Awareness-cum-training programmes for tribal farmers (450) from different Kala zeera growing areas of Gurez valley viz., Koragbal, Nayal, Chuntiwari, Chorwan, Markoot, Khopri, Khandyal and Achoora were conducted during years 2020 and 2021 (Fig. 3). In these trainings the farmers were given awareness regarding importance of conservation of Kala zeera crop in the form of a small booklet entitled, "Conservation of Kala zeera: A Heritage crop of Gurez valley" and side by side techniques for scientific cultivation were also demonstrated to the farmers through training camps. Some demonstration plots were also laid on spot in presence of farmers at the research station in Gurez.


**Fig. 3.** (A-B) Farmers awareness camp at Gurez. (C-D) Demonstration and farmers training at Gurez. (E-F) Release and distribution of booklet entitled, "Conservation of Kala zeera: A Heritage crop of Gurez valley".

## EXPERIMENTAL FINDINGS

The study revealed significant variability in number of branches per plant, number of umbelets per umbel, number of seeds per plant, 1000 seed weight, seed traits and seed yield per plant. The highest seed yield per plant was recorded from two entries collected from Nayal and Chuntiwari areas of Gurez valley of Jammu and Kashmir respectively. Five accessions were identified as elite accessions with better seed traits (seed size, seed shape, seed colour and seed weight) as demonstrated by Image J analysis. These elite accessions have been registered with national germplasm repository National Bureau of Plant Genetics Resources (NBPGR), New Delhi. We identified 24 accessions as earliest flowering types. The genotypes took 83-94 days for attaining 80% maturity. In addition, protein content in all the accessions was evaluated. In particular, five accessions had highest protein content and might be chosen for cultivation to partially satisfy the market requirement. Additionally, the germplasm accessions identified on the basis of trait data could be explored as high-yielding Kala zeera varieties for north-western Himalayas, as a genetic resource for variety of genomics studies including transcriptomics, for identification of differentially expressing genes particularly of medicinal importance and in mapping genes for important traits through development of bi-parental mapping populations.

## ACCOMPLISHMENTS

Based on the morphological evaluation of the Kala zeera germplasm, we identified few promising lines in terms of yield and nutritional profile. The promising genotypes were

multiplied and distributed to farmers from different tribal villages of Gurez in the form of twenty-five Front Line Demonstrations (FLDs) (Fig. 4).


**Fig.4.** Frontline demonstration (FLD) trials of Kala zeera being conducted at Gurez

The tribal farmers including women and youth were very keen and interested to cultivate Kala zeera in their own fields. As such domestication programme is intended to be continued over years to have maximum coverage in Gurez. A women farmer namely Mrs. Khatija (Fig. 5) from Izmarg Gurez has herself started conservation practices and adopted some area on hills, after adoption of scientific cultivation of zeera she has been identified as an Innovative farmer and recently Felicitated by Honorable Vice Chancellor SKUAST-K in June, 2022.


**Fig. 5.** (A & B) Felicitation of innovative woman farmer at Gurez

## CONCLUSION

The conservation of zeera accessions from Gurez and establishment of diverse genetic resources in the form of germplasm bank is a useful strategy to save the crop from extinction and open new horizons for its genetic improvement and its redistribution among breeders/farmers in the form of improved genetic stocks/ varieties. SKUAST-Kashmir is on forefront in training local farmers regarding scientific cultivation of zeera on one hand and simultaneously working on selection of high yielding promising accessions, their multiplication and distribution to tribal farmers to boost zeera farming in Gurez. Efforts are also on way to restrict zeera adulteration, its branding as organic zeera, and establishment of farmers' cooperatives and e-marketing of zeera that will boost the zeera cultivation in Gurez, improve its marketing and provide more livelihood opportunities to tribal farmers of Gurez.

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# TRADITIONAL GRAIN AND PULSE STORAGE TECHNIQUES, IN HILLY REGIONS OF KASHMIR

**Saima Tabasum, Gazala Nazir*, AalimaTabasum, Khursheed Hussain, Ummyiah H . Masoodi and Syed Berjes**

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**DIVISION OF VEGETABLE SCIENCE**

For the majority of people on earth, grains, which include cereals and pulses are the most important part of diet. Grain is an important consumable commodity that is used for human consumption at large scale. The production of different types of grains increased progressively due to implementation of advance production practices but because of improper storage facilities huge amount of grains has been spoiled. The post-harvest losses in India amount to 12 to 16 million metric tons of food grains each year which amounts to more than Rs 50,000 crores in monetary terms. The need of hour is to improve storage facility and also to look into innovative traditional techniques of storage for improvement. Some traditional materials may also be considered for improved storage like paddy straw, wheat straw, wood, bamboo, reeds, mud, bricks, cow dung etc.

The main function of storage in the economy is to even out fluctuations in market supply, both from one season to the next and from one year to the next, by taking produce off the market in surplus seasons, and releasing it back onto the market in lean seasons also grains and pulses are stored for seed to be sown next year. Farmers store these grains and pulses for future consumption in lean season. Natural contamination of food grains is greatly influenced by various environmental factors such as type of storage structure, temperature, pH, moisture, etc. Safe grain storage methods play an important role in preventing losses which are caused mainly due to weevils, beetles, moths and rodents. Although some high tech storage facilities are available, but these prove to be very much costly for small scale farmers. Kashmiri farming is small scale with mono or double cropping system. Rice or maize is grown during Kharif while field pea, oats or mustard is grown during rabi. In higher belts only single crop is grown annually which includes pulses or maize of excellent quality. All this produce is stored as home storage traditionally. All over India, It is estimated that 60-70% of food grain produced is stored at home level.

**SOME OF THE IMPORTANT GRAIN STORAGE STRUCTURES OF HILLY REGIONS OF KASHMIR**

**Open-air and aerial storage**

Cereals grain is frequently kept under roofs of homes, hung from roof beams, or spread out on a grid in the ceiling, where direct sun radiation heats the grains to a high temperature that reduces

moisture content and may also kill developing larvae in the seeds, reducing insect infestation.

**Terracotta containers**

To give strength for storing threshed food grains including cowpea, maize sorghum, rice, black gram, and millet weighing between 5 and 1500 kg for short to long periods of time, farmers all throughout the country use earthen bins/pots constructed of burnt clay mixed with or without straw as the binding substance (Bodholt and Diop, 1987). Depending on the region, these storage structures vary in size and design; it has a distinct shape with a narrow top and a smaller base for pouring grain. To prevent the stored grains from absorbing moisture, the grains are typically sun-dried to 12% or less moisture content before being loaded into the bin or pot and set on a concrete platform or pallet. Mud is used to seal the lid and cover the mouth, which is covered with an earthen plate that fits into the entrance.

**Plastic or Metal Drums**

After complete washing, food grains are hermetically stored in plastic or metal drums if a new one is not needed. Before being loaded into drums and sealed with a grease screw cap for later opening, grains intended for storage are first sun dried to reduce the moisture content to 12% or less. Then the drums are filled with the grains (threshed or unthreshed).

**Bags for storage**

Food grains are frequently kept in sacks for short-term storage in farms, villages, and industrial storage facilities. Jute, sisal, native grass, cotton, and other materials that are readily available in the region are used to weave sacks. Farmers still use jute or sisal bags, while they were once widely utilised in India before the invention of polypropylene bags. They typically come in a range of sizes, from 25 kilogram to 100 kg bags.

**Storage in mud houses**

Large quantities of food grains, weighing between 1000 kg and 2500 kg or more, are kept in mud homes. Depending on the farmer's needs, the size ranges from 4 metres by 4 metres by 3 metres, which provides a storage capacity of 2500 kg. The walls of mud dwellings are either built of mud alone or of mud combined with paddy straw and plastered over the bamboo split structure, with a tin roof covering the top. Clay and cow manure are applied over the entire construction, together with the covered wooden planks, and left to dry before being lime washed.

## DANDELION GREENS, MALLOW, PURSLANE AND AMARANTH- THE COMMON UNDERUTILIZED VEGETABLES OF KASHMIR VALLEY

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In nature, there are many under utilized greens of great nutritive value, which can nourish the increasing human population. They often have medicinal properties and provide options for improved income to the poor. Kashmir valley is a hilly terrain with a severe cold winter and the people living in this region are mostly dependent on under utilized leafy vegetables for their source of food when other vegetables are unavailable. Wild and underutilized leafy vegetables grow naturally in Kashmir Himalayas. Besides using leaves of such vegetables, petioles, seeds, roots of some species are also utilized. Most of these crops are easy to grow, resistant to pests and diseases, hardy and acceptable to the local taste. They are rich source of proteins, vitamins and minerals.
Four such wild and underutilized vegetables that are popular in Kashmir are briefly discussed below:

### DANDELION GREENS

*Taraxacum officinale* commonly called Dandelions in English and Handh in Kashmiri is a common weed found in orchards, roadsides, vegetable fields of valley. It belongs to family Asteraceae. They flower in May-June or sometimes in November and the seeds are disseminated by wind. Itgrows from unbranched taproots and produces one to more than ten stems. The stems are tinted purplish, upright or lax, which produce flower heads that are taller than the foliage. The foliage is upright growing or horizontally orientated, with leaves having narrowly winged petioles. Young dandelion greens can be eaten cooked. Raw leaves have a slightly bitter taste. The leaves are high in vitamin A, vitamin C and iron, which is higher than the amount of iron and calcium in spinach.A leaf decoction can purify blood, for the treatment of anemia, jaundice etc. in addition to having a diuretic effect. Being rich in iron, Handh is consumed by lactating mothers in Kashmir either as fresh vegetable or in dehydrated form.

*Kashmiri Handh- Dandelion Greens*

**MALLOW**

*Malva sylvestris* belonging to family Malvaceaeis commonly called Sotchal in Kashmiri. It grows in fields, hedgerows and in fallow fields.

It is a spreading herb, which is usually annual or perennial with a growth habit which can be straight or decumbent and branched. The leaves are borne upon the stem, are roundish, and have three or five to seven or five to nine shallow lobes. Cultivation is by sowing the seeds directly outdoors in early spring. The seed is easy to collect, and they often disseminate by irrigation water. Mild tasting young mallow leaves can be a substitute for lettuce, whereas older leaves are better cooked as a leafy green vegetable. The young leaves when boiled and fried are a wholesome vegetable and are eaten in several parts of Valley. The buds and flowers can be used in salads. The fruit can be used as demulcents and emollients giving a soothing effect, the seeds are used in a decoction as adiuretic and the leaves can be made into poultices as an emollient for external applications.

*Kashmiri Sotchal- Mallow*

**PURSLANE**

Common Purslane which is botanically *Portulaca oleracea* belonging to family Portulacaceaeand called Nunnar in Kashmiri is widely considered an edible plant. It has smooth, reddish, mostly prostrate stems and alternate leaves clustered at stem joints and ends which are oval or oblong and sub succulent. It commonly grows in orchards, vegetable fields and fallows lands. The stems, leaves and flower buds are all good to eat. Although purslane is considered a weed in Kashmir, it is mostly eaten as a leafy vegetable. In Valley it is cooked along with amaranthus and an egg to form a delicious curry. Purslane is rich in, (Artemis, 2004), vitamins (mainly vitamin A, vitamin C, and some vitamin B and carotenoids) and minerals such as magnesium, calcium, potassium and iron. Two types of alkaloid pigments, the reddish betacyanins (visible in the coloration of the stems) and the yellow betaxanthins (noticeable in the flowers and in the slight yellowish cast of the leaves) are present in purslane that are potent antioxidants. Purslane is used as a remedy for constipation and against inflammation of the urinary tract.

*Kashmiri Nunnar- Portulaca*

**AMARANTH**

*Amaranthus spinosus* of Family Amaranthaceae is locally called Lissa in Kashmir. Its English name is pigweed, several species of which are often considered a weed of orchards, vegetable fields and fallow lands. Kahmiri people consider amaranths as leafy vegetable. It is an annual herb, erect or trailing, scarce to profuse branching, stem green to purple or with mixed shades of these two colours, simple leaves with acute tip, green to purple or with different shades of these two colours. Purple colouration is prominent in young leaves and fades away at maturity. Amaranth seeds, like buckwheat and quinoa, contain proteins. Besides leaves, seeds of amaranth are consumedalong with jaggery in the form of small pellets, commonly known as Ganhar in valley, which are good source of protein, dietary fiber and minerals such as iron, magnesium, copper and especially manganese. Regular consumption reduces blood pressure and cholesterol levels, while improving immuni ty (Czerwinski *et al.*, 2004; Gonor *et al.*, 2006).

*Kashmiri Lissa- Amaranth*

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# SUSTAINABLE AGRICULTURE PRACTICES IN THE COLD DESERT LANDSCAPE OF LAHAUL & SPITI VALLEY OF NORTHWESTERN HIMALAYA, INDIA: TRADITIONAL APPROACH WITH SOCIO-ECONOMIC VALUES

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## INTRODUCTION

Agriculture is the process of cultivating plants on the soil for food, fiber, bio fuel and other products for human life. The role and importance of agriculture in the development of any nation always goes unnoticed. Agriculture in India has always kept pace with the increasing population and ensured food security of the nation. In India, agriculture is the primary source of livelihood. More than half of the population still depend on the agriculture. Among the three sectors i.e. service, manufacturing and agriculture, India is amongst the top rank countries in the agriculture sector. In a world that is rapidly undergoing climate change; substantial changes are required in agriculture techniques so that our country can meet sustainability and food security at the same time. Revival of traditional agriculture practices can provide the much needed innovations required to meet such challenges.

Traditional agriculture follows the concept of working with nature rather than against. It involves the intensive use of indigenous knowledge, natural resources, land use, traditional tools, cultural beliefs of the farmer and organic fertilizers. Traditional agricultural practices of Lahaul & Spiti district of Himachal Pradesh can provide the much needed insights on natural resource management, land use and cultural beliefs. The Lahaul and Spiti district of Himachal Pradesh extends from 31°44'34"N to 32°59'57"N and from 76°46'29"E to 78°41'34"E. It is situated in the north of Pir Panjal range of the Great Himalayas. Due to the sparce population and lack of industrialization, agriculture and animal husbandry are the mainstays. Agriculture is the main livelihood here. Due to the extremely difficult hilly terrain and cold desert habitat, very limited area is cultivable. It is a rain shadow region and the climate is characterized by high-speed winds, abrupt change in temperature, high altitude atmosphere and low humidity which results in making the soil dry and devoid of organic matter. Various traditional agricultural practices are followed for food security and socio-economic values.

## TRADITIONAL CROPS AND CROP CYCLE

Due to heavy snowfall in the valley, the cropping season is of short duration (April-September) In Lahaul & Spiti, traditionally crops like Kathu (Buckwheat), Jo (Barley) and Kala Matar (Black Peas) are cultivated. These traditional crops are highly nutritious and sustainable enough for the people living in this high altitude landscape. Apart from this

potatoes of this region are sold to various states of India. This traditional agriculture practice reflects the skills of local farmers to grow crops according to the natural cycle.

**Table 1:** Traditional Crops of Lahaul & Spiti

| **Crop Name** | **Sowing Time** | **Harvesting Time** |
|---|---|---|
| **Buckwheat** | July-August | September-October |
| **Barley** | April-May | July |
| **Kuth *(Perennial Crop)*** | November | September-October |
| **Potato** | April- May | September-October |

*(Source: Singh et al. 1996)*

## PLOUGHING TECHNIQUES & TOOLS

People of Lahaul & Spiti are highly religious oriented so various rituals are performed before preparing fields for the crop. A particular day is selected to plough the field and before plowing the fields offerings of *Chang* (local alcohol), *Kha* (roasted barley) are made to the local deity and to the nature. Bong (offspring of cow and yalk) is used for draught power. Two bong are joined together and plow is attached to them. Plow blade is used for plowing the field and wooden plank for leveling it. This work requires two to three manpower. This traditional method clearly depicts the balance among nature, man and animal. This method also shows the reconciliation among the people of Lahaul & Spiti valley. This practice also promotes rearing of cattle.

**Fig.1.** Ploughing Tools and Practices in Lahaul & Spiti Valley *(Source: https://www.himkatha.org)*

## TRADITIONAL IRRIGATION PRACTICES

Lahaul & Spiti being a rain shadow region receives very less rainfall and local people cannot depend on rain for irrigation. One of the remarkable indigenous and traditional practice of Lahaul & Spiti is its snow-fed irrigation system known as the Kulh or Kul. Kulh is an earthen water channel used to tap melting snow water (from glacier) from which water is let out in a trickle. The channel length covers distance from few meters to kilometers, running down mountain slopes. In the morning, water from the Kulh is released into the exit canal after collecting water over night. The tank is almost completely empty by evening and then the exit is locked. This cycle is repeated daily

**Fig. 2.** Traditional irrigation system in Lahaul & Spiti Valley *(Source: https://www.thethirdpole.net)*

## ORGANIC MANURE

Organic manure is the only solution for the long term sustainable agriculture. Due to the climatic conditions in this region, the vegetation is very less and with small population of cattle, it is very difficult to generate sufficient amount of organic manure. The local people of Lahaul & Spiti have developed a unique method for this challenge. They obtain organic manure derived from composting human excreta called Night Soil. Traditionally the form of the building structure is almost same throughout Lahaul. All the houses here are three storey. An in-house toilet connected to the living room is built on the first floor. Through a large rectangular hole in the toilet floor, the night-soil drops down to the ground floor adjoining the animal shed, where the composting takes place. After defecating, villagers cover the night soil with dry cattle dung, kitchen ash, dry grass or leaves. It prevents bad odour in the room and also makes the compost rich in nutrients. The composting room has a special door for the removal of the compost. Night-soil compost from the composting room is carried to the fields and dumped in a series of piles. It is scattered all over the fields after snow melts and before the beginning of the crop season.

**Fig. 3.** Organic Manure through Night Soil composting techniques in Lahaul & Spiti Valley
*(Source: https://www.youtube.com/watch?v=JQgdsE5r7ak)*

## FOOD GRAIN STORAGE TECHNIQUES

Due to the remote and difficult terrain, even nowadays many areas do not have cold storages, due to which the crop gets spoiled quickly. In such a situation, traditional storage techniques are adopted, which are still very effective today. In Lahaul and Spiti, *Datah* (container prepared with wood along with slate), *Khach* (underground structures), *Khal* (made up of the skin of goat or sheep to carry barley) are some of the structures/containers used traditionally to store food grains. Different types of grains are kept in different type of storage keeping in mind their quantity, temperature and time period.

The traditional agricultural practices are not limited to cultivation and are equally important for the climate, community and also for religious and cultural significance. The people of Lahaul and Spiti are very humble because they live in harmony with nature. Hardworking nature of the people of Lahaul & Spiti and their sprit to adjust and accept the abrupt changes of the nature reflects that with indigenous knowledge one can adapt with the climate.

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# TRADITIONAL WASTE MANAGEMENT IN AGRICULTURE FOR ECOLOGICAL SECURITY OF THE INDIAN HIMALAYAN REGION

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## BACKGROUND

Traditional knowledge refers to the knowledge and practices opted by indigenous people who are well aware of their surroundings and environment and this knowledge is passed on to them from their ancestors over the millennia. It is obtained from experience gained over the centuries. This knowledge is collectively owned and is expressed and transmitted in the form of stories, folklore, cultural values, beliefs, rituals etc. It involves the use of land and resources that inculcate agricultural practices which are sustainable as well as beneficial to the mother Earth. Indigenous people are well versed with their region and know their land better than anyone. Their practices are eco-friendly, sustainable and improve the fertility of the soil. As a well-known fact the Indian Himalayan Region (IHR) is a sensitive area and a profound habitat of a vast vivid biodiversity. In the recent decade, the rise of the tourism industry in this region is a matter of grave concern from the point of view of environment sustainability. However, if proper measures are implemented and traditional indigenous knowledge and practices are carried effectively then environment sustainability can be achieved.

Agriculture being the largest generator of any resource to the economy is also a large generator of waste materials. For the local inhabitants of the IHR agriculture is of very much importance. Agriculture is the main stay and livelihood and attains their basic needs, living in harmony with nature. With the recent bend towards cash crops production and use of chemical fertilizers to increase crop yield has put a blind-eye on environment sustainability and risen concerns for the future generations. Agricultural waste as well as other wastes can be treated and utilized in a manner that sustains the future and increases agricultural yield without hampering the environment if traditional practices of indigenous people are encouraged accompanied by modern day technologies. Proper waste management helps maintaining a healthy environment and reduces dependency on chemical fertilizers and provides other nutrients required to increase the crop yield both quantitatively and qualitatively. The Indian Himalayan Region is characterized with mountainous terrain and extremely cold environment with very less rainfall in some of its regions. Traditional practices of waste management in agriculture must be promoted as these are eco-friendly and suit the extreme weather conditions that prevail in the Indian Himalayan Region.

## SOME OF THE TRADITIONAL WASTE MANAGEMENT PRACTICES IN AGRICULTURE ARE AS FOLLOWS

### ORGANIC COMPOSTING

The process of organic composting involves disposing the organic waste in a pit for several day or even months. Through microbial degradation the organic waste is converted into compost. This humus-like material has the ability to fertilize crops. Due to release of $CO_2$, water and heat in the process of composting numerous pathogenic microorganisms are killed. The organic compost is known to reduce Green House Gasses (GHGs) emission and increases soil fertility, soil microbial diversity and maintain the moisture in the soil. It furthers reduces crop diseases and prevents soil erosion. Even today this practice is prevalent in the Indian Himalayan Region and it must be encouraged instead of burning the crops which cause various environmental hazards and air pollution resulting in degradation of the mountain glaciers present in the IHR as per studies.

**Fig.1.** Organic Composting *(Source: http://www.carryoncomposting.com)*

### TRADITIONAL DRY TOILETS (COMPOSTING OF HUMAN EXCRETA)

In the areas such as Ladakh (UT) and Lahaul & Spiti (district of Himachal Pradesh), the availability of natural water through rainfall is scarce and during winters the temperature enters into sub-zero conditions and thus hampering the water supply. Sewerage infrastructure costs can be very high in instances of unfavorable terrain or sprawling settlement patterns as present in these regions. As a result of which a unique traditional practice of dry toilets is followed. The practice needs to be optimized. Heavy metals in human excreta and foul odor and other such issues can be resolved with modern day technologies so as to produce effective manure for agricultural crops from human excreta. The manure is used so as to make the soil fertile and thus utilizing human waste for agriculture purpose. In the recent years factors such as apprehensions of the society, bend towards modernization and increase in the number of tourists has led to the popularization of septic toilets/modern toilets which has led to the decline in the number of traditional dry toilets that used to be present in these regions. It is high time that keeping in view of the tough conditions present in the IHR such as scarce availability of water and other resources, traditional practices must be encouraged and further improved with the help of modern day innovations and technologies.

**Fig.2:** An ongoing construction of a dry toilet *(Source: https://roundglasssustain.com)*

## IMPOSITION OF PLASTIC-BAN

Plastic is a big nuisance for the environment and even agriculture suffers great loss because of human dependency on plastic. Strict measures need to be imposed in order to ban plastic. In the states of Himachal Pradesh and Uttarakhand there is penalty system for use and littering of polythene carry bags. Such measures need to be adapted and implemented strictly across the IHR in order to curtail the waste that arises due to the use of plastic. Waste littering should be avoided and awareness programs should be carried on large scale. Plastic waste being non-biodegradable is becoming a major cause of pollution as the IHR which encompasses many areas that are tourist hotspots.

**Fig.3.** Increasing plastic waste in West Bengal hills *(Source: https://thedarjeelingchronicle.com)*

## WAY FORWARD AND CONCLUSION

The way forward is to combine the traditional knowledge with modern day innovative technologies and thus achieving the phenomenal way of waste management. For instance the existing practices such as landfills can be modernized by extracting the biogas and further treating it so that it can be used in various ways. The landfill gas is usually allowed to escape in the air which accelerates the greenhouse effect as the gas contains mostly methane. If collected and treated the Land Fill Gas (LFG) can be used as a renewable energy resource. This will further help in reducing Green House Gasses emission and thus avoid increasing global rise in temperature and melting of glaciers in the Indian Himalayan Region. Moreover the LFG's plants will generate revenue and provide job opportunities to the communities of

that particular region. The LFG gas can be used to generate electricity, in place of compressed natural gas or even as a fuel for vehicles.

In conclusion, it is obvious that waste can prove to be of great use and be of boon especially to the agriculture sector, if proper waste management practices are opted. Traditional knowledge is of very much importance and hence local involvement is essential for environment conservation and sustainable development in sensitive areas. It can be inferred from the above context that nothing is waste and proper utilization and management can produce useful products even from the so called “waste”.

# ORGANIC AGRICULTURE

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## INTRODUCTION

With the growing awareness of health and environmental issues in agriculture has increased in the demand of organic production in agriculture which has been emerging as a source of rural income generation. The demand for organic produce as raised with rise in demand for organic are discernible, sustainability in production of crop has become prime concern in agriculture development.

It can be defined as a system that begins to consider potential environmental and social impacts by eliminating the use of synthetic inputs, like synthetic fertilizers, pesticides, genetically modified organisms and use of any non-conventional method of supplementing the growth and production of agricultural crops. These are replaced by conventional site-specific management practices which will maintain and increase soil fertility and prevent pest and disease infestation in long run.

According to FAO/WHO codex Alimentarius commission, 1999 organic agriculture is defined as an, "holistic production management system which promotes and enhances agro eco health, including biodiversity, biological cycle, soil biological activity. It is more focussed to use the management practices rather using the off-farm inputs according to the locally prevailing climatic conditions. This is accomplished by use of agronomical, biological and mechanical methods and restricting the use of synthetic material to fulfil any specific function within the system"

## TRENDS IN ORGANIC FARMING

Still in India the organic farming is in nascent stage. Out of the cultivated area only 2.78 million ha of farm land is under organic cultivation (union ministry of agriculture and farmer welfare) which accounts for only 2% (140.1 million ha) of the net sown area. Madhya Pradesh accounts for 1020017.98 ha (organic + in conversion) area having 27% share in India's organic cultivation area with production of 1392095.93 MT and is on the top of the list followed by Rajasthan and Maharashtra. Sikkim is the only state which has become fully organic with area more than 75000 ha under organic certification.

India has introduced the organic farming policy in 2005. 2.78 million ha. was covered under organic farming in India which account for 2% of the 140 .1 million ha of net sown area of the country. Out of this 1.94 million ha is covered under national program for organic production (NPOP); 0.59 million ha under Param Paragat Krishi Vikas Yojana (PKVY); 0.07 million haunder mission organic value chain development for northeastern region (MOVCDNER) and 0.17 million ha under state schemes and non-schemes. Although India

has very small area under organic cultivation still in terms of number of farmer it has been ranked as 1st accounting to 1.9 million farmers in March 2020 which is 1.3 % of 146 million cultivators.

**Table 1.** Growth of area under organic management

| S. No. | Years | Area in ha under organic certification process |
|---|---|---|
| | | Cultivated + Wild Harvest (ha) |
| 1. | 2015-16 | **5710384.00** |
| 2. | 2016-17 | 4452987.00 |
| 3. | 2017-18 | 3566538.00 |
| 4. | 2018-19 | 3428638.77 |
| 5. | 2019-20 | 3669801.33 |
| 6. | 2020-21 | 4339184.94 |

**Table 2.** State wise organic farm production during 2020-21

| S. No | State Name | Organic production in MT |
|---|---|---|
| 1. | Madhya Pradesh | 1214919.50 |
| 2. | Maharashtra | 752176.23 |
| 3. | Karnataka | 355718.73 |
| 4. | Rajasthan | 237436.69 |
| 5. | Uttar Pradesh | 183089.90 |
| 6. | Odisha | 128264.72 |
| 7. | Gujarat | 112797.25 |
| 8. | Uttrakhand | 46645.41 |
| 9. | Jammu and Kashmir | 41043.93 |
| 10. | Kerala | 27850.11 |
| 11. | Tamil Nadu | 24068.86 |
| 12. | Meghalaya | 21753.32 |
| 13. | Chhattisgarh | 20630.65 |
| 14. | Andhra Pradesh | 20145.27 |
| 15. | Assam | 17839.16 |
| 16. | West Bengal | 17434.79 |
| 17. | Himachal Pradesh | 6368.45 |
| 18. | Haryana | 5439.00 |
| 19. | Goa | 3115.44 |
| 20. | Telangana | 2509.68 |
| 21. | Sikkim | 443.85 |
| 22. | Tripura | 348.53 |
| 23. | Punjab | 264.63 |
| 24. | Manipur | 27.74 |
| 25. | Bihar | 12.59 |
| 26. | Nagaland | 3.50 |
| 27. | Arunachal Pradesh | 1.09 |
| 29 | Total | 3240349.02 |

**Table 3.** State-wise details of total area under organic certification process and total production of raw organic commodities 2021-2022

| S. No | State Name | Organic production in MT |
|---|---|---|
| 1. | Madhya Pradesh | 1637730.46 |
| 2. | Rajasthan | 481862.38 |
| 3. | Maharashtra | 371798.28 |
| 4. | Chhattisgarh | 286684.52 |
| 5. | Himachal Pradesh | 203736.47 |
| 6. | Jammu and Kashmir | 192769.82 |
| 7. | Karnataka | 174423.56 |
| 8. | Uttar Pradesh | 159307.73 |
| 9. | Gujarat | 147866.41 |
| 10. | Odisha | 96306.88 |
| 11. | Uttarakhand | 82210.20 |
| 12. | Jharkhand | 81661.70 |
| 13. | Sikkim | 75729.66 |
| 14. | Kerala | 48364.18 |
| 15. | Tamil Nadu | 41618.68 |
| 16. | Meghalaya | 38376.39 |
| 17. | Andhra Pradesh | 36801.36 |
| 18. | Bihar | 29902.54 |
| 19. | West Bengal | 21002.61 |
| 20. | Punjab | 18637.50 |
| 21. | Assam | 18470.84 |
| 22. | Goa | 18222.16 |
| 23. | Nagaland | 14790.38 |
| 24. | Manipur | 14724.92 |
| 25. | Arunachal Pradesh | 13114.12 |
| 26. | Mizoram | 13038.89 |
| 27. | Telangana | 6865.56 |
| 28 | Tripura | 6521.31 |
| 29 | Haryana | 4903.06 |
| 30 | Lakshadweep | 895.51 |
| 31 | Ladakh | 817.85 |
| 32 | Pondicherry | 23.65 |
| 33 | New Delhi | 5.17 |
| 34 | Andaman and Nicobar islands | 0.00 |
| Total | | 4339184.94 |

## EXPORTS

India's organic food products exports raised by more than 50% in 2020-21 despite COVID-19 challenges. Exports of organic food rose by 51% up to 1040 million USD (Rs 7070 crores). Quantity wise the export of organic food raised grew by 39% to 888,179 metric tonne (MT) in 2020-21 from 638,998 MT in 2019-20.(Ministry of Commerce and Industry, 2021) India exported products 888179.68 MT produce worth 707849.59 lakhs.

Organic products from India are exported to USA, EU, Canada, Great Britain, Korea Republic, Israel, Switzerland, Ecuador, Vietnam, Australia and 48 other countries. Oil seeds - Soybean (57%) lead among the products exported followed by oil seed (9%), Cereals and millets (7%) plantation crop products Tea and coffee (6%), Spices and condiments (5%), medicinal plants (5%), Dry fruits (3%), Sugar (3%) and others.

India is bestowed with lot of potential to produce all varieties of organic products due to its various agro climatic regions. An inherited tradition of organic farming in several states of

the country is an added advantage. This holds the promise for organic producers to tap the market which is steadily growing (15 to 25 %) in the domestic market related to the export market. Farmers living in lands untainted by pollutants and away from the hassles of modernity are rediscovering the benefits of traditional and holistic farming that maintains soil health and bio-diversity. India exported more than 300 organic products under 19 categories for a volume of 69837 Mt realizing value of USD 157 million (2010-11). The major products exported were cotton and textiles-17363 Mt (25 %), basmati (5243 Mt) and non-basmati rice (1634 Mt) (10%), Oil crops-17966 Mt (26%) except sesame-2409 Mt (3%), processed foods - 8752 Mt (13 %), tea-2928 Mt and coffee (5%), honey-2408 Mt (3%), dry fruits -1472 Mt (2%), spices, medicinal plants and their processed products, miscellaneous (13%). The other products categories (5%) are cereals, spices, medicinal and herbal plants, coffee, vegetables, aromatic oil and pulses. 44 % of the organic products were exported to Europe followed by Canada (22%), USA (19%) and Asia (13%).

**Table 4.** Certified organic products produced and exported from India

| | |
|---|---|
| **Cereals** | Wheat, rice (Basmati) |
| **Spices** | Cardamom, Black Pepper, White Pepper, Ginger, Turmeric, Vanilla, Mustard, Coriander, Tamarind, Clove, Cinnamon, Nutmeg, Chilli |
| **Beverages** | Tea, coffee |
| **Pulses** | Red Gram, Black gram |
| **Fruits** | Mango, Banana, pineapple, passion fruits |
| **Vegetable** | Okra, brinjal, garlic, onion, tomato, potato |
| **Oil seeds** | Sesame, castor, sunflower, groundnut |
| **Others** | Cottons, cashew nuts, herbal extract |

## CONCLUSION

In developing countries due to limited resources it has become equally necessary to shift towards sustainable food production to support the countries exploding population. Using chemicals and inorganic fertilizers have provided temporary boost to the agricultural sector but that cannot be sustained in long run it has caused deterioration of human health and non-regulated use of inorganic fertilizers have led to decline in the soil and plant health which will affect the crop production. Due to the use of more acidic fertilizer the land of Punjab, Haryana, and Uttar Pradesh has been left barren and the production has shown declining trend with an increasing use of fertilizers. The present awareness about benefits and use of organic farming is limited, whereas it can contribute immensely toward sustainable food security by improving nutrient intake, supporting livelihoods in rural areas and enhancing biodiversity. On the other hand organic farming is simultaneously reducing venerability to climate change. Using organic sources have been reported by various workers to enhance the production and quality of the agricultural produce in longer run. Organic farming included basic practices like mulch applications, maintaining trees and shrubs in form of multiple cropping in farm helping to build a strong and sustainable system for food production.

# SUBSURFACE DRIP IRRIGATION AND CONSERVATION IN HILL AGRICULTURE

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## ABSTRACT

The water scarcity problem is increasing day by day consequently the cultivation of crops in limited water is cumbersome without knowing the efficient strategy of using per drop of water for good crop production. Keeping in view this burning problem, we have initiated a project work to enhance the water use efficiency through the subsurface drip irrigation technology. In this water saving technique we have installed the drip irrigation pipes about 15 cm below from the soil surface so that the surface water loss could be avoided and effective water absorption from rhizosphere zone could take place. After finishing the installation the seedlings of different vegetable crops were planted and straw mulch is added to conserve the soil moisture.

**Key words:** Subsurface drip irrigation, Zero tillage, mulching and Multiple cropping

## ACHIEVEMENT OF THE STUDY

The technology for sub surface drip irrigation has been developed successfully. The different vegetable crops were cultivated and some were harvested. The appreciable production of vegetables achieved with the micro irrigation and effective nutrient uptake. The application of water in the root zone of crops through the subsurface drip irrigation system worked effectively not only to conserve the water but also increased the water and nutrient use efficiency.

## PROJECT OUTCOMES

The outcomes of project work entitled “subsurface drip irrigation and conservation agriculture” Under the Unnat Bharat Abhiyan can be summarized under following heads.

1. More crops per drop of water
2. Prevent the soil and water loss
3. Time and labour saving technique
4. Awareness to surrounding farmers for conserving the water
5. Demonstration to the agricultural students

Subsurface drip irrigation technology is found very effective to conserve the water since it facilitates the water requirement directly to roots of crops hence the chances of water loss is negligible also with the adoption of subsurface drip fertigation the loss of fertilizer could be

minimized resultantly nutrient use efficiency could be increased. The amount of water saved with the use of subsurface drip irrigation system as compare to flood or surface application of water is given in table 1.

## DESCRIPTION OF STUDIES

The subsurface drip irrigation system has been installed in chhapang village of Sirmaur district, Himachal Pradesh, in 250 meter square (25.26 m X 9.9 m) area. This system contains disc filter which helps to filter the water, venturi injector for fertigation, pressure gauge, air vacuum release valve, Dripnet PC and flush valve etc. dripnet PC has been installed at 15cm depth from soil surface at 45 cm apart and each dripper is fixed at the distance of 30 cm. A single dripper covers 30 cm diameter to wet land. Discharge rate of water is 2 litres per hour. There are 22 rows of dripnet PC according to field lay-out and system installation. After successful installation, different vegetable crops viz. tomato, brinjal, okra, chilli, and cucumber were sown/ planted in strip cropping system at the distance of 5 cm from the dripnet PC. These crops have different row ratio. Tomato, brinjal, okra and chilli each crops were raised in individual 5 rows; and cucumber was grown in 2 rows.

## IMPACT OF SUBSURFACE DRIP IRRIGATION TECHNOLOGICAL DEVELOPMENT PROGRAMME

The purpose of developing the subsurface drip irrigation system is to conserve the resources along with the effective utilization of water and nutrient for more and better quality yield, for this reason, every dripper in the field delivers the optimal amount of water and nutrients to the roots of one plant. The following vegetable crops were cultivated in research stations in the area of 250 $m^2$, through subsurface drip irrigation system the flow rate was 2 lit/hr and total amount of water used, 64410 litres, shown in Table 1.

**Table1. Total water consumption under the subsurface irrigation system**

| S. No. | Crops | No. of plants | No of rows | Area ($m^2$) | Yield (kg.) | No. of Irrigation | Interval of Irrigation (days) | Total amount of Water used (liters) |
|---|---|---|---|---|---|---|---|---|
| 1. | Chilli | 285 | 5 | 56.84 | 80 | 50 | 4 | 14250 |
| 2. | Brinjal | 285 | 5 | 56.84 | 210 | 50 | 4 | 14250 |
| 3. | Tomato | 285 | 5 | 56.84 | 150 | 50 | 4 | 14250 |
| 4. | Okra | 285 | 5 | 56.84 | 60 | 50 | 4 | 14250 |
| 5. | Cucumber | 114 | 2 | 22.73 | 100 | 65 | 3 | 7410 |
| **Total water used (litre)** | | | | | | | | **64410** |

Subsurface drip irrigation has proven to be effective irrigation method in comparison to flood irrigation (surface irrigation), by using this technique of irrigation we've saved about 66.76% water in comparison to surface application of water (Table.2)

After successful development of this subsurface irrigation system, the demonstration was given to the farmers and farmers are also taking interest to adopt this technique.

**Table 2.** Compression between Flood irrigation vs. Subsurface Drip Irrigation

| S. No. | Flood Irrigation Crops | Total amount of Water used through Flood Irrigation (litre) | Subsurface Drip Irrigation | |
|---|---|---|---|---|
| | | | Total amount of Water used through Subsurface Drip Irrigation (litre) | Total water saving (litre) |
| 1. | Chilli | 42750 | 14250 | 28500 |
| 2. | Brinjal | 42750 | 14250 | 28500 |
| 3. | Tomato | 42750 | 14250 | 28500 |
| 4. | Okra | 42750 | 14250 | 28500 |
| 5. | Cucumber | 22230 | 7410 | 14820 |
| **Total water used (litre)** | | **193230** | **64410** | **128820** |

This photograph shows a water tank that is constructed and linked to an electric pump with pre-filter

This photograph shows the installation of main line of subsurface drip irrigation with water filter, venturi injector and control valve

This photograph depicts the labours are making optimum depth (15 cm) for installation of dripnet PC (lateral pipes)

This photograph is showing the functiong of drip system

This photograph is showing that one dripper moistened of about 30 cm diameter

This photograph is showing the successful installation of subsurface drip irrigation system and transplantaton of different vegetable crops

This photograph showing addition of the straw mulch which will help to conserve the moisture and weed control


This photograph is showing that the loss of water is more from surface drip irrigation system as compare to sub-surface drip irrigation system which could be directly delivered to the root zone with fertilizer


Performance of brinjal crop at chhapang village under subsurface drip irrigation with straw mulching


Performance of chili crop tomato crop at chhapang village under subsurface drip irrigation with straw

# CLIMATE RESILIENT SEEDS AND STORAGE SYSTEM OF KULLU VALLEY, HIMACHAL PRADESH

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## IMPACT OF CLIMATE CHANGE ON SEED PRODUCTION AND AVAILABILITY

The agricultural sector is very crucial part to the economic, dietary and food security.But due to extreme and unexpected changes in temperature and precipitation, it is one of the sectors most exposed to the effects of climate change.Increased trend of extreme weather events such as floods; landslides, earthquake, forest fires etc. are the impacts of climate change. All these events occurred due to some natural as well as anthropogenic activities (deforestation, burning of fossil fuel, waste burning etc.) (Kumar *et al.*, 2018). Resulting greenhouse effect and global warming which contribute to climate change and making agriculture sector most vulnerable. By the end of the 21st century, temperatures are predicted to rise by 3–4°C, according to the Intergovernmental Panel on Climate Change. It is observed from the other studies that the main negative impact of climate change is a decrease in agricultural productivity due to the crop failure, pests and disease, soil degradation etc. (Prowse and Mtisi, 2012). The impacts of changing climate on seed production of crops such as rice, soybeans etc. have already been seen (Singh *et al.*, 2013). Increased temperature alters the rate of organ development, respiration, senescence, and source-sink connections as well as increases several elements of plant metabolism. The majority of crop species are susceptible to heat stress both before and after fertilization, and any exposure to temperature over what is ideal for the species can cause large losses in seed yield.Temperature rise leads to fewer seeds, faster seed growth, shorter seed filling times, and occasionally smaller seed masses. Therefore, reduces the production and availability of seeds. Around 71 percent of the 6.86 million residents of Himachal Pradesh depend on agriculture for their primary source of livelihood and employment, making them more exposed and vulnerable to climate changes. Local inhabitants of the state depend on the traditional food crops as well as off-season crops. Major traditional food crops in the state are rice, barley, millets, buck wheat, mustard, maize, wheat etc.

## PRIME MINISTER'S VISION ON CLIMATE-RESILIENT CROPS

Due to climate change new types of pests and diseases, epidemics had evolved and posing a serious threat to human health as well as livestock and crops. In response to addressing issues relating to agriculture, there is a need to focus on more nutritious seeds, adaptation to new conditions, especially in changing climate. Prime Minister has launched 35 new climate resilient and nutritious rich content crop verities, in response to create awareness among people for adoption of climate resilient technologies. These crop varieties are drought-tolerant, disease- resistant varieties etc.

## TRADITIONAL SEEDS AND THEIR STORAGE PRACTICES IN KULLU VALLEY

Local inhabitant of the Kullu valley mostly depend on the agriculture for their livelihood. It is evident from the various studies/literature that people are practising or cultivating off season crops due to high market values. But changing climate drastically decreases the production of crops (Garlic, tomato, cabbage etc.) which directly affects the livelihood option or food availability. Therefore, there are some traditional seeds which were grown by the local people two decades ago and now today climate scenario they are known as climate resilient traditional seeds. These traditional seeds have various benefits such as they are highly nutritive and have ethnobotanical importance and medicinal importance. They are enriched with high content of protein, fat, and iron along with carbohydrates and potassium (Table no.1). These seeds can grow in any extreme weather conditions such as drought etc. which is also observed in other studies (Behera, 2017).

**Table 1.** List of Climate Resilient Traditional Seeds in Kullu Valley

| Sr. No. | Botanical Name | Common Name | Ethnobotanical Importance | Nutritional Value Constituents-Value (g per 100g) |
|---|---|---|---|---|
| 1 | *Amaranthus hypochondriacus*L. | Saliara | • Seeds are used to cook as rice and also used to made local dish called 'femda'.<br>• Grains are used to prepare *laddu* (mixed with jaggery) | Protein – 13.27<br>• Fats – 5.56<br>• Carbohydrates- 61.46<br>• Total fiber- 7.47<br>• Potassium – 0.41<br>• Phosphorus- 0.41<br>• Iron – 0.008<br>• Energy (KJ)- 1489 |
| 2 | *Eleusine Coracana* Gaertn. | Kodra | • Kodra is ground into flour and used to make chapatti and pudding.<br>• Grains are ground into powder and taken in the morning with milk or tea which helps to strengthen the bones. | Protein – 7.16<br>• Fats- 1.92<br>• Total fiber- 11.18<br>• Carbohydrates- 66.82<br>• Potassium- 0.44<br>• Phosphorus- 0.21<br>• Iron – 0.004<br>• Energy (KJ)- 1342 |
| 3 | *Setariaitalica*(L.) P. Beauv. | Kauni | Grains can be cooked as rice<br>• Grains are also used to cure chicken pox. | Protein – 8.92<br>• Fats- 2.55<br>• Total fiber- 6.39<br>• Carbohydrates- 66.19<br>• Potassium- 0.09<br>• Phosphorus- 0.10<br>• Iron – 0.002<br>• Energy (KJ)- 1388 |
| 4 | *Fagopyrum esculentum* Moench | Gandadi, Kathu, Buckwheat | • Leaves are used as vegetable with potatos, onion<br>• Its grains are cooked as rice and mixed with Rajmah to make pulao | Protein – 13.27<br>• Fats- 3.40<br>• Total fiber- 10.10<br>• Carbohydrates- 71.5<br>• Potassium- 0.46<br>• Phosphorus- 0.35<br>• Iron -0.002<br>• Energy-1435 |
| 5 | *Panicum miliaceum*L. | Cheeni | Grains used as human consumption.<br>• Grains also used to feed | Protein – 12.5<br>• Fats- 1.1<br>• Total fiber- 2.2 |

| | | | | |
|---|---|---|---|---|
| | | | for animals such as poultry.<br>• The grains are boiled as a rice, and cooked into porridge, ground and baked into chapatti and also cooked with milk to prepare kheer. | • Carbohydrates- 70.4<br>• Potassium- 0.20<br>• Phosphorus- 0.21<br>• Iron – 0.001<br>• Energy (KJ)- 1582 |
| 6 | *Macrotyloma uniflorum* (Lam.) Verdc. | Kolath | • It is an extremely drought resistant crop.<br>• Used as food to make popular and regular dishes.<br>• Crop is resistant to extreme wheather conditions and can grow when the monsoon fails and farmers are unable to plant any other crops. | • Protein – 21.73<br>• Fats- 0.62<br>• Total fiber- 7.88<br>• Carbohydrates- 57.24<br>• Potassium- 1.06<br>• Phosphorus- 0.30<br>• Iron – 0.009<br>• Energy (KJ) - 1379 |

*Source:https://hpbiodiversity.gov.in/Pdf/Traditional%20Food%20Grain%20Crops%20of%20Himachal%20Pradesh.pdf*

## STORAGE

The grains and seeds are stored to protect and maintain their value for future use. In Kullu valley local people use large wooden boxes called ‘Kothad’ and ‘dath’ to store grains (Fig. 1). Therefore, whenever they wanted to use grains for food or sowing only then the grains are taken out of the storage boxes/ container.

**Fig. 1.** Traditional method for Storage of seeds in ‘Kothad’ and ‘Dath’ in Kullu valley

**Fig. 2.** Cultivated *Eleusine Coracana* (Kodra) in Kullu Valley

Traditional seeds have great potential for growing in the adverse condition and don't need more maintenance, labors so it is very economical for farmers. This article highlighted the importance of traditional seeds as a climate-resilient seeds. These practices should be promoted at village level with the help of seed bank so we can develop climate-resilient society.

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# ORGANIC MULCHING: A TRADITIONAL AGRICULTURE TECHNIQUE FOR MODIFICATIONS OF SOIL ENVIRONMENT IN RAINFED AREAS OF HIMACHAL PRADESH

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Agriculture is the main occupation of the people of Himachal Pradesh with around 76% of population securing their livelihood and contributes around 9.4% to the total GDP of the State. Whereas, 80 percent of the total cultivated area in the state is rainfed. As rainfall is the only source of moisture to crops, therefore it is a constant objective of the agricultural production system to increase soil moisture retention particularly in Himachal Pradesh. Therefore the farmers have evolved the practice of mulching the soil especially for soil moisture conservation. Mulching can be done using the crop residues, straw, dry plant leaves, pine mulch, twigs, saw wood dust and bark to provide a protective cover on soil around the plants. Usually farmers in ignorance burn residue left after harvesting of crops. However, same can be used as organic mulch, which is mainly being practiced in organic or natural farming in the state as one of the major elements "*acchadana*" in Zero Budget Natural Farming (ZBNF). Organic mulching is mainly seen as one of the major water saving techniques, because it can slow down the water consumption rate by limiting evaporation losses from both above and below the soil surface and assure the minimal water consumption and also decreased soil erosion in rainy season. However, mulching, especially organic mulching has the ability to enhance the soil's physical characteristics, chemical environment and biological activity. The physical state of the soil beneath mulch is improved by a favorable alteration of the soil hydrothermal regime, improvement of soil aggregation, prevention of erosion and therefore minimizing soil loss (Chalker, 2007).

## EFFECT OF MULCHING ON SOIL ENVIRONMENT SOIL MOISTURE CONSERVATION

A bare soil's ability to absorb irrigation or rainfall water is reduced when it is exposed to heat, wind and is more vulnerable to compaction and erosion losses. Whereas, mulches help the soil retain more water, experience less evaporation and do not support weed growth. It has been observed that straw mulch can reduce evaporation losses from soil by 35%. Organic mulches are more effective at conserving water and do not restrict water infiltration or retention. The use of irrigation may be reduced or even completely eliminated in some settings with the use of the right mulch. Coarse organic mulches protect soil water reserves holding water for later release soil and therefore prevent runoff losses. Mulch can also protect trees and shrubs from cold damage and drought stress.

## REDUCED COMPACTION AND SOIL EROSION

Mulches shield the soil from wind, water and traffic-induced compaction and erosion, all of which are major causes of root stress and poor plant health. Utilizing straw mulch, pine needles or wood chips as mulch can lessen runoff impact and therefore can reduce erosion. On compacted urban soils, applying bark or jute restores soil aggregation and porosity. Mulch application is preferably done prior to compaction, since it is hard to undo. Mulching proactively will safeguard soil integrity.

## MAINTENANCE OF IDEAL SOIL TEMPERATURE

Mulches have the tendency to reduce soil temperature. Extreme soil temperature can kill fine plant roots, which can lead to stress and further root rot. Mulches shield soil from extremely hot or cold conditions. Compared to heavy layers of finely textured mulches, coarse mulches are more effective in controlling temperature and facilitating greater water and gas transport. The type of mulch has an impact on how warm the surface is. Some mulches heat the soil as a function of solar radiation absorption more than bare soils. Pine bark mulch is reported to increase soil surface temperature.

## BETTER SOIL NUTRITION

Organic mulches can increase nutrient levels depending on mulch type, soil chemistry and particular nutrients of interest. Organic residue used as mulch in soil further decays and turns into an important component of the soil. It is observed that proportion of biocomponents in soil is raised to the optimal level of 5% by the application of organic mulching materials. This indicates that the soil fertility can also be enhanced by this traditional approach. Mulches with relatively high nitrogen content often results in higher yields, while low nitrogen mulches, such as straw, sawdust and bark can also increase soil fertility by adding humus.

## REDUCED SALT AND PESTICIDE CONTAMINATION

Mulches reduce salt concentration in soil. As mulches are able to retain water in the soil and their coverage prevent evaporation. Organic mulches can actively accelerate soil desalinization and helps in degradation of pesticides and other contaminants. Plastic mulches are not able to bind ions as organic mulches can and are not effective in this regard.

## ENHANCED PLANT ESTABLISHMENT AND DEVELOPMENT

Mulches promote root establishment, seed germination and survival of the plant. In comparison to bare soil, mulch improves water retention, allowing roots to develop and grow beyond the trunk. Plants thus become more stabilized. Root development is greatest under organic mulches compared to inorganic plastic mulch or bare soil. Sheet and film mulches encourage root growth on top of the mulch, injuring plants when removed. Plastic mulches can lead to increased mortality of transplanted material and cause extensive damage to fine root systems. Roots tend to grow into organic mulch layers, and it does not appear to injure the plant to have roots exploring a mulch layer.

## REDUCED WEED GROWTH

The germination and development of many weeds can be controlled by mulching. The mulches can cover the soil surface or work like a physical barrier for the germination of weeds and reduces light, which stresses existing weeds. The less weed intensity is recorded in straw mulch plots compared to the un-mulched plots.

*Practice of organic residue mulching in Pomegranate crop*

*Use of Pine mulch in seed beds*

## CONCLUSIONS

Mulching with organic materials has the potential to increase the soil nutrients, maintains the optimum soil temperature, restrict the rate of evaporation from the soil surface, restrict weed growth and prevent soil erosion. It enhances the physical, chemical, and biological characteristics of soil. The organic mulches are decomposing easily and increase the organic carbon in the soil which helps to improve soil health and serves as food for the beneficial microorganisms. Organic mulches also have several other significant advantages like they are environmentally benign and enhancing the soil fertility with helpful nutrients. It could maintain the soil moisture and increase water use efficiency. Organic mulching materials are cheap materials; therefore the cost of mulching is economical. Therefore, it can be concluded that the organic mulches offers a more beneficial opportunity for farmers of rainfed areas.

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# SUSTAINABLE LIFESTYLE PRACTICES FOR ENVIRONMENT CONSERVATION IN HIMACHAL PRADESH, INDIA

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## ABSTRACT

Global trends right now are really concerning. Raw material and product usage has dramatically increased in recent years.India's per capita carbon footprint is 60% lower than theaverage global value.This is due to the fact that our way of life is still based on untenable traditional approaches.Three important aspects of sustainable development are economic growth, environment, and health.Nowadays, one of the most important factors influencing health and environment is human lifestyle. This unsustainable consumption puts a stress on natural resources and has long-term effects on the environment. Traditional practices that are environmentally friendly and sustainable are still a part of daily life in many areas in Himachal Pradesh. There are numerous examples of sustainable practices and community initiatives found in the state, and some of these practices and community initiatives have been recorded in this article, so these initiatives should be encouraged more and adopted more by the communities in other areas. Adopting alternative fuel practices such as solar energy and solar powered buildings like *mud* and *kath-kuni* architecture houses which acts as insulators making them all-weather houses. In order to meet the water demands, various traditional water storage practices like '*baoris', 'kulhs'*, etc. are still being used in the villages of Himachal Pradesh. Environmentally friendly technology '*Tar Span*' gravity goods ropeways basically used to transport goods in rural areas. It is non-motorized mode of transportation and does not cause air pollution by emitting $CO_2$ or any other gases.Government is also providing subsidies for adopting e-vehicles in the state. Therefore, all these sustainable traditional practices shall be adopted in other places too for conserving and sustaining environment.

**Keywords:** Sustainable Lifestyle, Environment, Conservation practices, $CO_2$ and Traditional solar energy.

## INTRODUCTION

Unsustainable lifestyles and patterns of production and consumption have negative effects on the environment and are now broadly acknowledged (http://moef.gov.in/wp-content/uploads/2017/08/Lifestyle-Brochure_web_reordered.pdf). The Inter governmental Panel on Climate Change (IPCC) claims that factors such as population size, economic activity, lifestyle, energy usage, land use patterns, technology, and climate policy are the key contributors to anthropogenic greenhouse gas emissions (GHG) (IPCC, 2014). Further more, livelihoods, lifestyles, behavior, and culture have a significant impact on climate change

susceptibility, GHG emissions, and the ability to adapt and mitigate. Improvements in consumption practices, the implementation of energy-saving measures, dietary changes, as well as the reduction of food waste all can significantly reduce emissions. Therefore, there is a need for change in general attitude and behavior toward sustainability needs to shift. Traditional practices that are environmentally friendly and sustainable are still a part of daily life in India. These should be supported rather than supplanted by more advanced methods. Since many years ago, our Indian society has been living sustainably by reducing, repairing, reusing, recycling, and discarding, with the values of sharing and caring. But over time, the western world's impact, our country's globalization and liberalization policies, and the unparalleled acceleration of scientific and technological advancements have altered consumer behavior (Mohanty, 2012). This results in excessive consumption and puts great stress on natural resources. Anthropogenic activities such as deforestation, mining, and over harvesting of natural resources have resulted in global warming and climate change (Schuetzenmeister, 2009).
(file:///I:/life%20style%20for%20environment/18591648.pdf)
"A sustainable lifestyle means rethinking how we buy, live, and organize our daily lives is necessary for a sustainable existence (UN, 1992). It also involves changing the ways in which we communicate trade, share, educate, and create our identities. It entails changing our cultures and coexisting peacefully with nature. As citizens, many of our decisions - regarding energy consumption, transportation, food, waste, communication, and solidarity - at home and at work help to create sustainable lifestyles". A sustainable way of life is essential for lowering greenhouse gas emissions. The sustainability guidelines advise reducing travel, utilizing sustainable energy sources, and conserving natural resources in daily living to lessen the exploitation of our finite natural resources.This contributes to keeping our planet safe and green. All of the steps we take to live sustainably will assist our nation in reaching the Sustainable Development Goals (SDGs). Therefore, the main aim of this study is to document some of the traditional, sustainable and climate-friendly lifestyles forthe environment.

## FINDINGS AND DISCUSSION

The word LiFE means the Lifestyle for the environment. Due to today's lifestyle, there is a need for all of us to join hands and take steps toward a sustainable lifestyle (Bozkurt and Ergen, 2018). These steps can become a great step towards an environmentally conscious lifestyle.
(file:///I:/life%20style%20for%20environment/Brochure_LIFE_vf_with_Cropmarks_19042022.pdf). A growing number of methods are being developed to meet needs while reducing carbon emissions. Using traditional processes and recycled garbage, a range of minimal impact dwelling designs have been constructed.In addition to these technology options, there are a number of societal and cultural approaches.

## HABITS AND CULTURE

People are more inclined toward necessities for their consumption and have a deep responsibility to minimize wasteful consumption. It is estimated that of the total population of Himachal Pradesh state, around 89.97 % live in the villages of rural areas, whereas 10.3 %

live in urban areas (Himachal Pradesh Census Data, 2011). The inhabitants of rural areas are close to nature and follow an economical lifestyle who consumes less as compared to urban communities.There are different skills and local practices which are still followed by the people in their life style from one generation to another generation to continue the tradition and balance the consumption.To attain their basic requirements, local inhabitants rely on agriculture, organic farming, skilled labour and other climate-friendly practices rather than high energy-based products. Most of the items used on a daily basis are handmade and constructed of materials from locally available resources. Which help them not depend on another source of power, for example handloom and "*khadi"* etc. (Fig. 1)

**Fig.1. a.** Weaving **b.** Shoes

Rural inhabitants also live in their traditional houses such as '*Kath kuni'*.'*Kath Kuni'* is the environment friendly, sustainable, vernacular architecture of hilly regions of Himachal Pradesh especially Kullu district (Fig. 2).

**Fig. 2. (a)** "*Kathkuni"*environment friendly, sustainable, vernacular architecture of hilly regions of Himachal Pradesh

**(b)** Mud House in Lahual and Spiti , Himachal Pradesh

The origin of the architecture there is no such written information available but the knowledge has been passed orally from one generation to another. It evolved with time according to climatic conditions, culture, resource availability and peoples need. Himachal Pradesh is a seismic zone IV and V state where earthquakes occur. There is number of natural calamities viz. flash floods, cloudbursts etc. that occurs in the area beside earthquake. The characteristics of this architecture viz. strength, stability (due to stone and wood), flexibility (due to fillers and no cementing agent) make it earthquake resilient and Environment friendly.Its vernacular architecture, keep it warm in winters and cold in summers, thus leading to reduced usage of cooling and warmer appliances in homes. People also maintain their places of worship, such as temples, along with the nearby bathing ghats, gardens, ponds, and sacred trees because they recognize the sanctity and importance of nature and its ecosystem.

Mud houses are also sustainable and environmentally friendly architecture. Because it is extremely malleable and provides better insulation than steel-and-concrete structures; it decentralizes the construction process by utilizing local techniques and materials, eliminating the need for a contractor; and mud buildings are much less expensive to maintain.
(https://www.downtoearth.org.in/indepth/mud-housing-is-the-key-30237)

## FOOD AND AGRICULTURE

Food production, processing, marketing, consumption, and disposal entail significant environmental externalities due to the use of energy and natural resources and associated GHG emissions.According to FAO, there are 1.6 gigatonnes (Gt) of "primary product equivalent" wasted globally each year, yet only 1.3 Gt of that waste comes from edible food (FAO, 2013, 2011). Also the carbon foot print from food wastage has been estimated at 3.3 $GtCO_2$ equivalents. About 54 % of overall wastage is accounted for by upstream wastage, which includes production, post-harvest handling, and storage, while 46 % is accounted for by downstream wastage, which includes processing, distribution, and consumption (FAO, 2011). Transportation is also one of the fastest-growing sources of Green House Gas (GHG) emissions worldwide. Local markets provide easy access to locally grown products acquired from neighbouring rural areas, eliminating the need for shipping and packaging.Therefore, local communities mostly depend on the local markets to sell their products such as vegetables, cereals, fruits etc.

In Himachal Pradesh state, natural methods of food preservation are cold storage (Lahual and Spiti district) for the consumption and protection of vegetables for next six winter months (Fig. 3 a). By using this process they neglect the usage of electricity to make vegetables fresh for next six months. Also frequently used natural food preservation technique, include neem (*Azadirachta indica*) as a biopesticide and natural disinfectant, sun drying, salting pickles, and storing grains in native structures such as '*kothad*' (Fig. 3 b). The local communities practise natural farming such as using cow dung and urine in their agricultural field helps to improve the soil quality and also increases the natural species of earthworm and maintains moisture content in the soil.

**Fig. 3 a.** Cold Storage in Lahual&Spiti district, Himachal Pradesh **b.** Storage for grains 'Kothad'

## ALTERNATIVES TO ENERGY INTENSIVE PRACTICES

One of the most plentiful and readily available energy sources on our planet is sunlight. A growing number of people are using solar energy to complement their energy needs. The advantage of using this renewable energy is, it reduces carbon footprint (Green, renewable sources of energy don't release carbon dioxide or other harmful pollutants into the atmosphere) (Fig. 4).

**Fig. 4.** Solar Energy used by local inhabitant

Lahual and Spiti, and Upper Kinnaur, which are located in the Trans-Himalayan cold desert belt of Himachal Pradesh, have a 6-month long winter with temperatures as low as -30 degrees Celsius. Further more, vegetation is limited due to its high altitude (the average altitude is 3700 m.asl) and harsh winter environment. This makes fuel wood very limited, and the majority of the winter stock is imported from outside and distributed to the local community at a hefty subsidy by the government. Further more, the use of wood, coal, manure, and other materials to cook, heat water, and heat their homes puts a strain on the environment and contributes to the consequences of global warming and climate change. Despite the fact that Lahual and Spiti is extremely cold in winter, but in summer it has an abundance of sunny days. During the winter, simple solar systems based on passive solar concepts and the use of locally available materials are being utilized as tools to establish new economic avenues by the local community. Greenhouses, poultry farming, handicraft development, and solar dryers for fruit processing are just a few examples of these activities. The same technique is also being utilized to reduce the usage of fuel wood during the winter,

which helps to reduce greenhouse gas emissions (https://www.spitiecosphere.com/conservation_climate_change.htm).

## ENERGY EFFICIENT BUILDINGS

It is a south-facing building that incorporates passive solar architecture to capture heat (through an attached greenhouse, double glazing windows, or trombe walls) and thermal insulation to keep the building warm inside. The techniques use natural materials (dung, straw, and mud brick) to increase access to reliable, sustainable, and economical energy. Passive solar buildings are greatly enhancing the lives of the residents in these rough and harsh climatic zones, as well as helping to reduce greenhouse gas emissions.Over the previous three years, 75 passive solar cottages in the Spiti valley and 10 in Lahaul have been built (https://www.spitiecosphere.com/conservation_climate_change.htm).

## WATER RESOURCES

Himachal Pradesh is blessed with a variety of natural water resources that are utilised to fulfill the daily water needs. Water is an essential necessity for humans and one of the life's most important supporters. Water resources are used for agriculture, domestic, industrial and environmental activities. There are various practices which are followed by the local communities of the state to conserve these water resources. Traditional structures such as '*Baoris', 'Kuhls'*are example of efficient conservation anduse of natural resources (Fig. 5).

Kuhls are a traditional irrigation system in Himachal Pradesh, consisting of surface channels that redirect water from naturally running streams (khuds). The kuhls were built and maintained by the villagers. These channels used for irrigation system in Himachal Pradesh. Other practices followed by the local communities are 'Naula'. It is a surface–water collection practices common in Himachal Pradesh. These are little wells or ponds that collect water by building a stone wall over a stream. These types of water conservation practices should be followed or encouraged more to conserve water (http://www.rainwaterharvesting.org/Rural/Traditional3.htm).

Other water conservation structure/practice in Himachal Pradesh is '*Khatris'*. '*Khatris'*are square, deep trenches dug into the sides of hills composed of solid rocks, where rainwater is collected through seepage from the rocks. The Himachal Pradesh districts of Hamirpur, Kangra, and Mandi are home to the majority of these traditional water storage structures. Khatri's primary function is to collect rainwater that seeps through the rocks and soil of mountainous areas rather than surface runoff. (http://cpreecenvis.nic.in/Database/Indigenouswaterconservationsystems_3793.aspx?format=Print)

**Fig.5.** Traditional structure *Baoris* to collect water.

## TRANSPORTATION

Today, transport contributes for over 23% of total energy-related CO2 emissions, with road transport contributing for 17-18% (Sims *et al*., 2014, UNEP, 2015). In urban areas, due to growing number of passenger cars in cities, transportation is becoming one of the most difficult concerns. Therefore, electric vehicles appear to be a novel and unique solution to protecting environmentally sensitive areas from air pollution. E-vehicles generate zero direct emissions, which not only improves air quality but also reduces gas emissions in urban and Himalayan areas. Adopting EVs will be a helpful step (Chand, 2019). Electric vehicles will not only enhance energy security, reduce greenhouse gas emissions, and improve air quality, but also enable new economic development possibilities and technological development in the transportation and electrical sectors.
(https://www.tribuneindia.com/news/himachal/electric-vehicle-policy-approved-to-be launched-in-2-tourist-towns-in-himachal-346018).

The construction of roads in mountain regions makes them more vulnerable to landslides and other disasters. Alternative technologies, such as dieselspan operated by fossil fuels, emit a huge number of atmospheric pollutants. Alternative means of transportation like gravity goods ropeway are a sustainable transport solution for mountain rural communities, which also increase their involvement in the local economy. It is a sustainable practice which is used by the local communities of Himachal Pradesh. It is a very easy and simple technology that can be operated or maintained by the local communities. This technology is environmentally friendly because it is non-motorized mode of transportation and does not cause air pollution by emitting $CO_2$ or any other gases (Laxman, 2009, Yadav and Khura, 2015). To minimize carbon emissions, gravity goods ropeways are a sustainable technology that should be encouraged more in the hilly region.

## CONCLUSION

Sustainability has always been a part of our lifestyle (tradition, culture and values). Sustainable movements like LiFE seek to transform persons into ‘pro-planet people’, who would adopt sustainable lifestyles. Therefore, sustainable way of life is essential for lowering greenhouse gas emissions and keeping our planet safe and green. Traditional practices of Himachal Pradesh are contributing to sustain the natural resources. Local inhabitants of

Himachal Pradesh rely on agriculture and horticulture for their livelihood. Inhabitants are still practicing natural farming by using cow dung, cow urine; neem leaves etc. in their farm. Sacred grooves are also contributing to conserve the natural resources such as forests and water resources. In order to reduce food wastage, inhabitants prefer selling their products in the local markets, which not only reduces the cost of transportation, but also provide fresh and healthy food at their doorsteps. The inhabitants are also adopting alternative fuel practices such as solar energy and solar energy buildings like mud and *kath-kuni* architecture houses which acts as insulators making them all-weather houses. In order to meet the water demands, various traditional water storage practices like *baoris, kulhs,* etc are still being used in the villages of Himachal Pradesh. In order to reduce $CO_2$ emissions, local communities are practising Tar-span,which is environmentally friendly because it is non-motorized mode of transportation and does not cause air pollution by emitting $CO_2$ or any other gases. The state government and central governmentare also providing subsidies for adopting e-vehicles in the state. All these sustainable traditional practices shall be adopted in other places too for conserving and sustaining the environment.

Environmental deterioration is increasing $CO_2$. However, it is not just up to the government to take action; each person must re-evaluate their own way of life in terms of consumption habits and rates. This necessitates a comprehensive and serious evaluation of people's actual needs as opposed to desires. Individual habit change involves work and assistance on various levels.

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# TRADITIONAL WASTE MANAGEMENT IN AGRICULTURE

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## INTRODUCTION

Agriculture wastes are defined as the residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops. The product obtained from production and processing contain material which can provide benefit to man but the economic values less than the cost of production, transportation and processing for beneficial use. The agriculture waste can be in form of solids, liquids and slurries. It is also called as agro-waste which consists of animal waste (animal carcasses and manure), crop waste (sugarcane bagasse, corn stalks,drops and culls from fruits andvegetables, prunings), food processing waste (only 20% of maize is canned and 80% is waste), and hazardous and toxic agricultural waste (pesticides, insecticides and herbicides etc). It has been estimated that almost 998 million tonnes of agriculture waste are produced annually (Agamuthu, 2009). The importance of recycling of agriculture waste includes reduction in greenhouse gas emission and use of fossil fuel. Moreover, it also contributing significantly in the development of new green markets, conversion of bio-energy, bio-conversion of solid agriculture waste to animal feed and creation of jobs (McCormick and Kautto 2013; Scarlat *et al*., 2015).In this article, we intend to explore the agricultural wastes and how they can be properly managed.

## TRADITIONAL AGRICULTURAL WASTE MANAGEMENT SYSTEMS

The agricultural waste management for ecological agriculture and sustainable development has become an issue of concern for policy makers. There are options how different agricultural waste could be handled and there is need to focus people's attention on efficient ways to managing these wastes. Agriculture waste management system consists of six basic functions and these are given below in Fig 1. These are production, collection, storage, treatment, transfer, and utilization. The function production is the nature and quantity of agricultural generated waste. Such waste is only requiring management if the produced quantity is sufficient enough to become a resource concern. Collection refers to the initial capture and gathering of the generated waste after identifying method of collection, location of collection, scheduling of collection, labour requirements, necessary equipment or structural facilities, management and installation costs of the components and the impact that collection has on the consistency of the waste. The storage function has to do with the temporary containment or holding of the waste. This storage function provides control over the scheduling and timing of the system functions such as the treatment and application or use of the waste which could be affected by weather or interfered with by other operations.

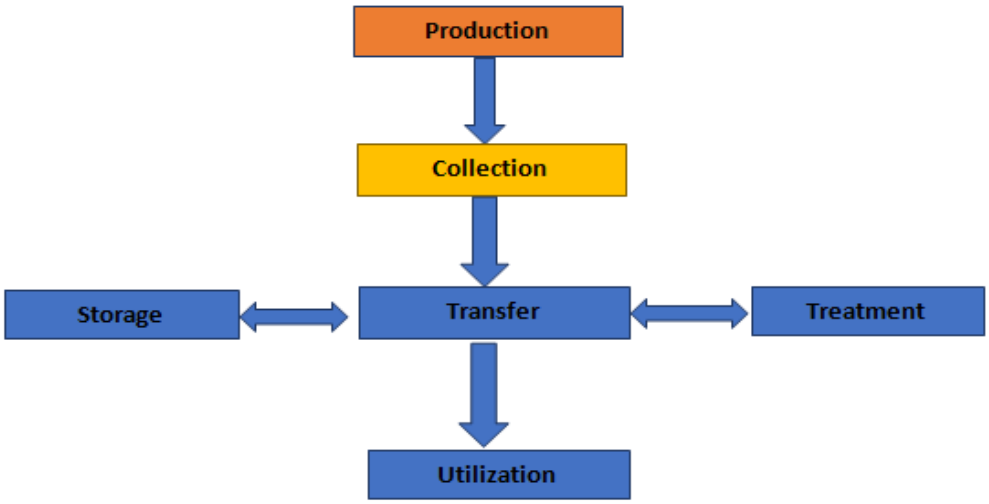


**Fig. 1.** Agricultural Waste Management Functions

The treatment function is designed to diminish the pollution or toxic potential of the waste. This function including physical, biological, and chemical treatment and increases its potential beneficial use. Transfer refers to the movement and transportation of the waste throughout the system from the collection to the utilization stage either as a solid, liquid, or slurry, depending on the total solids concentration. Utilization is the application of the waste for beneficial use and it includes recycling reusable waste products and reintroducing non-reusable waste products into the environment (USDA, 2012). The detailed agricultural waste management system alternatives are shown in Fig 1.1

**Agricultural Waste Management System Alternatives**

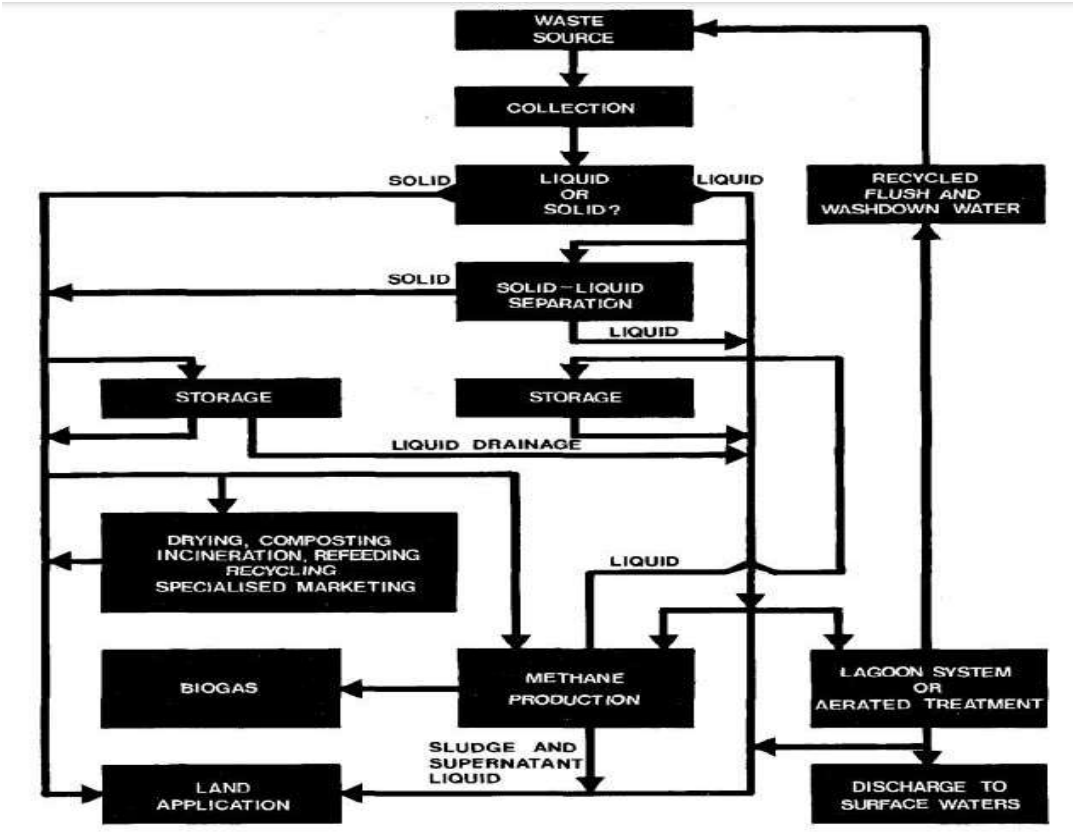


**Fig. 1.1** Agricultural Waste Management System Alternatives

### 1.1 The '3R' Approach to Agricultural Waste Management

Waste minimization efficiency is stated to be better achieved applying 3Rs in a hierarchical order- Reduce, Reuse and Recycle (Fig. 2). The concepts of minimizing waste lessen the quantity and ill-effects of the generated agricultural waste, reusing and recycling of the waste products by simple treatments as resources to produce same or modified products. This is usually referred as '3R'.The principle of reducing waste, reusing and recycling resources and products (3Rs) aims at achieving efficient minimization of waste generation by:

- Choosing to use items with care to reduce the amount of waste generated.
- Repeated use of items or parts of items which still have usable aspects.
- The use of waste itself as resources

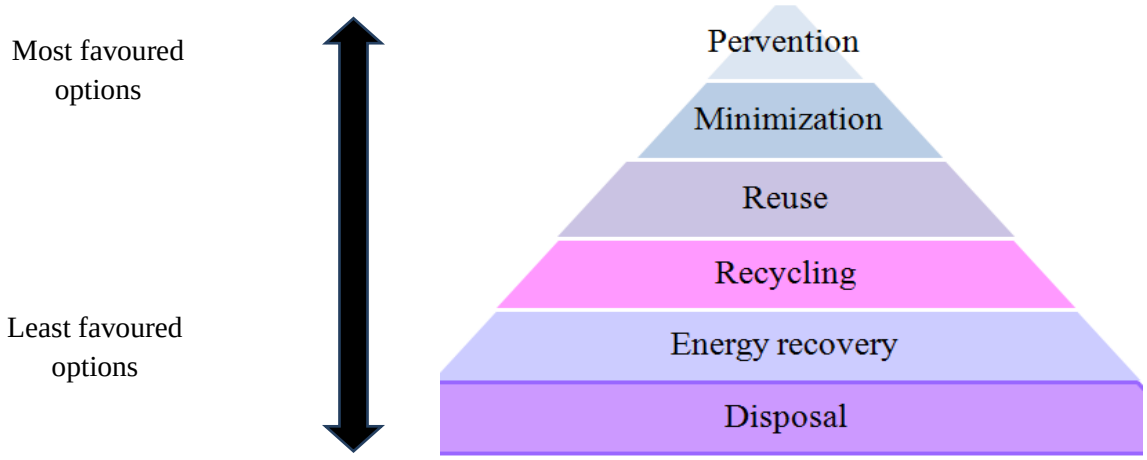


**Fig. 2.** The 3R's Hierarchy

The 3Rs are meant to be a hierarchy, in order of importance. The waste hierarchy has taken many forms over the past decade, but the basic concept has remained the foundation of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The 3R approach is conventionally expressed through a pyramid hierarchy in which increase in environmental benefits of each approach is placed from bottom to top.

## CONCLUSION

The residues of agricultural wastes from the growing and dispensation of raw agricultural produce may contain material that can benefit man. These generated residues are from various agricultural activities and they include cultivation, livestock production and aquaculture. These wastes when managed properly through the application of the knowledge of agricultural waste management systems such as the "3Rs" can be transformed into beneficial materials for human and agricultural usage. It is important to note from the findings so far that proper waste collection, storage, treatment, transfers, and utilization is a panacea to a healthy environment. Proper waste utilization will assist in developing our agricultural sector and provide viable biofuel resource for many.

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# STRENGTHENING THE RESILIENCE OF HILLY SCHEDULED CASTE COMMUNITIES BY PROMOTING RESPONSIBLE NATURAL FISH FARMING

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An adage about farmers being "**Mud-Magicians**" who turn dirt into cash is undeniably true. A cluster of Scheduled Caste fish growers in the Harinagar hamlet of the Bhimtal block of Nainital, Uttarakhand, have made this a reality. The community is located in a precipitous hill side village, at a distance of about 7 kilometres from Bhimtal and spread over an area of around 10 square kilometres. Villagers typically rely on agriculture and cattle for their livelihoods, while the heads of households are mainly involved in daily wage work. The majority are small and marginal Scheduled Caste fish farmers and earn a meagre income. An ample opportunity to develop fish farming in the region is there owing to the availability of a perennial water source, *Ghatigar,* an outgoing water channel from Bhimtal Lake that flows east of the hamlet from top to bottom (Fig. 1). In addition to ensuring the villagers have access to healthy food, this can also provide them with a means of generating additional income.

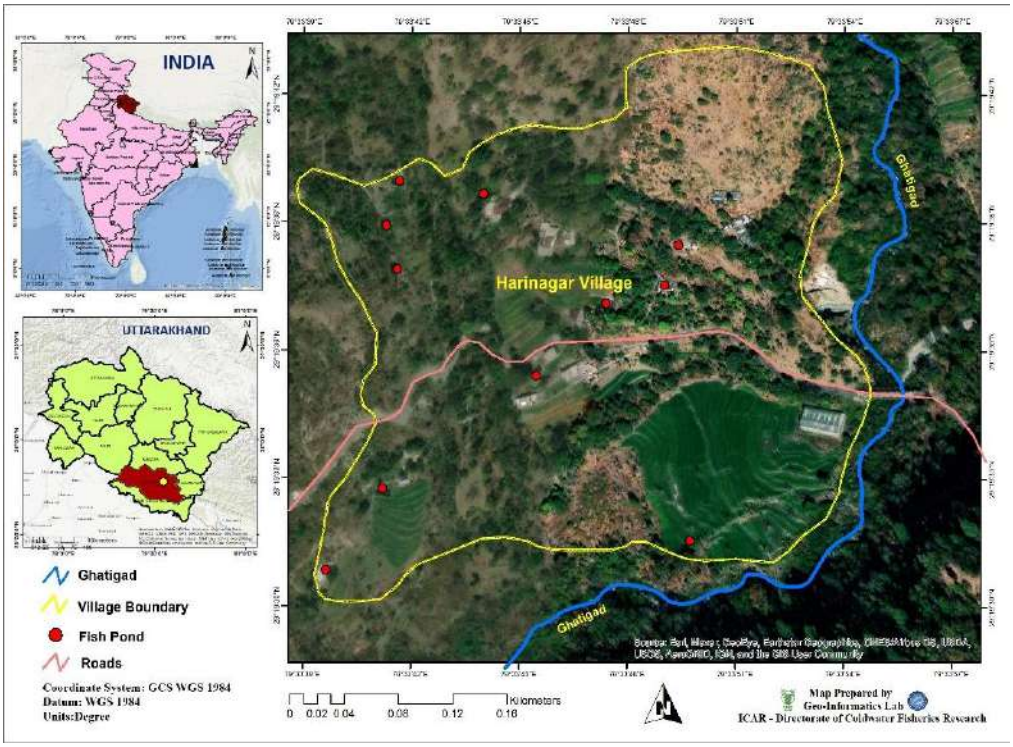


**Fig. 1.** A map of the study area Harinagar shows the locations of the representative fish ponds as red dots, and the river's path as a blue line, which runs along the hamlet's edge.

The selection of beneficiaries in a cluster was done with the intention of achieving the overall goal of improving the socio-economic conditions, minimizing outside dependence with self-sufficiency in inputs for fish farming. The size of each tank ranges anywhere from fifty to

two hundred square meters, and there were a total of thirty functional ponds and tanks at the time of intervention.

Issues relating to the socioeconomic state of the cluster, the baseline status of existing aquatic and land resources, and the aquaculture methods that were being followed were gathered before interventions were carried out. It was decided to prioritize the most significant problems and devise solutions to those limitations. Harinagar is situated in a relatively small valley, making it warmer than neighboring mountain regions. The water temperature in the valley can reach up to 28-29 degrees Celsius during the summer months, making it an excellent location for the cultivation of carps during that time of year. Harinagar hamlet was one of the many communities in the area that were adopted by the institute in Bhimtal as part of this initiative. The base line information and field survey revealed that the fish farmers were stocking the pond with small fry ranging in size from 25 to 40 mm, comprised of exotic and Indian Major Carps (IMC). The damaged pond embankments and water seepage were a big problem, with low retention of water up to 2.5–3.0 ft, occasional feeding with available household resources, and limited knowledge of scientific fish farming, including feeding and health monitoring, were the common issues reported.

The first step in the intervention was training on fish farming for the capacity building of the beneficiaries. In the beginning, three fish farmers received Agricultural Skill Council of India (ASCI) training at the ICAR-DCFR, Bhimtal for a period of one month on aquaculture farming. Later, training was imparted on a variety of topics, including pond preparation, pre and post-stocking fish management, value addition, and saving fish farms during natural disasters. Topics were chosen based on the feedback of the farmers, taking into account the areas of climate, agricultural activity, and season. The interactions took place primarily in the villagers' free time. Over time, this contributed to the improvement of fish farmers' competence, awareness, and outlook. The measures to be adopted for minimizing the loss during extremes like provision of inlet and outlet pipes, water quality monitoring kits, nets, extra holding tanks at the time of emergency, oxygen cylinders, provision for quick market transport and suitable site selection in case of new pond construction, etc. were identified.

During the COVID-19 pandemic, around four earthen ponds were constructed and approximately seven were repaired through *Sharmdan* (a voluntary and collaborative effort by the villages to aid the community and contribute to helping and transforming the pond environment). The majority of ponds were earthen and provides a natural environment. In pre-stocking management, cowdung, single super phosphate (SSP), and mustard oil cake (MOC) were applied at rates of 5,000 kg/ha, 50 kg/ha, and 700 kg/ha, respectively, (scaled down to actual pond size) to promote the growth of natural fish food organisms (phytoplankton and zooplankton) and enrich the pond habitat. This helped in reducing the cost of artificial feed and production costs. Following that, cage-reared stunted carp fingerlings of ICAR-DCFR, Bhimtal were stocked into these ponds at a rate of 4–5 fish per $m^2$. Under the Directorate's scheduled caste sub-plan (SCSP) programme, adopted scheduled caste (SC) fish farmers received regular supplies of pelleted feed with 28% protein. About nineteen ornamental goldfish were stocked with the carp to help increase income generation. HDPE water pipes, nets, and covering current nets were also provided for empowering and developing self-sufficiency. At the end of approximately 12–18 months, the average growth of stocked common carp and grass carp ranged from 700 to 1100 g, with a significant improvement in production and productivity.

**Important scientific interventions and best management practices include:**

Regular interactions with fish farmers for technical guidance

Stocking of quality stunted carp fingerlings

Basal manuring for optimizing the pond environment

Pond raking at regular intervals

Diversification of species through gold fish stocking

Utilization of balanced pelleted feed and household by-products

Cyclic- stocking and harvesting

Demand-based fish harvest for market supply

Before intervention, average production was 20-40 kg/100 $m^2$

Increased 60-100 kg/100 $m^2$ (2.4-2.5 times higher) in a culture duration of one and a half years

Better growth and income within a short time frame motivate fish farmers to engage in fish farming, and a few additional tanks are being constructed. During the study period, however, frequent excessive flooding was common, resulting in the sudden depletion of the fish population. Proactive preparations such as the provision of a robust outlet system, the availability of high-quality fish-harvesting nets, and other site-specific arrangements would aid in establishing fish farming as a sustainable income-generating occupation in hilly areas with limited agricultural crop potential.

Fig 2 to Fig 11 depicts some of the activities that have been carried out in the village Harinagar.

**Fig. 2**. A representative earthen ponds in village Harinagar, Bhimtal

**Fig. 3.** Distribution of stunted carp seed to fish farmers

**Fig:4.** Farmers receiving ornamental fish for stocking in their carp ponds

**Fig.5.** Capacity building through value addition training and interaction with fish farmers on pond

**Fig. 6.** Pond preparation through *Sharmdan* and seed stocking and harvested ornamental fishes

**Fig. 10.** A representative fish sample from the harvested fish stock (Grass Carp) A fish farmer displaying his harvested stock

**Fig. 11.** An enthusiastic young kid holding the harvested Grass carp and A fish farmer weighing his harvest

# TRADITIONAL AGRICULTURE SYSTEM IN THE HIMALAYAN STATE UTTARAKHAND

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Traditional knowledge is the information that locals have gained through their past experiences and developed over time. The Himalayan area of India is home to numerous ethnic people that are well-known for their traditional expertise in farming methods. Traditional agriculture is special because it is ecologically sound and feasible from an economic, environmental, and social perspective. It develops site-specific agriculture strategies that are suitable to the regional climatic condition and maintains productivity by properly utilizing the readily available local resources. These methods are founded on local knowledge and are adapted to the local context, giving them greater flexibility in situations when other approaches could experience failure. These practical and evidence-based traditional adaptations have now become a part of history. Re-examining and re-implementing ancient agricultural methods are needed for sustainability and conservation. Modernization has wiped out the traditional techniques and disturbed the integrated system of rural resource management and employment generation along with agriculture.

The techniques followed in traditional agriculture in the Himalayan region are performed with minimum mechanization. After much trial and error, people discovered and applied a variety of techniques, from planting seeds to cultivating in the terraced fields of mountainous locations.

## PRE-HARVEST TECHNIQUES

Manure application to enhance soil fertility was prepared from animal's dung combined with the grass spread on the animal shed floor is kept in a heap which undergoes aerobic decomposition in the open air and applied in the field to restore the soil fertility.Ash obtained from the combustion of wood in the rural area is mixed with manure and applied in fields. Ash can supply phosphorous to the plants. Every field has left fallow once in two years helpful in enhancing the nutritional status of the soil. Bullocks performed ploughing operations over the entire hill region (Photoplate 1). A lighter shower has been preferred a day before ploughing. Before sowing seeds are treated with a mixture of cow dung and ash to increase yield and decrease pest damage to the seed.

The crops are produced in rotation. Crops like Mandua, Bhatt, and gahat have been sown in the fields where the wheat crop had been cultivated during the Rabi season. Mandua is a hardy crop that, when grown in an already depleted field can withstand fertilizer and water stress. Leguminous crops like gahat and bhatt can fix atmospheric nitrogen into the soil and withstand low moisture levels. The ancient people were aware that one crop cannot guarantee food security, particularly in regions where agriculture depends on rain. As a result, mixed cropping methods, known as "baranaja" in Uttarakhand, were adopted. Twelve grains that are planted in the same fields and can coexist are referred to as baranaja. Oilseed plants like til,

bhangjeer, sann, and bhang including creeping pulse and legume species like rajma, lobia, bhatt, gehat, naurangi, urad, and mung, as well as grain species like mandua (finger millet), ramdana (amaranthus), kuttu/ogal (buckwheat) were grown which utilize multiple levels of space in the field. The method was sustainable and scientific, ensuring both food and nutritional security. Now due to changes in agriculture methods, the cultivation of cash crops is limited to particular varieties of single crops.

**Photoplate. 1.** Bull driven ploughing

**Photoplate. 2.** Traditionally built kuthar

## CROP PROTECTION TECHNIQUES

One well-known and widely used form of crop protection is the scarecrow. Instead of the use of toxic and harmful pesticides, it is a very effective technique for protection against vertebrates. Typically, it is constructed by hanging a knotted wooden pole in the field with an old cloth filled with straw. It is best to use a bright fabric that makes noise when air is blown, scaring away birds, blue bulls, and monkeys. When mustard crops are attacked by aphids, cow urine is applied to the affected plants. Additionally, firewood ash has been spread to control the aphid problem in mustard.

Crop damage is being caused by white grub (*Holotrichia* spp.) in hilly regions. The damage was most severe during the Kharif season. White grub was once a minor pest but it has now grown to be a severe concern for all crops. Its caterpillar, which remains in the soil and feeds on the roots of crop plants, is responsible for the damage. The most harm was caused to crops like potatoes and reddish ones. Farmers use table salt to control white grub. In one nali area of land, one kilogram of table salt has been sprayed. The alternative way is to disrupt the pest's life cycle by leaving the field fallow for one season.

## POST-HARVEST TECHNIQUES

The crop was collected when it was still in the green stage rather than when it was fully ripe since harvesting a fully matured crop resulted in a significant loss of grain due to shattering. Following that, the farmers collect the plants and arrange them in a pile on the threshing floor. Because the grains weren't adequately ripened, these green plants weren't spread out on the threshing floor. The pile has thus been left for around a week. The harvested plants were spread out on the threshing floor after one week and let to dry in the sun. According to scientists, the crop's production of ethylene is what causes the grains to ripen when they are piled together. A plant hormone called ethylene is released by the crop during the ripening period, and crop stacking raises the concentration of ethylene, which further aids in crop

ripening. Bullock trampling technique was used for threshing. The sun-dried crop is spread on the floor and covered with straw to prevent damage to the crop when bullocks walk over it.When wind blows, a fan like bamboo made material called a "soop" is used to release the grain mixture into the air, allowing the heavier grain to pile up and the lighter chaff to be blown away.

Depending on the seed capacity, people in the Himalayas employ a variety of devices to store seeds, including kondas, manches, bhakhars, kuthars, dalas, and tupairs (Photoplate 2). These objects were crafted from wood or wood bark. They were aware that the grains needed to be protected from dampness and insects. A kuthar was a home-like structure made of pine or deodar or sheesham to protect against insect attack. Ringaal was known as the bamboo of hills and used to create various seed-storage materials. Additionally, this offers locals work through handcraft.

## CONCLUSION

Traditional Knowledge effectively reduces agricultural damage from pests and promotes organic crop productivity and maintains very well seed storage system. All of these time-tested methods, which have been passed down from one generation to the next are efficient at improving crop yields and beneficial to soil health and sustainability. To realize full potential and the socio economic condition of the local farmers, these traditional techniques must be improved in accordance with site-specific requirements on a scientific basis.

# TRADITIONAL NUTRIENT MANAGEMENT PRACTICES IN THE MARGINALIZED AGRICULTURE SECTOR OF KUMAUN HILLS

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Uttarakhand has 53,483 km$^2$ geographical area of which 65% area is covered with forest and 23.6% is under agriculture and associated activities. Agricultural land of Uttarakhand broadly divided into plains (43.2%) and hills (56.8). Agriculture is significant contributor to Uttarakhand's Gross State Domestic Product (11% in 2011-12) and main source of livelihood for over 70% of its population (SDP, 2021).Varity of crops are grown in the state such as rice, wheat, sugarcane, maize, soybean, pulses, oilseeds and a number of fruits and vegetables. Basically, two kinds of agricultural methods are followed by the state farmers i.e., rain fed and irrigated. The largely rain-fed agriculture and very low use of chemical fertilizers and pesticides, provides an opportunity to develop environment and farmer friendly organic farming that provide better value in the market. The soil of *tarai* region is very fertile and supports a number of crops. Indiscriminate use of chemicals and overexploitation of groundwater makes the soil of this region less fertile. On the other hand, the hill region is very susceptible to continuous soil erosion due to steep slopes, and making it less fertile in perpetuity, which could be controlled and mitigation can be achieved through adoption of better management practices. In Uttarakhand, nitrogen-based fertilizer is preferred over others. Although organic farming using organic manure is prominent in state but it is unorganised and has many problems. Due to limited resources in the hilly region farmers mainly used farmyard manure (FYM), based practices for nutrient management in the agricultural field. However, now-a-days vermi-composting (VC) is frequently being used by farmer.

## INDIGENOUS NUTRIENT MANAGEMENT PRACTICES IN THE KUMAUN HILLS

In the Uttarakhand state large number and area is under small and marginal holdings. They use cattle dung for the preparation of agriculture fields. Due to absence of harmful chemicals in this manure, it plays a significant role in development of organic agriculture in this area.

## APPLICATION OF FARMYARD MANURE (FYM)

Farmyard manure (FYM) prepared with animal dung has been the main soil preservative in the region. The manure is prepared by collecting animal excretions with dried leaves and grasses spread on the floor of animal shed in form of bedding material. The dried leaves absorb the urine and excreta of the farm animals. After clearing this animal bedding material from time to time, it is kept with the dung in form of a heap in open areas near shed, after decomposition it become ready for application in the field. In general, it is kept for 4-6

months for the decomposition and nutrient enrichment. The main primary sources of the dung are domestic cattle Goats and Sheep are secondary sources.

## DISTRIBUTION PROCESS OF FARMYARD MANURE (FYM)

The manure prepared by aerobic decomposition is carried out to the field in *Daliya* or *Doka* (Bamboo based baskets, used in carrying manure, grasses etc.) by the women mostly just before the ploughing of field. During ploughing the manure is spread over the field.The reason for the practice is to save the recently sown seed from cold and very low temperature during the winter as the manure generates heat from gaseous oxidation. In some areas it is also reported that farmers make a number of small heaps of FYM in the field. They carry the FYM from their animal shed to field throughout the year, especially during lean period. The FYM from these small heaps is spread into the field just before the ploughing. The small size heaps remain exposed to the sun and rain for a long period in the field, which result is considerable loss of nutrient. In some areas farmers collectively carry the FYM to their field by the sharing of labor. All the farmer (mainly women) of village work together for one farmer by sharing FYM load with one another. In this method all the FYM of the farmer is transported to his field during one or two days. This manure is then spread into the farmer field before of ploughing. This method is helpful in conserving nutrient of the FYM as the manure have not been exposed to the sun and rainfall for a longer period (Photo plate 1).

**Table 1. Physicochemical properties of FYM (Source, Mate *et al*., 2014)**

| Parameter | pH | OC (%) | OM (%) | N (%) | P (%) | K (%) | Zn | Cu | Mn | B |
|---|---|---|---|---|---|---|---|---|---|---|
| FYM | 6.7 | 20.6 | 94.4 | 0.91 | 0.36 | 0.89 | 56 | 2.6 | 240 | 2.3 |

Zn, Cu, Mn and B are in PPM

## USE OF MIXTURE OF ASH AND MANURE

In the hilly region of Uttarakhand, the wood obtained from forest is the important source of fuel and the ash is a by product obtained after the burning of fuel wood. This kitchen based ash is usually mixed with the farmyard manure (FYM) and applied into the field. This practice is primarily used in vegetable crops, such as Potato, Onion and Garlic. This ash containing organic manure improves the soil structure and water holding capacity in addition to supply of nutrient. The ash also fulfils the requirement of phosphorus in the crop field.

## BURNING THE RESIDUES OF CROP

After the harvesting of crop, organic matter of harvested crop takes long time in its degradation which usually leads the farmer to burnt it in the field itself. The residues left over in the field after harvesting is burnt after few days of harvesting. Ash obtained from burning gradually gets mixed in the soil during the ploughing. In some areas the crop residue is burnt with the help of mixing of pine needles locally known as *Pirul*.

**Fig. 1.** FYM heap in the crop field and ploughing of Agriculture field

## CROP ROTATION

In the hills of Uttarakhand, it was observed that the soil loses it nutrient value due to continues crop production in the same piece of land. To overcome this problem farmers use apply the crop rotation system of farming in this region. In this practice of farming different crops are sown sequentially on the same plot of land to improve soil health, optimize nutrients in the soil, and combat pest and weed pressure.In the hill region of Uttarakhand, farmers cultivate crops on a 2-year rotation. In the first year, during Rabi season, wheat (*Triticum aestivum*), barley (*Hordeum vulgare*) and lentil (*Lens culinaris*) are sown. While in the Kharif season, rice (*Oryza sativa*) and barnyard millet (*Echinochloa frumentacea*) are cultivated as mixed crop. In the next Kharif season, nearly 12 or more crops (including finger millet, amaranth and legumes) are cultivated in the intermixed pattern. In this practice, culm of millets and stem of amaranth provide support to the growing legumes, and in exchange, legumes fix atmospheric nitrogen and provide nourishment to other crops. Finger millet is a hardy crop which can tolerate nutrient and water stress when sown in nutrient-poor field, however leguminous crop which are capable to fix atmospheric nitrogen into soil and can develop in low moisture condition. Apart from this, the traditional crop rotation system also helps in the efficient use of rainwater, improves soil health and increases crop productivity. Widespread use of chemical fertilizers ultimately leads to soil deterioration; therefore, yield levels can be effectively increased in a stable and sustainable manner only by adopting organic farming. Thus, the traditional system of nutrient management is important for promoting organic farming in the hill region of the state, as it plays an important role in enhancing soil health and productivity of fields and leads to sustainable agriculture.

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# TRADITIONAL LAND-BASED PRACTICES BY THE COMMUNITIES IN SIKKIM AND THEIR EFFECTIVENESS FOR SOIL AND WATER CONSERVATION

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In the face of great environmental and biophysical change, a significant emphasis has been given in government policies and programs towards soil and water conservation for protection of mountain ecosystem through the use of both, modern and indigenous land - based practices. Techniques for conservation of soil and water are very closely related as majority of the soil conservation methods are the principal methods to conserve water resources as well. In the Himalayan region, soil erosion is one of the most pressing socio-environmental problems in Sikkim Himalayan region. To tackle this problem several traditional land-based practices have been adopted by the farmers of Sikkim, which are broadly classified into structural measures, biological measures and soil fertility management practices. This article presents sixteen dominant soil and water conservation practices traditionally adopted by the farmers of Sikkim Himalayan region (Table 1), which reflects farmers' adaptation towards various changes, including the climate change. Among the sixteen dominant soil and water conservation techniques (Mishra and Rai, 2013), terracing is one of the oldest indigenous conservation techniques adopted by the farmers of Sikkim, along with bunding, construction of waterways and diversion channels. These practices have assisted in regulating and reducing runoff rates and enhancing infiltration by holding water for longer period of time.

In Sikkim Himalaya, there are primarily three types of terraces: levelled, sloping, and reverse terraces. Levelled terrace helps to reduce the rate of soil erosion and prevents mass wastage during heavy rainfall and contributes greatly towards water conservation which results in overall increased land productivity. This type of terracing is mostly used for paddy cultivation followed by maize, mustard, potatoes and vegetables as secondary crops. On the other hand, sloping terraces are the most common type of terrace in Sikkim. They are constructed on large retaining walls located at the base of a steep slope which significantly entraps eroded sediment and controls soil erosion. It is also known as dry fields (Bari) where vegetables, horticultural crops, fodder grasses, trees are grown. Additionally, reverse terrace is less common but more effective in terms of soil conservation, compared to other two types of terraces but the construction cost of which is extremely higher than other two terraces as a result of which construction of such terraces is very limited. Terracing has proven to be effective measure of soil and water conservation in Sikkim Himalaya (Mishra *et al*., 2020) because of its efficacious nature in minimizing the slope gradient, capturing eroded soil, limiting soil movement, controlling runoff, increasing infiltration and ultimately reducing soil erosion. Similarly, bunding method (terrace bunds and contour bunds) is another traditional

method adopted by the farmers of Sikkim. Terrace bunds, constructed at the outer limit of the terraces, help in controlling water flow and extensively used to store water in leveled terraces (paddy fields). Whereas, stone-based contour bunds are built along the edge of the farm to help prevent soil erosion and siltation.

**Table 1.** Land- based Indigenous soil and water conservation practices in Sikkim Himalaya

| **Land-Based Practices** | **Descriptions** |
|---|---|
| **Structural Measures** | |
| Terrace | Narrow strip of land carved out across the hill slopes for the cultivation of cereals |
| Terrace bund | An embankment at the outer edge of khet terrace made to control water flow |
| Contour bund | An embankment built along the contour line to control soil erosion and siltation |
| Waterway | Small canal at the inner toe of terraces made to convey runoff at a non-erosive point |
| Gully control | Plantation of bamboo species to control gully expansion and soil erosion in the hill slopes |
| Diversion channels | Constructed to drain the water to leveled terrace from nearby situated natural drainage ways. |
| Stone barriers | Removal of large stones from the field and deposited downstream |
| **Biological Measures** | |
| Alley cropping | Alternate rows of field crops and perennials grown in a contour pattern in sloping land |
| Mulching | The practicing of covering the plowed land by crop residues and leaf litters for moisture and soil conservation |
| Minimum tillage | Ploughing of field only once during land preparation, which is followed by seed showing |
| Crop rotation | It Involves incorporation of legumes with cereals in a sequence to take advantage of different feeding zones for nutrients and water. |
| Mixed cropping | With growing of main crop (maize etc.) as usual, the vegetables (principally beans or cabbage) are scattered in smaller quantities over the whole field. |
| Vegetative barriers | Establishment of different shrubs and tree species with extensive root systems for rehabilitation and control of landslides |
| Agroforestry | Land use management system in which trees or shrubs are grown around or among crops or pastureland. |
| **Soil Fertility Management** | |
| Farmyard manure | Dung mixed with leaf litter and crop residues used for fertilizing land |
| Green Manure | Plant species containing soil nutrients |

Additionally, farmers in this region have been growing bamboo species, particularly *Bambussa balloca, Dendrocalamus hamiltonii, Bambussa spp.,* and *Arundinaria raccum,* as these species spread quickly and have fibrous root systems with strong soil-binding abilities which plays a crucial role in preventing soil erosion and gully expansion in the hilly terrain. Furthermore, alley cropping has tremendously contributed towards increasing soil moisture and preventing wind and water erosion. Peas, beans, soybean and high fodder-yielding shrub species, like *Bahuhinia variegata, Leucaneia leucocephala* and *Morus indica* are grown as alley cropping in the region. Similarly, farmers have also regarded mulching as an effective

way to increase soil moisture and water retention in farmlands, which are susceptible to significant moisture loss during the dry season particularly during winter and early spring. Mulching also serves as a protective layer for the soil by preventing its erosion. The leaves of Siris (*Albizza odoratissima*) trees are commonly used for this purpose. Generally, 4 tons/ha of mulching considerably reduces the soil loss and runoff from the field (Mishra and Rai, 2013). It has been observed that mulching with rice straw helps in minimizing soil runoff by 18% (Atreya *et al*., 2008).

Likewise, technique of minimum tillage, carried out with animal traction using a wooden plough or a mould board plough, offer minimum soil loss caused by wind and water. Its adoption, however, is determined by factors like the climate, slope, soil characteristics, crop preferences, and other socioeconomic conditions. It has been found that soil loss in minimum tillage plots is often less than that in ploughed plots (Mishra and Rai, 2013). Accordingly, vegetative barrier is a well-known practice adopted in Sikkim Himalayan region which is also known as contour cultivation or contour planting. This method plays a major role in reducing soil erosion and preventing gully formation by decreasing the velocity of runoff and trapping the soil near the roots. The associated vegetative-barriers on the contour consists of grasses and trees on dry field (bari) and pulses on wet field (khet).

Different types of agro-forestry systems, such as farm-based agro-forestry, farm forest based agro-forestry and high value cash crops based agro-forestry characterize Sikkim Himalaya. These practices help in minimizing runoff and maximizing water retention. In farm-based agro-forestry, farmers nurture multipurpose tree species for lumber, fuel wood, fodder on terrace edges, grows a variety of traditional crops on terrace, fruits and fodder bearing trees on terrace riser which significantly helps in trapping surface runoff and soil erosion. Similarly, farm forest-based agro-forestry comprises plantation of multipurpose tree species, which are used for making building, repairs, fodder, and pasture land for seasonal grazing. The best illustration of this agroforestry system is bamboo groves at the edge of agricultural fields which aids in preventing landslides, soil loss and provides household requirements. High-value cash crops-based agroforestry practice comprises of large cardamom (*Amomum subulatum*), locally called alainchi-bari, (Fig. 1.) and mandarin orange (*Citrus reticulata*), locally called suntola-bagan, based practices.

**Fig. 1.** Photograph of large cardamom-based agroforestry practices in Sikkim Himalaya.

The large cardamom is cultivated either under mixed tree species or under *Alnus nepalensis* cover. Likewise, mandarin orange is a major tree crop while intercropping of maize, pulses, ginger, buckwheat, finger millet, pulses, oilseeds, taro and yam are practiced. This

agroforestry system is greatly contributing towards soil conservation. Similarly, use of farm yard manure and green manure has been practiced by the farmers which are contributing greatly in terms of increasing soil organic matter. In the current organic farming scenario of Sikkim state, these traditional land-based practices of soil and water conservation, *viz.* mulching, farmyard manure, green manure, compost, vegetative barrier, play a crucial role in promoting organic practices which are environment friendly and sustainable.

These traditional measures of soil and water conservation are based on farmer's decades-long practices and knowledge, which help to ensure the long-term sustainability of the land and agricultural production. However, the economic condition of farmers has prevented them from implementing all of the soil and water conservation measures at once. Mostly, farmers in the state are marginal and there is great strain on the land owing to population growth; as a result, only biological measures of soil and water conservation are widely adopted by the farmers because these conservation measures are cost-effective and gives higher return in less time. On the other hand, mechanical measures require higher construction and maintenance cost and productivity is very low during initial years. Only farmers with large landholdings tend to invest more in mechanical measures. However, for the interminable soil and water conservation, biological measures must be combined with mechanical measure. Loss of traditional measures is a threat to the valuable indigenous knowledge that has helped farmers of Sikkim to manage their livelihood for generations effectively. Thus, considering the role of traditional practices of soil and water conservation in managing natural resources, policies need to be framed to incentivize and promote marginal farmers for practicing the traditional soil and water conservation approaches.

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# PROMOTING USE OF LOCAL AGRI-HORTICULTURAL PRODUCE AND AGRICULTURAL WASTE FOR SOCIO-ECONOMIC UPLIFTMENT OF RURAL FARMERS IN ZIRO VALLEY, ARUNACHAL PRADESH

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## BACKGROUND

Ziro valley, which lies tucked in the lower ranges of the Eastern Himalayas in Arunachal Pradesh, North-East India, is included in the tentative list of UNESCO World Heritage Sites for its unique cultural landscape. It comprises of about 32 $km^2$ of cultivable area out of 1058 $km^2$ of the plateau and is undulated by small hillocks. It lies at an elevation of 1525 m.s.l. Its mountain peaks range from 1830 to 2900 m.s.l.

The valley is home to the Apatani tribe, one of Arunachal Pradesh's major ethnic groups, with its distinct civilization and colourful culture interspersed with various festivals and displaying intricate handloom designs, cane and bamboo crafts. The tribe also has a wealth of traditional knowledge that has been accumulated over the centuries through informal experimentation, as evidenced by their systematic land use practises, natural resource management and conservation, and vibrant traditional village councils known as Bulyañg.This has crafted Ziro valley an outstanding demonstration of a living cultural landscape in which man and environment have harmoniously coexisted in a state of interdependence even through new circumstances, with such coexistence fostered by traditional customs and spiritual belief systems, which also contribute to the region's socioeconomic development. This represents a vital component of Apatani life that is inextricably linked to the sacredness of their landscape, livelihood, and traditions.

## IMPORTANT BIORESOURCES OF ZIRO

The Ziro valley is endowed with a rich biodiversity, a hard working population, and a quintessential socio-cultural and economic setup, all of which have enormous potential for socioeconomic development through the sustainable exploitation of its humongous bioresources. The recent example of only certified organic fruit, Kiwi, has greatly increased the economic status of Ziro valley and farmers have recognized its potential to be evolved as a significant cash crop. Arunachal Pradesh is India's largest producer of Kiwi, accounting for more than 56% of total production. According to the reports of Economic Survey of Arunachal Pradesh 2016-17, 3379 ha of land is under kiwi cultivation with a production of 6047 tons of fresh fruit.

In contexts of agriculture, the region has a high agro-biodiversity, with 16 landraces of rice and 4 landraces of millet, respectively. Agronomic yield is five times higher than the state average, with a maximum of 55 $qha^{-1}$, and is additionally augmented by the incorporation of fish culture. The paddy-cum-fish cultivation technique of the Apatani tribe has been

distinguished as one of the most efficient and effective farming systems in the area where wet rice production is integrated with fish farming and indigenous millet cultivation. (*Eleusine coracana*). Paddy is grown on the actual field, whereas millet is grown along the bunds that surround the rice fields. Wet-rice farming systems have been reported to grow approximately 16 indigenous rice varieties and 4 millet varieties, which are classified as early- and late-maturing. (Kala, 2008; Dollo *et al*., 2009)

## INITIATIVES FOR SOCIO-ECONOMIC DEVELOPMENT OF LOCAL COMMUNITY

Through various consultations with the local community of the area, including Gram Panchayat leaders, Village Heads, farmer groups and line departments, it was learnt that the area has immense potential for promotion of agriculture and horticulture, beekeeping, mushroom cultivation, value-addition of local fruits and vegetables, and organic farming as livelihood options. Taking this opportunity, the North-East Regional Centre of G.B. Pant National Institute of Himalayan Environment under the In-house Project entitled "*Community driven eco smart model village development to improve livelihood & foster ecological security in the Himalaya*" has initiated different field interventions for socio-economic development of the local community through use of low-cost agricultural technologies and locally available bioresources.

Depending on community preference and willingness, the following interventions were made in the study area:

### (i) Value addition of locally available bioresources

The local community of the study area has been using variety of wild vegetables and fruits for household consumption. The interested people were trained on the value-addition process of these locally grown and wild bioresources for generating additional income and reduce post-harvest agricultural losses. If properly preserved, value-added products can be stored for one to three months. Subsequently, value-added products viz., chilli, wild brinjal, bamboo shoot, wild apple, wild olives, bayberry pickles were prepared by few members of the community, packaged and sold in local markets (Fig 1).


**Fig. 1.** Samples of Value-added products from locally available bioresources

**(i) Vermicompost production using agricultural waste (paddy straw, cowdung, and other weeds from agricultural fields)**

Agricultural waste such as paddy straw, cowdung and other garden weeds all common household organic wastes that are usually disposed of, are collected and stored. The local farmers were trained on how to use these waste products to produce vermicompost which can enhance the agricultural produce as well as sold to generate additional income. Five vermi-compost units have been installed in five villages of Sirro, Ziro Valley.The agricultural waste materials were stored for few weeks to undergo partial decay, after which the earthworms (*Eisenia foetida*) were added on top. In light of the varying climatic conditions, the entire process took between 3 and 5 months.the local women farmer groups has started preparing vermicompost packages and selling them at a rate of Rs.30/- to Rs.40/- per kg and it is also reported that there is an increasing demand for the compost (Fig. 2).


**Fig. 2.** Vermicompost Unit and packaged product

**(iii)Mushroom cultivation using paddy straw as substrate**

Mushroom cultivation is another emerging 'green' livelihood option which has the potential to uplift the socio-economic condition and nutritional security of the rural people. According to Chang and Miles (1991), the amount of protein in mushroom is double than any other vegetables. Oyster mushroom cultivation can be under taken for generating additional income during the lean seasons when the farming activity is at a low scale. Keeping this in mind, the local women were trained on mushroom cultivation techniques initially at household level using the locally available substrate, i.e. paddy straw. Under this initiative, two low-cost mushroom cultivation units have been developed in two villages of the study area in collaboration with State Rural Livelihood Mission, Arunachal Pradesh. The production and marketing is entirely managed by the women farmers and Self-Help Groups (SHGs) (Fig 3).

**Fig 3.** Oyster Mushroom (*Pleurotusostreatus*)

## FUTURE PROSPECTS

The study emphasizes that there is immense availability and potential of locally grown agri-horticultural resources in the area. Thus, encouraging the use of these resources, as well as proper waste disposal, will be a beneficial step toward improving the rural economy and sustainable utilization natural resources.

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# NATIVE ORCHIDS OF NORTH EAST INDIA: UNDER THREAT

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## INTRODUCTION

Orchids are the most fascinating flowers under family Orchidaceae, which is the second largest family after Asteraceae comprising of diverse number of flowering plants. Orchid flowers owing to its varied form, shades of color, longevity, fragrance *etc*., are of keen interest to the academician, breeders, researchers, and flower growers thus paving way for its exploration and trading. The five states of North East India are having orchids as their state flowers;Arunachal Pradesh and Assam (*Rhynchostylis retusa*), Meghalaya (*Paphiopedilum insigne*), Mizoram (*Renanthera imschootiana*) and Sikkim (*Dendrobium nobile*).Sikkim is the leading state in the orchid trade specially of cymbidium, for which it has been named as the '*home of Cymbidium orchid'*. Despite development of many commercial varieties for cut flowers, threat to population of native orchids in the present time is increasing due to over exploitation by traders, destruction of the natural habitat owing to developmental activities.Though conservation measures have been taken up by the Government and Non-government organization of all the states, the measure are not adequate in helping in maintaining its population stablility.

## STATUS

There are about 28,349 species of orchids with 763 genera distributed world over. The largest genera in the family belongs to *Bulbophyllum* comprising about 2000 species, *Epidendrum*; 1500 species, *Dendrobium*; 1400 species and *Pleurothallis*; 1000 species, *Vanilla*;110 species, *Vanda*; 87 species, *Catlleya*; 46 species with 35 natural hybrids, *Phalaenopsis*; 70 species etc. There are about 1,256 species of orchids distributed in India out of 28,349 species. The highest diversity of orchid species is concentrated in North Eastern India with 856 species while Western Ghats have the highest endemism with 128 species followed by Kerala; 111 species and Tamil Nadu; 92 species of 388 endemic species. Among the Indian states, Arunachal Pradesh has the highest record of orchid species with 130 genera and 622 species, followed by Sikkim; 132 genera and 560 species, 479 species in Darjeeling Himalayas of West Bengal while among the eight states of North Eastern Region, Arunachal Pradesh occupies the highest number of species followed by Sikkim, Meghalaya; 98 genera with 389 species, Assam with 290 species belonging to 72 genera, Nagaland 246, Manipur 215 and Tripura with 57 species. Owing to the highest number of orchid diversities; Arunachal Pradesh is known as the 'Orchid Paradise or Orchid State' of India. Orchid has a wide range of habitat, growing from sea level up to alpine forest. About 60% of the orchids found in the country are epiphytic in nature (757 species); *Dendrobium* being the largest genus with about 70 species, 447 species are terrestrial with *Habenaria* having nearly 100 species is the largest genus and 43 species are mycoheterotrophic. North Eastern states harbors mainly the epiphytic orchid which grows up to an elevation of 2000 m amsl while terrestrial orchids are found growing mainly in humus rich soil under shade in the North

Western part of the country. Major orchid species growing in the North Eastern states are mentioned below Table 1.

**Table 1:** Major orchid species growing in the North Eastern states

| S.No. | State | Name |
|---|---|---|
| 1. | Arunachal Pradesh | *Acanthephippium*, *Aerides odorata*, *A. williamsii*, *A. rosea*, *Anoectochilus*, *Anthogonium gracile*, *Arundina*, *Bulbophyllum* spp., *Calanthe*, *Coelogyne* spp., *Cymbidium pendulum*, *C. aloifolium*, *Dendrobium aphylla*, *D. nobile*, *D. moschatum*, *D. fimbriatum*, *D. densiflorum*, *D. giganteum*, *D. grandiflorum*, *D, eburneum*, *D. mastersii*, *Epipogium*, *Eulophia*, *Galeola*,*Gastrodia*, *Geodorum*, *Paphiopedilum*, *Phaius*, *Renanthera imschootiana*, *Rhynchostylis*, *Stereosandra* and *Vanda coerulea* |
| 2. | Assam | *Acam pepapillosa*, *Acanthephippium*, *Aerides multiflora*, *A. odorata*, *Agrostophyllum*, *Anoectochilus*, *Apostasia*, *Arundina graminifolia*, *Bulbophyllum*, *Camarotis*, *Calanthe angusta*, *Coelogyne*,*Cymbidium aloifolium*, *Dendrobiuma phylum*, *D. acinaciforme*, *Didymoplexis*, *Eria*, *Eulophiamannii*,*Galeola*, *Geodorum*, *Goodyera procera*, *Habenaria*, *Malaxis*, *Nephela phyllum*, *Oberonia*, *Rhyncostylis retusa*, *Spiranthes sinensis*, *Vanilla borneensis* and *Zeuxine* |
| 3. | Manipur | *Aldrovenda vasiculosa*, *Anoectochilus tetraplerus*, *Ascocentrum ampullaceum*, *A. miniatum*, *Dendrobium bensoniae*, *D. draconis*, *D. heterocarpum*, *D. wardianum*, *Rananthera imschootiana* and *Vanda coerulea* |
| 4. | Meghalaya | *Anoectachilus brevilabris*,*Coelogyne corymbosa*, *Cymbidium elegans*, *Dendrobium devonianum*, *Liparis pulchella*, *Paphiopedilum insigne*, *P. venustum*, *Rynchostylis retusa* and *Vanda coerulea* |
| 5. | Mizoram | *Arundina graminifolia*, *Eria spicata*, *Eulophia nuda*, *Geodorum densiflorum*, *Malaxis acuminata*, *Phaius tankervilleae*, *Paphiopedilum hirsutissimum*, *P. villosum*, *Pholidota imbricata*, *Renanthera imschootiana*, *Rhyncostylis retusa*, *Vanda coerulea* and *V. testacea* |
| 6. | Nagaland | *Acampe*, *Acanthephippium*, *Aerides*, *Anoectochilus*, *Anthogonium*, *Aphyllorchis*, *Arachis*, *Ascocentrum*, *Bulbophyllum*, *Calanthe*, *Ceratostylis*, *Cleisostoma*, *Coelogyne*, *Cryptochilus*, *Cymbidium*, *Dendrobium*, *Diplomeria*, *Eria*, *Eulophia*, *Flickingeria*, *Galeola*, *Gastrochilus*, *Goodyera*, *Habenaria*, *Kingidium*, *Liparis*, *Luisia*, *Malaxis*, *Micropera*, *Oberonia*, *Otochilus*, *Paphiopedilum*, *Papilionanthe*, *Perisrtylus*, *Phaius*, *Pholidota*, *Pleione*, *Renanthera*, *Rhyncostylis*, *Spathoglottis*, *Thunia* and *Vanda* |
| 7. | Sikkim | *Anoectochilus sikkimensis*, *Biermannia bimaculata*,*Calanthe trulliformis* , *C. alpina*, *C. whiteana*, *C. chloroleuca*, *C. anganii*, *C. keshabii*, *C. yuksomensis*, *Coelogyne cristata*, *Cymbidium devonianum*, *C. eburneum*, *C.whiteae*, *Cypripedium tibeticum*, *C. himalicum*, *C. elegance*, *Dediciea cunninghamii*, *Dendrobium chrysotoxum*, *D.densifloru*, *D.falconeri*, and *D. wardianum*,*Gastrochillus affinis*, *Liparis dongchenii*, *Malaxissapro phyllum*,*Oberonia micranthus*, *Risleyaatro purpurea*, *Satyrium nepalense*, *Taeniophyllum retro – apiculatum*, *T. crepidiforme*, *Thrixpermum pygmaeum*, *Unciferalancifolia*, *Vanda pumila*, |
| 8. | Tripura | *Dendrobium*, *Renanthera imschootiana*,*V. coerulea* and *Vanda teres* |

Of the 1,256 orchid species belonging to 155 genera distributed in the country, 388 species are endemic to India. Out of endemic species found in the country, more than $1/5^{th}$ of the orchid species found in North East India are endemic to the region as well to a particular state. The region also harbors highest number of monotypic genera of orchids which includes *Anthogonium, Arundina, Acrochaene, Bulleyia, Cremastra, Cleisocentron, Dickasonia, Diglyphosa, Eriodes, Herpysma, Jejosephia, Mischobulbum, Myrmechis, Neogyne,*

*Ornithochilus, Risleya, Renanthera,* and *Tipularia.* The list of endemic orchids of the region are enlisted in Table 2.

**Table 2:** Orchid species endemic to North Eastern states

| S.No. | State | Name of endemic orchid |
|---|---|---|
| 1. | Arunachal Pradesh | *Bulbophyllum odoratissimum, Bulleyia yunnanensis, Calanthe densiflora, Ceratostylis subulate, Cheirostylismunn acampensis, Cheirostyliss essanica, Cissus assamica, Cleisostoma tricallosum, Cymbidium eburneum, Dendrobium cathcartii, D. hookerianum, D.nareshbahadurii, D. palpebrae, D.sulcatum, Diplomerispulchella, Epipogium indicum, E.sessanum, Eria clausa, E.ferruginea, E.lohitensis, Galeolafalconeri, Gastrodia arunachalensis, Herminium longilobatum, Liparis assamica, L. distans, L. plantaginea, Oberonia acaulis, O. sulcate, Paphiopedilum fairrieanum, Pholidota convallariae, P. pygmaea, Renanthera imschootiana, Sarcoglyphis arunachalensis, Vanda coerulea, Zeuxine lindleyana* |
| 2. | Assam | *Dendrobium assamicum, D. aurantiacum D.spatella, D.parciflorum, Eriacalamifolia, Eulophiamanii, Liparis delicatula, L.prainii, L.vestita, Luisia macrotis, Physurus hirsutus, Vanilla borneensis,* |
| 3. | Manipur | *Ascocentrum ampullaceum* var. *Auranticum, Epidendrum radicans* and *Vanda stangeana* |
| 4. | Meghalaya | *Anoectochilus crispus, Aphyllorchis vaginata, Corybus purpurens, Cymbidium eburneum, Eria ferruginea, E.pusilla, Goodyera recurve,G. robusta, Habenaria concinna, H. furfuracea, H. khasiana, Liparis acuminata, L. deliculata, Micropera mannii, Pantlingia serrata, Pennilabium proboscidcum, Paphipedilum venustum, Taeniophyllum khasianum, Tainia khasiana* and *Trias pusilla,* |
| 5. | Mizoram | *Dendrobium palpebrae* |
| 6. | Nagaland | *Renanthera imschootiana* and *Cymbidium tigrinum* |
| 7. | Sikkim | *Calanthe whiteana, Cymbidium whiteae* and *Vanda pumila* |
| 8. | Tripura | *Renanthera imschootiana* |

In the recent years many new orchids have been discovered for the first time from the region thus adding a greater number of species in the list of orchid flora. Few species reported from Arunachal Pradesh includes *Spathoglottis arunachalensis* from Sessa orchid sanctuary in West Kameng is a critically endangered species as per the IUCN criteria (2014). *Spathoglottis* consists of about 50 species, of which only four are found in India. *Thrixspermum japonicum* was discovered from Ziro valley in the year 2017 and *Gastrochilus platy calcaratus* in 2019. There are11 species of *Thrixspermum* and 20 species of *Gastrochilus* in India of which 5 and 13 are reported from Arunachal Pradesh respectively. *Oberonia bopannae* a *critically endangered species as per the* IUCN criteria (2012) was discovered from the forest of Tengapani. The list of threatened orchid species of North East India are listed in Table 3.

The developmental activities taking up at a rapid phase in the region is posing threat to many of the flora diversity and orchid is no-exception. Besides the discovery of many new species, many are under threat and the list of orchid species which are threatened under the natural habitat are presented in Table 3.

**Table 3.** List of orchid species which are threatened under the natural habitat

| S. No. | Orchid species | Conservation status |
|---|---|---|
| 1. | *Anoectochilus sikkimensis* | Rare |
| 2. | *Bulleyia yunnanensis* | Endangered |
| 3. | *Ceratostylis teres* | Endangered |
| 4. | *Cleisostoma paniculata* | Rare |
| 5. | *Corybus purpureus* | Rare |
| 6. | *Cymbidium eburneum* | Vulnerable |
| 7. | *Cymbidium tigrinum* | Rare |
| 8. | *Dendrobium falconeri* | Rare |
| 9. | *Diplomeris pulchella* | Vulnerable |
| 10. | *Epigeneium rotundatum* | Vulnerable |
| 11. | *Oberonia bopannae* | Critically endangered |
| 12. | *Paphiopedilum fairreanum* | Critically Endangered |
| 13. | *Paphiopedilum insigne* | Endangered |
| 14. | *Paphiopedilum venustum* | Vulnerable |
| 15. | *Paphiopedilum villosum* | Critically endangered |
| 16. | *Renanthera imschootiana* | Critically endangered |
| 17. | *Spathoglottis arunachalensis* | Critically endangered |
| 18. | *Vanda coerulea* | Rare |
| 19. | *Vanda pumila* | Endangered |
| 20. | *Vanilla borneensis* | Rare |

## TRADE

The trade of orchids has increased many folds both in the international and national market for different purposes. Besides its use in the floriculture industry as a potted and cut flowers, medicine and food, this flower has made its way to the cosmetic and perfume industry thus widening its usage and trade. Orchids are one of the best-selling potted plants in the world market and about 10% of the cut flowers at international level are occupied by the orchids, ranking it one among the top 5 position of cut flowers. The most traded species both for cut and potted plant mainly comprises the hybrids of *Cattleya, Cymbidium, Dendrobium, Paphiopedilum, Phalaenopsis, Vanda* etc. Thailand, Taiwan, The Netherlands and Japan are few of the largest producers of hybrid orchids for cut as well potted plant. Orchid is gaining popularity among the elite group of Indian society but the domestic production is unable to meet out the need for which, large part of the demand in country is met out by import from Thailand, accounting for 80.67% followed by The Netherlands, New Zealand and China. Among the orchid species, *Dendrobium* is in high demand and most of it is being imported from Thailand and The Netherlands. Apart from the hybrid orchids, many orchid species are being collected from the wild by the orchidologist, locals and traded in the local market or sold to a middleman for various purposes. At present China is a threat to the Indian orchids specially to the orchids of North East region as these are in huge demand in the Chinese market specially for preparation of medicine and health drinks due to aphrodisiac property. The orchids from this region are mainly smuggled to China, Japan and Korea through middlemen who buy them from the villagers at Rs. 600-900 per kg. Orchid trade is regulated under the Convention of International Trades for Endangered Species (CITES) and have been brought under Schedule VI of the Wild Life Protection Act, 1972 and the trade is regulated as per rule. In present time trading of orchid in the region has increased many folds owing to growing awareness among the people. Despite the ban in collection and sale of this plant by

the state government, orchids are still being collected from the wild and sold in the local markets or interstate selling is carried out without the knowledge of authority because of the good market price fetched. The price of a single plant sold in the local market varies with the size of the plant, species, number of plants in a bundle, size of the bundle, naked plant or a potted plant etc. In remote villages of Arunachal Pradesh, the Vandas are sold @ Rs. 100-200 per plant comprising of 4-5 leaves, a single cane of matured *Dendrobium* @ Rs. 150-250, single keiki @ Rs. 50, while in Shillong, the capital of Meghalaya, these are sold at the price starting Rs. 250 to 1800 in the midst of city market both by the locals and non-locals making the traders fetch good return thus opening up the scope for the traders to collect more orchids from the wild and thus threatening the orchid population.

## CONSERVATION MEASURES

Developmental activities like felling of trees for dam and road construction, widening of township, collection of orchids from wild for sale, shifting cultivation, climate change and many more factors are responsible for depletion of orchid numbers thus posing threat to their population from the natural habitat. In view of the threat to orchid population, few species namely Blue Vanda, Red Vanda and Ladies slipper have been included under Schedule VI of the Wild (Life) Protection Act, 1972, restricting its collection from the wild. The state government of the region have taken up several steps to conserve the orchid population both *in-situ* and *ex-situ*, Sessa Orchid Sanctuary in Arunachal Pradesh being the first orchid sanctuary of India to be established in 1989 for preservation of orchid under protected area followed by Assam to set up the Deorali Orchid Sanctuary. Department of Environment and Forest, Govt. of Arunachal Pradesh has established an Orchid Research and Development Station at Tipi, West Kameng district for propagation of the orchid. In Manipur, under the Foundation for Environment & Economic Development Services (FEEDS), Orchid Research & Development Centre was established in the year 2010. Mizoram Orchid Centre has been established to study, preserve and propagate endemic and endangered orchids. Besides the government organizations, NGOs and private organization, are also engaged in the conservation and propagation of orchids. The Kaziranga National Orchid and Biodiversity Park; largest orchid park of North East and India has been established to preserve and create awareness. Despite the several efforts made by the government for conservation of the native orchids, the population is still under threat owing to the anthropological activities, climate change and lack of knowledge on sustainable harvesting system. To prevent the further decrease in number under natural habitat, developmental activities carried out should be well planned as well awareness should be created for harvesting and collection from wild in sustainable manner.

## CONCLUSION

North eastern region being one of the biodiversity hotspots is home to many floras. The region has rich diversity of orchid but the number of orchid species is few and owing to the increasing human interference and developmental activities, the number is decreasing each passing year. Therefore, awareness has to be created among mass regarding the importance and significance of orchids, conservation measures both under *ex-situ* and *in-situ* condition, development of different tissue culture strategies by the R&D institutes, and collaboration of all the government, NGO, private firms and local villagers to conserve the orchid population.

# COMMUNITY INVOLVEMENT AND GENDER ROLES IN SHIFTING CULTIVATION OF NORTHEAST INDIA

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## INTRODUCTION

Northeast India, a region where shifting cultivation (SC) is highly practiced by the tribal communities is also a biodiversity hotspot of India with rich flora and fauna. Communities practicing SC have built their social organization around land ownership, participation, and societal roles, and responsibility with consideration to this practice (Siddiqui and Chohan, 2015). Both male and female play important role in different stages of shifting cultivation.

## COMMUNITY INVOLVEMENT

Joint or community involvement during certain phases of the cultivation process is an important sociological characteristic of SC. There is a mutual exchange of labor, especially during the harvesting period where groups of families come together to aid in crop harvest from a plot that belongs to a particular family. This act of labor exchange is practiced for every household of the community. Such joint involvement increases productivity and strengthens community bonds. Besides increasing productivity, dissemination of traditional knowledge and sharing of ideas and innovation among participating farmers happens during these times. It is a common practice where the family who owns the plot, which is being harvested, would host the harvesting with refreshments (Punitha *et al.*, 2018). Therefore, SC is not merely a means for sustenance and ensuring food security, but a practice that communities look forward to enjoyable work and social interaction.

## GENDER ROLES AND RESPONSIBILITIES

Division of labor exists in SC, where men and women carry out different tasks and these tasks may vary from one tribe to another (Jamir, 2014). The Jhumias (communities practicing SC) in Manipur and Arunachal Pradesh portray this pattern of division of labor where women were predominantly found to carry out tasks such as seed selection, planting, weeding, and other activities, while activities like cutting of trees, clearing of jungle and burning of vegetation are generally done by men. The harvesting of crops and their transportation to the village is however, done by both men and women (Reimeingam, 2017). The economic structure of SC was once considered egalitarian, except the village headman who has the jurisdiction powers


**Fig. 1.** Role of women in shifting cultivation which include plantation (Fig. a and b), wood gathering (Fig. c), and harvesting (Fig. d). Plantation is generally done by women of the jhumia communities. Fig. (e) to (k) are vegetables and cereal seeds that planted after the burning period in shifting cultivation lands in overseeing the welfare of the jhumia society and these powers are exhibited during the allocation of jhum lands among the fellow jhumia members of the village (Punitha *et al*., 2018).

In the past, when the lands were ruled and governed by maharajas, the village headmen were able to allocate larger jhum lands for themselves. The reason for this was that the headmen generally had more manpower to deploy for labor than common people of the village and by their position. Village headmen also possess more capital and influence, enabling them to take up roles as agents for traders and money lenders in the jhumia society (Punitha *et al*., 2018).

As observed from the above discussions, SC has a profound impact on the social structure of communities practicing it. This indicates landholding systems of jhum areas with no permanent ownership of land and no permanent set boundaries. Instead, landholding is decided by the headman or village committee or by a mutual understanding of people involved in the cultivation. Such a landholding system may be rare in settled cultivation systems since land rotations or shifting of cultivation spaces are not intrinsic to the cultivation process. Social bonding is also strengthened with the presence of the SC as the cultivation processes involve group or community participation in land clearing and harvesting. In addition, festivals and rituals have added to the social bonding and have provided a cultural identity to the communities. Overall, SC has played a major role in bringing communities together and in defining the social structure of such communities.

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# TRADITIONAL AGRICULTURE SYSTEM

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## INTRODUCTION

The twenty-first century is the era of global environmental problems such as increasing population, natural resource degradation, climate change and ecosystem disturbance. Green Revolution multiplied agricultural production many folds but at a huge environmental cost. Now the time is to quittance the loss by introducing an environment-friendly and climate-smart approach, Traditional agriculture is the practice which is getting increased attention in the context over the world. Traditional Agriculture System was revisited when United Nations announced 2014 as the International Year of Family Farming (IYFF, 2014) to promote family farming or small land holder farming with ultimate aim to end hunger, improve livelihood and manage natural resources and for well-being of rural people. Though, the prevailing farming system of Central Himalayan Region is advocating the true concept and model of family farming for generations. There are many other ancient farming practices which are still in existence and advocating traditional agriculture system for centuries. For example,the Hani rice terraces of Yunnan Province in south-west of China is one of the well-known traditional agriculture systems of mountainous regions which have been designated as Globally Important Agricultural Heritage System (GIAHS) in 2009 by FAO and World Cultural Heritage (WCH) sites by United Nations Educational, Scientific, and Cultural Organizations (UNESCO) in 2013 (Zhang *et al*., 2017). Around 1.9 to 2.2 billion people are already engaged in the system of traditional agriculture worldwide (Altieri, 1993; Pretty, 1995). There are proven facts that says traditional agriculture fits well in the category of small land holding farmers and report says "globally about 84% of the farmers have land holding of less than 2 ha and that falls in the same category. This is not it but the counting of small land holding farmers is increasing in exponential fashion every year (Altieri, 2004; Lowder *et al*., 2016).

## WHAT MAKES TRADITIONAL AGRICULTURE SYSTEM DIFFERENT?

- Traditional agriculture integrates crops with livestock which eventually helps farmers to reduce their dependency on external inputs such as fertilizers, pesticides and fossil fuels **(**Schiere and Kater, 2001; Naylor *et al*., 2005; Anex *et al*., 2007).
- Unlike the modern agriculture system where the link between consumer and agro-ecosystem is uni-directional, traditional agriculture system is linked with bi-directional approach which includes recycling of agricultural and agricultural allied wastes (Ellis and Wang, 1997)

- Agrobiodiversity which is an inherent feature of traditional agriculture system reduce the need of off-farm inputs and thereby supplies range of ecosystem services to agriculture.
- Vermicompost and green manuring improves the soil microbial activities and thereby maintain the nutrient cycle in the soil (Mader *et al*., 2002; Reganold *et al*., 2010; Kremen and Miles, 2012).

As per the FAO report, 75% of the world's food-crop diversity has lost in the twentieth century due to replacement of local varieties by genetically uniform High Yielding Varieties (HYV's) and intensive monoculture farming. Whereas traditional agriculture system advocates the polyculture farming as a whole and this may integrate different agricultural practices as detailed in Table 1.

**Table 1.** Different agricultural practices and their benefits

| S.N. | Agricultural Practices | Benefits |
|---|---|---|
| 1 | Agroforestry | Agroforestry offers multidisciplinary benefits e.g. it enhances soil organic matter, agricultural productivity, carbon sequestration, water retention, agrobiodiversity and farmer's income. |
| 2 | Crop rotation | System of Crop rotation enhances the soil quality and crop productivity through altering soil structure and aggregation and nutrient cycling. |
| 3 | Intercropping | It is a practical application of fundamental ecological principles e.g. diversity, competition and facilitation. It is one of the highly productive farming practices which reduces the climate-driven crop failure as variety of crops have different climatic adaptability. Intercrops efficiently utilize the natural resources e.g. land, water, light and nutrient and eventually increases productivity, resilience, stability and biodiversity of the agroecosystem. |
| 4 | Cover cropping | This is a sustainable approach for enhancing soil health, soil microbial biomass and agroecosystem services e.g. moisture conservation, weed and pest control, nutrient cycling and corban sequestration. |
| 5 | Integrated forming | It has the potential to fix not only the agroecosystem problems but also to resolve unemployment and migration problems from rural to urban India. |
| 6 | Traditional organic composting and green manuring | Fertilizer-driven Green House Gas (GHG) emission is the largest source of total GHG emission from agriculture sector. Besides, contributing to GHG emission, nitrogenous fertilizers decrease soil microbial activity and bacterial diversity. On the other hand, organic compost enhances fertility and productivity in a joint manner. Composting refers to the natural processes of decomposition of organic matter (e.g. straw, crop residues, agroindustry by-products, livestock waste and kitchen waste) by micro-organisms under controlled condition. It not only removes the waste but also transforms waste into nutrient-rich organic manure. |

## CONCLUSIONS

- Cooperation and coordination between various stakeholders such as local peasant, researchers and policy makers of the agroecosystem are urgently need to form effective plans and strategies for implementation of traditional agriculture system.
- Integration of modern agriculture system with traditional agriculture system is a need of hour to boost agriculture-based economy as well as climate change mitigation.

- More inclusive research focused on the identification and exploration of traditional agriculture knowledge at a broader perspective is a need of hour.

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# मानव का प्रकृति से संबंध विच्छेद

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आज समूचे विश्व में इस सदी की सबसे बड़ी महामारी कोरोना COVID–19 द्वारा मची तबाही और विनाश का मंजर दिखाई पड़ रहा है। इस महामारी से पूरे विश्व मे करीब ३५ लाख से अधिक लोगों की जानें जा चुकी हैं, अपने भारत देश मे ही करीब ३ लाख से ऊपर लोगों की जान जा चुकी है के आधिकारिक वेबसाईट के २८ मई, २०२१ के आकडों के अनुसार लाखों लोग इस समय देश मे इस गंभीर बीमारी से संक्रमित हैं। असलियत तो यह है कि सम्पूर्ण विश्व की आर्थिक, सामाजिक और राजनीतिक व्यवस्था अनुपालन को तार–तार करते हुए यह मनुष्य के भविष्य पर एक बड़ा प्रश्न चिन्ह लगाने की कगार पर आ चुका है। सम्पूर्ण विश्व में फैली यह अप्रत्याशित उथल–पुथल विपदापूर्ण रोष और कार्यविहीन वंचित करोड़ों का जन समुदाय निकट भविष्य में सकारात्मक संकेत के अभाव को देखते हुए इस महामारी को मानव द्वारा पृथ्वी पर किए गए दुर्व्यवहार और प्राकृतिक संसाधनो के अनियंत्रित दोहन के विरुद्ध पृथ्वी की प्रतिक्रिया या रोष के रूप में भी मानने लगा है। अगर हम पिछले कुछ वर्षों को देखे तो बर्ड फ्लू, स्वाइन फ्लू, इबोला, कोरोना, हंता वायरस जैसी बीमारियां कही ना कही मानवों द्वारा प्रकृति मे किए गए अप्राकृतिक परिवर्तनों के कारण ही हुए हैद्य इन सभी नई नई बीमारियों के कारण मानव के जीवन में इतना दुख, इतनी पीड़ा और इतना अवसाद बढ़ गया है कि आज प्रौद्योगिकी एवं विज्ञान भी उसके सामने अपने को असहाय महसूस कर रहे हैं। समय–समय पर ऐसी महामारियों के आने का प्रमुख कारण है मानव का प्रकृति से संबंध विच्छेद।

मानवों ने अपने मनोरंजन और भोजन के लिए जानवरों का इस्तेमाल सदियों से किया है आजकल तो खाद्य पढ़ार्थों मे इनका इस्तेमाल बहुत ज्यादा ही बढ़ गया है, इन्ही कारणों से बार बार ऐसी घातक महामारी आती जा रही है द्य चीन से शुरू हुआ कोरोना वायरस भी जानवरों के अंत्यधिक इस्तेमाल से ही हुआ है द्य दरअसल चीन में इन जानवरों को खाद्य पदार्थ के रूप में औद्योगिक रूप से तैयार किया जाता है। अप्राकृतिक रूप और चोरी छुपे संरक्षित जीवों की तस्करी के बुरे नतीजे सबके सामने हैं। इससे एक बात साफ होती है कि परिस्थितिकी के एक हिस्से में छोटी–सी हलचल दूसरे हिस्सों में तबाही ला सकती है। हम विकास के नाम पर हम धरती को नुकसान पहुचाने में कोई कसर नहीं छोड़ रहे हैं, फिर बात चाहे पर्यावरण की हो, प्राकृतिक संसाधनों की हो या फिर जैव विविधता की। मानव के स्वार्थ का ही यह नतीजा है कि धरती पर मौजूद बहुत से जीवों के विलुप्त होने के कगार पर है और कई तो विलुप्त भी हो चुके हैं। कोरोना वायरस द्वारा उत्पन्न हुई महामारी के फैलाने के कारणों मे से एक है पारिस्थितिकी संकट। पृथ्वी पर सभी जीव–जंतुओं का अस्तित्व बनाए रखने के लिए जैव विविधता बुनियादी आवश्यकता है। इसके लिए वैश्विक स्तर पर व्यापक एवं समन्वित योजना बनाने की जरूरत है। इस संबंध में संयुक्त राष्ट्र की जैव विविधता की रिपोर्ट हमें आईना दिखाती है कि जल्द ही कदम न उठाए गए तो मनुष्य को इसकी बड़ी कीमत चुकानी पड़ सकती है। अब भी हम नहीं संभले तो मानव जीवन बहुत बड़े संकट में फंस सकता है। आज हमें प्रकृति का संदेश समझने की आवश्यकता है कि ठहरिए, समझिए, विचारिए अन्यथा पृथ्वी को आप विनाश की तरफ ले जा रहे हैं। दरअसल विकास के नाम पर पर्यावरण से छेड़छाड़ का ही परिणाम है कि आज पर्यावरण क्षति, जलवायु परिवर्तन, कार्बन उत्सर्जन, ग्लोबल वार्मिंग, प्राकृतिक संसाधनों का अंधाधुंध दोहन, जल प्रदूषण, वायु प्रदूषण, ध्वनि प्रदूषण, पीय प्रदूषण आदि भयानक समस्याएं उत्पन्न हो रही हैं।

अमेजन और ऑस्ट्रेलिया के जंगलों में लगी आग की वजह से जंगली जानवरों की मौत भी मानवों की लापरवाही का ही परिणाम है। उद्योगीकरण के बढ़ने के साथ जंगलों की बेतहाशा कटाई ने इंसान एवं

जीवों को आमने–सामने ला खड़ा कर दिया है। आज तेंदुए, हाथी आदि जानवरों का मनुष्य की बस्तियों एवं शहरों में आना, बंदरों की टोलियों द्वारा मानव बस्तियों में घुसना बेवजह नहीं है। उत्पादन की नई तकनीकों के कारण इन दिनों बड़ी संख्या में मुर्गियों, सुअरों एवं अन्य पशुओं को बड़ी तंग जगह में रखा जाता है, जिससे संक्रमण का खतरा उतना ही अधिक बढ़ जाता है। जानवरों से संबंधित मीट उद्योग ने भले ही खाद्य सुरक्षा को बढ़ाया है, परंतु इससे फैलने वाले स्वाइन फ्लू, बर्ड फ्लू एवं अन्य बीमारियों से बचने के लिए हमारे पास सुरक्षा कवच कमजोर है। कोरोना वायरस के संकट ने मनुष्य को उसके विकास के पुनर्मूल्यांकन के दोराहे पर खड़ा कर दिया है। आज हमें विकास के नए मापदंड अपनाने होंगे। कोरोना के बाद नई दुनिया का विकास पर्यावरण संरक्षण के साथ हो, जिससे वन्य प्राणियों के पर्यावास पर विशेष ध्यान दिया जा सके। खाद्य सुरक्षा के अंतर्गत आने वाले पशु–पक्षियों में संक्रमण न फैले, इसके लिए उनके रखरखाव संबंधी नए कानून बनें एवं जो कानून मौजूद हैं उनका कड़ाई से पालन हो जिससे फ्लू जैसी बीमारियों को रोका जा सके। हमें अपनी आहार शैली बदलने की सख्त जरूरत है। हमें यह तय करना होगा कि हम क्या खा सकते हैं और क्या नहीं विशेष रूप से, परस्पर विरोधी मानव–पशु संबंध, जंगली निवास स्थान के पासबढ़ते पशुधन, खेती और जंगली जानवरों की परस्पर क्रिया मनुष्य के लिए रोगजनकों के प्रसार के महत्वपूर्ण कारण हैं। ये सभी कारक पर्यावरणीय अस्थिरता से संबंधित हैं जो हमने पृथ्वी पर बनाए हैं। गहन खेती के लिए वनों की कटाई और भूमि उपयोग ने जूनोस के जोखिम को काफी बढ़ा दिया है। प्राकृतिक आवास का नुकसान और थाली में जंगली प्रजातियों को शामिल करने के कारण, जंगली जानवरों और उनके शरीर के वेक्टर जीवों का प्रसार बढ़ गया है।

## पर्यावरण दोहन और जलवायु परिवर्तन

पृथ्वी मानव का आवास है। प्रकृति से मनुष्य ने बहुत कुछ पाया वर्तमान पीढ़ी ने ऊँचे पर्वतों, हिमाच्छादित शिखरों, भरपूर पानी और शुद्ध हवाओं का भरपूर आनन्द उठाया परन्तु भावी पीढ़ी को शायद प्रकृति के प्रकोप से बचने की तैयारी में ही अपना सम्पूर्ण जीवन बिताना पड़े। मानव अपने जीवनयापन के लिए सदैव पर्यावरण पर निर्भर रहता चला आया है। मानव के विकास के साथ–साथ उसकी आवश्यकताएँ तो बढ़ी है। पर्यावरण पर निर्भरता भी बढ़ती चली गई है। उपभोक्ता संस्कृति ने मनुष्य की पर्यावरण के दोहन की प्रवृति को शोषण की प्रवृति में बदल दिया है। एक अनुकूल पर्यावरण के लिए जैवमण्डल के विभिन्न घटकों का आपसी तालमेल अनिवार्य है भौतिक विकास के साथ हमारी बेतहाशा बढ़ती जरूरतों को पूरा करने के लिए पर्यावरण के उपलब्ध संसाधनों का अन्धाधुन्ध दोहन लगातार जारी है। इस दोहन का ही परिणाम है कि हम सभी ग्लोबल वार्मिंग, ओजोन कवच क्षरण, विश्व में विभिन्न स्थानों पर जलवायु का प्रलयकारी औद्योगिक और ऑटोमोबाईल प्रदूषण आदि रूपों में पहचानने लगे है। विकसित देशों द्वारा लगातार पर्यावरण को नुकसान पहुँचाने वाली हानिकारक गैसों का उत्सर्जन किया जा रहा है। मानवीय जरूरतों के लिए विश्व भर में बड़े पैमाने पर वनों का सफाया किया जा रहा है। विकासशील देशों द्वारा विकास के नाम पर सड़कों, पुलों और शहरो को बसाने के लिए अन्धाधुन्ध वृक्षों की कटाई की जा रही है। बिजली की जरूरत के लिए बड़े पैमाने बाँध बनाकर नदियों के प्रवाह को अवरुद्ध करने के साथ ही अवैज्ञानिक एवं अनियोजित खनन को बढ़ावा दिया जा रहा है। फलस्वरूप हमारी धरती विनाश और प्राकृतिक प्रकोपों की ओर अग्रसर है। विश्व पर्यावरण की अधिकतर समस्याओं का सीधा सम्बन्ध मानव के आर्थिक विकास से है। शहरीकरण औद्योगीकरण और संस्थानों के विवेकहीन दोहन के परिणामस्वरूप संसाधनों पर बोझ लगातार बढ़ता जा रहा है। परिणामतः पर्यावरण असन्तुलन की बढ़ती दर के कारण पारितन्त्र लड़खड़ाने लगा है।औद्योगिक गैसों के लगातार बढ़ते उत्सर्जन और वन आवरण के तेजी से होते ह्रास के कारण ग्रीन ओजोन गैस की परत का क्षरण हुआ है। पृथ्वी से जाने वाली हानिकारक पराबैंगनी विकिरणों से जैवमण्डल को बचाने वाली कार्बन डाइऑक्साइड और ओजोन गैस की मात्रा में हुए इस अस्वाभाविक बदलाव का प्रभाव स्थानीय, प्रादेशिक और वैश्विक स्तर पर हो रहे जलवायु परिर्वतनों के रूप में दिखलाई पड़ता है।

विश्व के आर्थिक विकास के साथ राष्ट्रों की आवश्यकताएँ भी बढ़ी है इन बढ़ती हुई आकांक्षाओं की पूर्ति के लिए मानव ने प्रकृति का बेतहाशा दोहन किया है। इससे वन विरल होते जा रहे है, जीवों की प्रजातियाँ विलुप्त हो रही है। मानव और प्रकृति का सह–सम्बन्ध सकारात्मक न होकर विध्वंसात्मक होता जा रहा है। वनों के विनाश के साथ समाप्त होते वन्यजीव निश्चित ही मानव की समाप्ति का भी संकेत दें रहे हैं। वायु, जल और मृदा में होता प्रदूषण, मानव को बीमारी, भूख–प्यास, कुपोषण, गरीबी और प्राकृतिक आपदाएँ भेट स्वरूप प्रदान कर रहा है। ऐसी स्थिति में पर्यावरण का प्रदूषण सिर्फ समुदाय या राष्ट्र विशेष की निजी समस्या न होकर एक सार्वभौमिक चिन्ता का विषय है। पारिस्थितिकीय असन्तुलन हर प्राणी को प्रभावित करता है अतः यह जरूरी हो जाता है कि विश्व के सभी नागरिक पर्यावरण समस्याओं के सृजन में अपनी हिस्सेदारी को पहचाने।

पर्यावरण में असन्तुलन गम्भीर चिन्ता का विषय बन गया है जिस पर अब ठोस पहल की आवश्यकता है अन्यथा बदलती जलवायु, गर्माती धरती और पिघलते ग्लेशियर मानव जीवन के अस्तित्व को खतरे में डाल देंगे। प्रकृति में उत्पन्न असन्तुलन प्राकृतिक प्रकोपों का जन्मदाता बनेगा। जिनसे बचने की पूर्व तैयारी अब समय की आवश्यकता है । मानव का वजूद प्रकृति से है न कि प्रकृति का अस्तित्व मानव से है। इस सच्चाई को जब तक मनुष्य स्वीकार नहीं करेगा, उसकी जीवनशैली में बदलाव भी नहीं होगा। इसके लिए मनुष्य को अधिक संवेदनशील होना होगा और वैश्विक समाज को एकजुट होकर काम करना होगा। साथ ही प्रकृति को अपने एक अंग के रूप में स्वीकार करना होगा। महात्मा गांधी ने कहा था कि पृथ्वी हर मनुष्य की जरूरत को पूरा कर सकती है, परंतु पृथ्वी मनुष्य के लालच को पूरा नहीं कर सकती है। कोरोना का संकट आज हमें इस सीख को अपनाने को संदेश दे रहा है।

ग्लोबल वार्मिंग और जलवायु परिवर्तन, मिट्टी, पानी और हवा में प्रदूषकों के बढ़ते स्तर, वनों की कटाई, प्राकृतिक वातावरण का विखंडन, गहन खेती और वैश्वीकरण ऐसे कारक हैं जो घातक महामारी की नई लहर के उद्‌भव और प्रसार में योगदान कर रहे हैं। जलवायु परिवर्तन जिसमें तापमान में वृद्धि, समुद्र का स्तर, महासागरों के पीएच में परिवर्तन और वर्षा, सूखे के बदलते पैटर्न भी जूनोटिक रोगों के प्रभावों को प्रभावित कर रहे हैं। वैश्विक तापमान में मामूली वृद्धि से नए निवास क्षेत्रों, क्षेत्रों में वेक्टर जनित रोगों के जोखिम बढ़ने की उम्मीद है।

उदाहरण के लिए, वैश्विक तापमान वृद्धि से मच्छरों का नए क्षेत्रों में प्रवासन हुआ है और इसके परिणामस्वरूप जीका वायरस, जापानीज इन्सेफेलाइटिस और डेंगू बुखार का प्रसारण नई जगहों पर हुआ जहां वे पहले नहीं बताए गए थे। यह स्पष्ट रूप से दर्शाता है कि ग्लोबल वार्मिंग मानव रोगजनकों (वैक्टर के माध्यम से) के उन देशों में स्थानांतरण के परिणामस्वरूप है जहां उन्हें पहले रिपोर्ट नहीं किया गया था। कुछ देशों में बाढ़ की घटनाओं और तापमान में वृद्धि के कारण, वेक्टर–जनित बीमारियों जैसे मलेरिया और डेंगू की घटनाओं में भी अत्यधिक वृद्धि हुई है। जलवायु परिवर्तन के कारण सूखे पड़ने में भी वृद्धि हुई है और इसके परिणामस्वरूप पशुधन और जंगली जानवरों के मांस पर निर्भरता बढ़ी है।

पारिस्थितिक तंत्र में प्रदूषकों की वजह से कृषियोग्य भूमि का बंजर हो जाना, साथ ही साथ अत्यधिक दवाइयों के प्रयोग से बीमारी फैलाने वाले बैक्टीरीया अवाम अन्य जीवों पर उन दवाइयों का असर ना होना भी पर्यावरण को नुकसान पहुचाने से ही हुआ है।

## वन्य प्राणियों से उत्पन्न होते हैं संक्रामक रोग

विगत वर्षों मे आई गई प्रमुख बीमारियाँ जैसे की SARS, MERS, EBOLA,AIDS इत्यादि संक्रामक रोग वन्य प्राणियों से उत्पन्न होते हैं। साफ सफाई की बात क्या की जाए, जीवनदायिनी नदियों का जल पीने योग्य तो दूर, स्पर्श करने लायक भी नहीं है। विभिन्न जलस्रोतों को भी हमने प्रदूषित कर दिया है। सार्वजनिक स्थान और पानी के स्रोत मानव द्वारा उत्पन्न गंदगी से भरे पड़े हैं। अफ्रीका और एशिया के देशों में स्वच्छता न के बराबर है। यहां न तो साफ पानी पर्याप्त मात्रा में है और न ही करोड़ों लोगों के घरों में शौचालय है। इन देशों में घरों आदि से निकलने वाले कूड़ें के प्रबंधन की भी

व्यवस्था नहीं है और न ही सीवर व उद्योगों से निकलने वाले कचरे के ट्रीटमेंट की व्यवस्था है। मानव की महत्वकांक्षाओं और जरूरतों को पूरा करने के लिए प्राकृतिक जंगलों को बेतहाशा काटा जा रहा है। इन सबसे पृथ्वी का पारिस्थितकीय संतुलन बिगड़ता जा रहा है। परिणामस्वरूप, डेंगू, स्वाइन फ्लू, कैंसर, कोरोना वायरस, हंता वायरस जैसी तमाम बीमारिया सामने आने लगी। कई शोधकर्ताओं का मानना है कि कोरोना वायरस पर्यावरण के साथ खिलवाड़ से तैयार किया गया है। उसी प्रकार हंता वायरस, जो चूंहों और गिलहरिओ मुख्य कारण बताया जा रहा है, लेकिन वास्तव में पर्यावरण का अंत्यधिक दोहन और स्वच्छता का अभाव ही मुख्य कारण है। लेकिन हमे समझना होगा कि चूंहे और गिलेहरियां इंसानों के अस्तित्व के पहले से ही धरती पर हैं, किंतु आज तक इस प्रकार की बीमारी उनसे किसी को नहीं हुई, जबकि भारतीय संस्कृति में तो इन दोनों जीवों की पूजा भी की जाती है और चूंहे को गणेश भगवान से जोड़कर देखा जाता है, जो लंका जाते वक्त सेतु बनाने में गिलेहरियों द्वारा भगवान राम की सहायता करने के रूप में है। मान्यता है कि इसी कारण भगवान राम ने गिलेहरियों को वरदान भी दिया था। इसलिए इन जीवों पर बीमारी उत्पन्न करने का ठीकरा फोड़ना तर्कसंगत नहीं लगता है, क्योंकि इसकी मुख्य वजह मानव द्वारा स्वच्छता के पर्याप्त आयामों को न अपनाना और प्रकृति का दोहन है।

## प्रकृति का दोहन

दरअसल, प्रकृति के दोहन से ग्लोबल वार्मिंग का खतरा उत्पन्न हुआ है। इसने वैश्विक स्तर पर जलवायु को काफी हद तक परिवर्तित किया है। गर्म दिनों से संख्या में इजाफा होने लगा है, बेमौसम बारिश, बर्फबारी और ओलावृष्टि हो रही है। इसने जीवों के जीवनचक्र को बिगाड़ दिया है। नई बीमारियां सामने आने लगी हैं। यहां तक कि जानवरों को अभी अब विभिन्न प्रकार की नई बीमारियों हो रही हैं। कैंसर जैसी बीमारियों से जानवरों की भी मौत होने लगी है। लेकिन केवल इंसानों के जीवन को महत्व देने के कारण ये बाते सुनाई नहीं देती हैं। इसके अलावा मांसाहार बढ़ने से जानवरों का अवैध व्यापार भी बढ़ा है। ऐसे में चीन जैसे कई देशों में हर प्रकार के जीव को खाया जा रहा है। सैंकड़ों लोग अपने शौक को पूरा करने के लिए इन जानवरों को पालते भी हैं। ऐसे में इन जानवरों के संपर्क में आने के मामले भी अधिक बढ़ रहे हैं। जिसे पर्याप्त स्वच्छता न अपनाने से लोगों को जीवन खतरे में आ गया है। ऐसे में समय पर्यावरण संरक्षण का है और जीवों को कैद में रखने के खिलाफ मुहिम चलाई जानी चाहिए। साथ ही हंता वायरस से बचने के लिए कोरोना वायरस की तरह ही नियमित तौर पर खुद को साफ रखना होगा। हाथों को कम पानी का उपयोग करते हुए नियमित तौर पर धोएं। कचरे के प्रबंधन की पूरी व्यवस्था होनी चाहिए। नदियों और जलस्रोतों को निर्मल रखने की तरफ कदम बढ़ाना होगा। खेती को पूर्ण रूप आर्गेनिक बनाना होगा। तभी इस प्रकार के वायरस के प्रकोप को टाला जा सकता है।

## मौजूदा हालात चिंताजनक और सोचनीय

वर्तमान हालातों का आंकलन यह तो संकेत देता है कि आज नहीं तो कल मनुष्य इस महामारी पर विजय प्राप्त कर ही लेगा। हालांकि यह भी निश्चित है कि मुख्यतः जलवायु से संबंधित परिवर्तन और जैव विविधता के विनाश के संदर्भ में पहली बार एक विपदा ने सम्पूर्ण मानव समाज को नए सिरे से आत्मनिरीक्षण एवं अपने कार्यकलापों के पुनर्मूल्यांकन करने के लिए बाध्य कर दिया है। इतिहास गवाह है कि किसी भी आपदा और विपदा पर विजय के बाद उनसे सीख ना लेना मनुष्य की मुख्य प्रवृत्ति रही है लेकिन हमें इस बार इस दिशा में विशेष सतर्कता और सावधानी रखते हुए भविष्य की योजनाओं एवम सुधारात्मक कार्यों को प्राथमिकता देनी है। यही नहीं, गंभीर प्रतिबद्धता के साथ नीतिगत और आर्थिक समर्थन भी मुहय्या कराना होगा अन्यथा इस दिशा में थोड़ी सी चूक और प्रतिबद्धता की कमी

अगली बार पृथ्वी का कोप एक नए और विकराल रूप में दर्शित होगा जो सम्पूर्ण मानव जाति के अस्तित्व के बचाव पर एक बड़ा प्रश्न चिन्ह खड़ा कर देगा। तभी हम विकास, उपभोक्तावाद और पर्यावरण के मध्य नाजुक संतुलन की परिरक्षा कर पाएंगे और स्थाई विकास एवम प्रकृति के साथ शांतिपूर्ण सह–अस्तित्व के उद्देश्यों को प्राप्त करने के साथ–साथ ब्ट्प्क जैसे महामारियों का भविष्य में डटकर मुकाबला कर पाने में सक्षम होंगे।

## समाज मे पर्यावरण और प्रकृति संरक्षण के लिए जगानी होगी जागरूकता

चिंतकों, समाजसेवकों और सामान्य जन मानस का एक बहुत बड़ा समुदाय जहां एक ओर मनुष्य द्वारा पृथ्वी के इन संकेतों की अनदेखी करते हुए दूरगामी परिणामों की सतत उपेक्षा को ही वर्तमान परिस्थिति का जिम्मेदार मानने लगा है जो काफी सीमा तक उपयुक्त भी प्रतीत होती है।

वहीं, दूसरी ओर परिमाण स्वरूप अविस्मरणीय सदमें के रूप में आई यह महामारी पृथ्वी और पर्यावरण के मध्य संतुलन की नाजुकता के मध्य मानव के दुर्व्यवहार का एहसास भी दिलाती है।

उत्तरजीविता के लिए मनुष्य का प्राकृतिक संसाधनों का दोहन एक अपरिहार्य सच्चाई है मगर मानव जाति के भविष्य और अस्तित्व के लिए पर्यावरण और विकास के नाजुक सम्बन्धों के परिपेक्ष में प्रतिबद्धित नीति और नियति से सम्रद्ध कार्यचरन प्रणालिका और उसका यथार्थ क्रियान्वयन वर्तमान परिस्थिति की मांग है।

इसके लिए आत्मावलोकन के साथ साथ प्राकृतिक धरोहरों के संरक्षण तथा विवादहीन उपभोग वाली मजबूत निर्णायक नीतियों का हस्तक्षेप ही मांगों और आपूर्ति के बीच सामंजस्य ला सकता है और जलवायु परिवर्तन की चुनौतीयों का भी सक्षम रूप से सामना कर सकता है। इसके लिए नवयुवकों, सरकारों, नौकरशाहों, समाजसेवी संस्थानों और समुदायों में जागरूकता के साथ साथ वांछित पहल और ठोस कदम ही आने वाली पीढ़ियों और सतत विकास के लिए प्रधान विकल्प हैं।

## निष्कर्ष

भारतीय संस्कृति में प्रकृति प्रेम और उसका संरक्षण हमेशा से ही महत्वपूर्ण माना गया है। अथर्ववेद के मन्त्र १२.१.१२ के अनुसार **माता भूमिः पुत्रोऽहं पृथिव्याः पर्जन्यः पिता स उ नः पिपर्तु"अर्थात् मैं तो तुम्हारे (पृथ्वी) पुत्र के जैसा हूं, तुम मेरी माँ हो और मेघों का हम पर पिता के जैसा साया बना रहे।"**

मानव द्वारा की गई उपेक्षा ने प्रकृति और मनुष्य के सम्बन्धों को कठोर और उग्र बना दिया है। फलस्वरूप पुराणों में भूमि, वसुंधरा, विश्वंभरा, सर्वसहा, मृणमयी, रत्नगर्भा आदि नामों से वर्णित जीवनदायिनी धरा आज मनुष्य के क्रियाकलापों से व्यथित होकर अपने रौद्र रूप को दर्शा रही है। हमे जल्द से जल्द प्रकृति को सवारने का काम करना पड़ेगा।

इसके लिए सख्त वन्यजीव व्यापार नियमों को अपनाने और पर्यावरण की सुरक्षा के लिए व्यापक उपायों पर अधिक जोर दिया जाना चाहिए। सस्टेनेबल वाइल्ड लाइफ मैनेजमेंट (एसडब्ल्यूएम) समय के साथ–साथ मानव आबादी की सामाजिक आर्थिक जरूरतों को ध्यान में रखते हुए उनकी आबादी और निवास स्थान को बनाए रखने के लिए वन्यजीव प्रजातियों का प्रबंधन है।

इसके लिए आवश्यक है कि वन्यजीवों के आवास के भीतर मानव के अतिक्रमण को बंद करना चाहिए। सबसे महत्वपूर्ण है पर्यावरण के साथ अपने संबंधों को बेहतर बनाने के लिए समग्र दृष्टिकोण पर पुनर्विचार करना जो हमें कृषि स्थिरता की ओर ले जाएगा और पशु उत्पादों पर निर्भरता कम करेगा।

क्या हम पर्यावरणीय महामारी से लड़ने के लिए एकजुट होंगे जिसके परिणामस्वरूप जीवन और जैव विविधता का नुकसान हो रहा है। क्या हम वृक्षारोपण करेंगे,क्या हम ग्रीनहाउस गैस उत्सर्जन में कमी लाएंगे क्या अनावश्यक यात्रा पर अंकुश लगाया जाएगा क्या हम प्रकृति को सांस लेने के लिए पारिस्थितिक तंत्र में प्रदूषकों को कम करेंगे, क्या हम स्थायी कृषि प्रथाओं को अपनाएंगे, और जंगली जानवरों को परेशान करना बंद करेंगे।

अभी भारत मे कोरोना वायरस की दूसरी लहर चल रही है, जो बहुत घातक है लाखों लोगों की जान चली  अस्पतालों मे बेड की कमी, आक्सिजन की कमी, दवाइयों की कमी जैसी दिककते सामने आई है, हमे यही उम्मीद रखनी होगी की ये लहर जल्दी से जल्दी खत्म हो और जो तीसरी लहर के बारे मे जो कुछ कहा जा रहे है, समय रहते ही हम उसके रोकथाम की तैयारी कर पाए, प्रकृति को उसके पुराने रूप मे लाना ही होगा तभी मानवों की आने वाली पीढ़िया सुरक्षित रह पायेंगें।

**"प्रकृति बचाइए, जीवन बचाइए"**

**नोट–** उपरोक्त लेख, लेखक के अपने स्वरचित विचार है पर्यावरण को लेकर, इस लेख के लिए लेखक ने इंटरनेट पर उपलब्ध जानकारियाँ, विज्ञान की पत्रिकाओं एवं अखबारों का गहन अध्ययन किया है ।

# Section -II
# Special Report on Reintroduction of Cheetah

# CHEETAH (*ACINONYX JUBATUS*): A KEYSTONE SPECIES OF THE SAVANNA WAS REINTRODUCED IN INDIA AT KUNO NATIONAL PARK

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## ABSTRACT

Cheetahs are apex predators and keystone species of the savanna. They play a role in regulating the population of other organisms in the food web. Cheetahs were abundant in the Indian grasslands seventy year ago. They were the only large mammal that became extinct due to excess hunting and burgeoning Indian population. African Cheetahs are similar to Indian Cheetahs. So for the first time intercontinental translocation of Cheetahs took place in September 2022, at Kuno National Park. The Government of India made large effort to sensitize the public about the reintroduction of Cheetah in India so that people become aware, and can differentiate between Cheetah and other large cats which are similar like Leopard, Tiger and Jaguar etc. The Cheetahs will play an important role in returning the ecological balance of the Indian grasslands and also boost eco-tourism. The ENVIS centre on Himalayan Ecology took part in sensitization programme on Cheetah in various schools of Almora.

## INTRODUCTION

Cheetahs were reintroduced in India, Kuno National Park, Madhya Pradesh on 17th September, 2022. The Indian Cheetah was the only large carnivore in India that became extinct when the last cheetah was killed in 1952. After a gap of almost seventy years the Cheetah was reintroduced in the Indian Savanna, to commemorate the country's seventy five years of independence (*Azadi ka Amrit Mahatsav*).This article presents the history of Cheetah, their importance in the ecosystem, their process of reintroduction and sensitization campaign of reintroduction of Cheetah in India.

## DISTRUBUTION AND PHYSICAL CHARACTERISTICS OF CHEETAH

Apart from India Cheetah's are also found in Sub- Saharan Africa and extending eastward into Middle-East and to Central India. However at present it is distributed in small fragmented population in Central Iran, South, East and West African countries. The difference between African and Asiatic Cheetah is presented in Table 1.

**Table. 1.** Difference between African Cheetah and Asiatic Cheetah

| African Cheetah | Asiatic Cheetah |
|---|---|
| Scientific name: ***Acinonyx Jubatus*** | Scientific name: ***Acinonyx Jubatus Venaticus*** |
| Found all over the African continent in thousands of numbers | Found only in Iran with less than 100 individuals left |
| Slightly larger than the Asiatic counterpart | Slightly smaller than the African Cheetahs |
| They have slightly brownish and golden skin which is thicker than the Asiatic Cheetahs | They have pale yellowish fawn coloured skin with more fur under their body, specifically on the belly |

| | |
|---|---|
| They have much more prominent spots and lines on their face as compared to their Asian cousins | They have much less prominent spots and lines on their face |
| Much larger in population and listed as Vulnerable in the (IUCN) Red List of threatened species | Very small population base and are listed as critically endangered species in the (IUCN) red List of threatened species |
| Have a much diverse prey base that spans the whole African continent | Have a much smaller prey base than their African cousins. They prey only on small and medium-sized animals |

Cheetahs were widely distributed in India. They were found in Punjab in the North to Tamil Nadu in the South. They were found in Gujarat in the west to West Bengal in the East. The word Cheetah is derived from Sanskrit and literally means variegated as they have solid black spots all over their body. They are fastest animal on the planet with an estimated speed of 113km per hour. They use their tails to steer while running. The average weight of Cheetah is approximately 50 -60 kg and live up to 12-13 years. They hunt during day and they purr or growl. They have small rounded head with black "tear marks" and partially exposed claws. Cheetahs are apex carnivores and help shape every aspect of the environment (Fig.1). The difference between Cheetah and other apex carnivore found in India, e.g. Leopard and Jaguar are presented in Table.2.

**Table. 2.** Difference between Cheetah, Leopard and Jaguar

| | **Cheetah** | **Leopard** | **Jaguar** |
|---|---|---|---|
| **Definition** | Cheetah refers to a large slender spotted cat found in Africa and parts of Asia and is the fastest animal on land, while | Leopard refers to a large solitary cat that has a fawn or brown coat with black spots, native to the forests of Africa and southern Asia. | Jaguar, on the other hand, refers to a large heavily built cat that has a yellowish-brown coat with black spots, found mainly in the dense forests of Central and South America |
| **Scientific name** | *Acinonyx jubatus* | *Panthera pardus* | *Panthera Onca* |
| **Habitat** | Lives in Africa and parts of Asia, and leopard, while the | Lives in the forests of Africa and southern Asia | Lives in the dense forests of Central and South America |
| **Running Speed** | 80 – 130 km/h | 58 km/h | 80 km/h |
| **Height** | 67 – 94 cm at the shoulder | 60 – 70 cm at the shoulder | 63 – 76 cm at the shoulder |
| **Weight** | 21 – 72 kg, | 31 kg | 56-96 kg |
| **Fur Colour** | Has an upper coat of fur that is tawny, pale buff, or grayish-white, with under parts that are paler and whiter | The base colour of the coat is cream-yellow on the belly and it darkens slightly to an orange-brown on the back | Has tawny-coloured fur with black rosettes, but some have black-on-black, or melanistic, coloration |
| **Lifespan** | 10-12 years | 12-17 years | 12-15 years |

## ECOLOGICAL IMPORTANCE OF CHEETAH

The Cheetahs control the number of prey species in their ecosystem. Cheetah's main prey are herbivores. Without apex carnivore like Cheetah there are chances of population explosion of herbivores that often lead to over grazing and lead to desertification. Thus they play an important role in regulating the population of other organisms in the food web and overall environment (Fig.1).

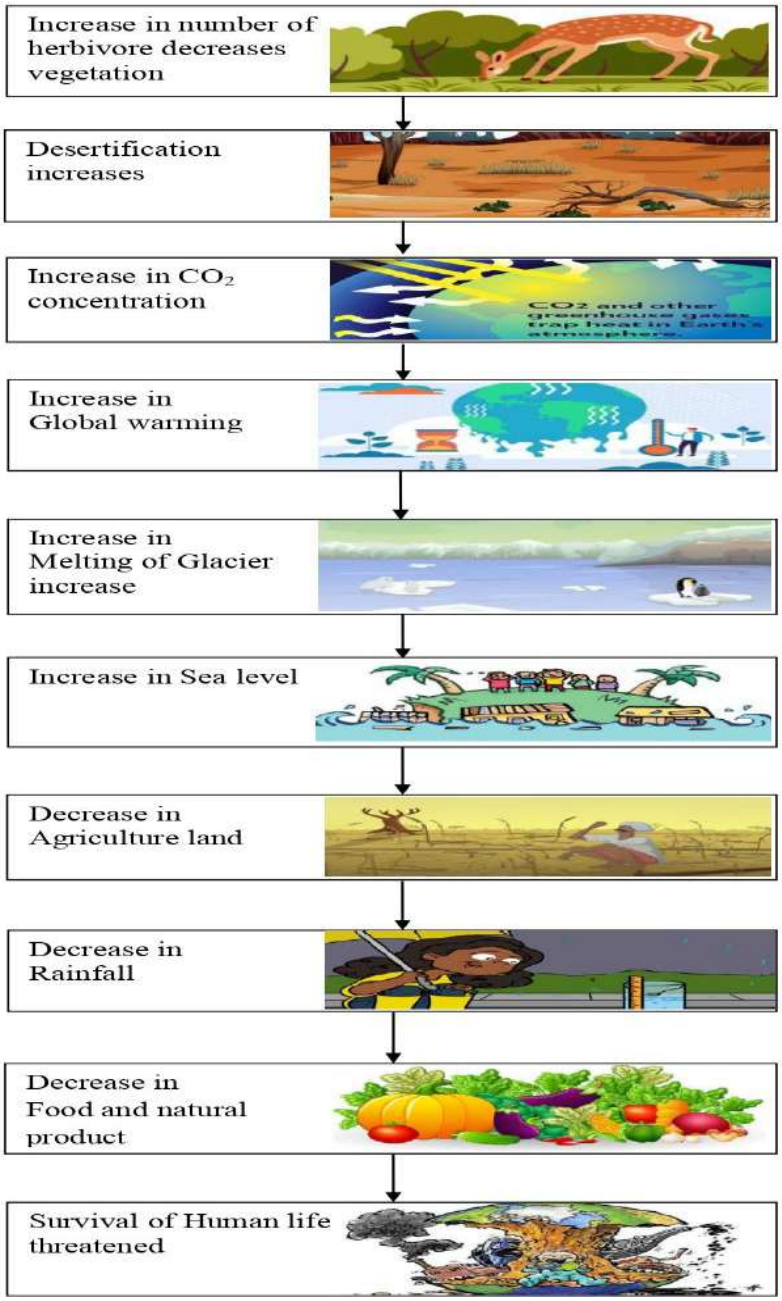


**Fig.1.** Top carnivores help shape every aspect of the environment

The presence of Cheetah will help in restoring open forests and savanna systems that will benefit biodiversity conservation and improve ecosystem services of these ecosystems. It will also contribute to carbon sequestration and mitigate climate change. A cheetah ecosystem has the potential for eco-development and eco-tourism that will enhance local community livelihood and also help to study human- wildlife conflict.

## PROCESS OF REINTRODUCTION OF CHEETAH

African Cheetahs were brought from Namibia on 17th September, 2022 to celebrate India's 75th independence year. This was the first intercontinental translocation of a carnivore. Eight Cheetahs were introduced in the Kuno National Park of Madhya Pradesh. The reintroduction took place in an unfenced protected area. Till date Cheetahs have been introduced from one site to another in fenced protected areas and this approach is known as "***fortress conservation***". However fortress conservation is no longer popular as it prevents the local fringe community from harvesting the natural resources and it impacts their livelihood.

The Indian approach to reintroduce Cheetahs is known as "***co-existence approach"*** where protected area are not fenced and locals have the right to utilize natural resources in their surrounding for their livelihood. However in this approach there is always threat from Leopards attacking Cheetahs, poaching and they also suffer stress of relocation and capture. In Kuno National Park there are nine Leopard's per sq kilometer. Leopards attack adult Cheetah and spotted Hynas kill Cheetah cubs. The co-existence methods also pose threat to human beings and livestock though Cheetah usually do not attack humans and prey on domestic livestock.

It is anticipated that if one or two breeding female can settle in the core conservation area of Kuno, they will be able to produce two to six litters every two years and consequently the population will increase and ecological imbalance be restored. 238 Chitals or spotted deers (*Axis Axis*) were relocated from Pench and Narsingarh wildlife sanctuary to increase prey base for Cheetahs at Kuno National Park. The locals living around Kuno National Park have been sensitized and they are optimistic that there will be a surge in tourist foot fall in Kuno and their income and livelihood will get a boost. The 500 hectare enclosure created to acclimatize the Cheetah were made free of Leopards and the fencing has been energized with 7 to 8 KW power with an aim to keep leopards away during the establishment phase. It will also prevent local trespassers who cross the buffer zone for collecting firewood and minor forest produce and they often destroy camera traps laid out for monitoring the cheetahs in order to escape getting identified and penalized.

## SENSITIZATION CAMPAIGN ON REINTRODUCTION OF CHEETAH

The Government of India entered into MoU with African countries like Namibia and brought in eight Cheetahs to India and The Prime Minister of India, Shri Narendra Modiji released the Cheetahs in Kuno National Park on his birthday on 17th September 2022, this also co-insided with the 75th independence anniversary of India (*Azadi ka Amrit Mahotsav*). The Ministry of Environment and Forest and Climate Change carried out massive sensitization campaign on Cheetahs so that people should know the benefits of Cheetah in nature.

The ENVIS Centre on Himalayan Ecology also participated in the national campaign. Sensitization programme was carried out in person in five schools in Almora by ENVIS Staff and five schools in Kullu district of Himachal Pradesh (Fig. 2.).

**Fig. 2.** Cheetah sensitization programs in school of Almora (Uttarakhand) and Kullu district (Himachal Pradesh)

A total of 5013 students were reached out in person. The ENVIS team also carried out sensitization programme virtually and 54 schools across Almora district were connected to the campaign and 7551 students were made aware about the new animal in Indian soil and how

different it is from other carnivores, mostly leopard which causes human wildlife conflict in the Indian Himalayan region including Almora district of Uttarakhand (Table 2).

## CONCLUSION

After approximately seventy years the pride of India, Cheetah was brought back from Africa and introduced in the Indian Savanna at Kuno National Park. Eight Cheetahs have been put in Kuno National Park to acclimatize and breed so that their population increases with time. This will help in balancing the Indian savanna ecosystem, boost eco-tourism. Humans need to know the importance of top predators in natural food chain and also distinguish Cheetahs from other carnivores like Leopards, Tigers, and Jaguars. Cheetahs will help the future generation to learn to live in co-existence. More research is needed on the animal lifestyle and livestock management to avoid human-wildlife conflict that may endanger the species again.

## Section- III

# Himalayan Ecology and Environment

# BIOPROSPECTING IN MEDICINAL PLANTS: AN OVERVIEW

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## ABSTRACT

Plants had been friend to mankind since Aryans, Sumerians, Babylonians and Chinese have started to colonize different parts of world as civilizations. Though they are different in their cultures on thing which was common among them was using plants as their primary source of food, lodging and clothing. Other than these plants were also seen as source of medications against various ailments and this is how human came to know about the utility of plants against various diseases. With the developments of sciences and civilizations a vast number of medications were produced from plants and recorded throughout the world especially by Chinese and Indians. In the modern world after using a huge number of chemically synthesized medications now researchers and medical fraternity looking back towards plants produced chemicals as promising source of medications in order the nullify the side effects of chemically synthesized medication. Thus, studying about and analyzing different phytochemicals that could be therapeutically important has been area of interest for researchers. Further in the search of newer potential phytochemicals scientists have been searching among the plant world and such search is known as Bioprospecting. This current review explains the requirement, process and need of Bioprospection among medicinal plants.

**Keywords:** Medicinal plants, Bioprospecting, Phytochemicals, Phytochemistry and Pharmacognosy

## BACKGROUND

Plants have been friends of human race since beginning of the life in every aspect whether it is food, cloth or shelter, another important property of plants is their medicinal utility. Plants have been a major source of medicine and resource for healthcare since ancient times with some traditional herbal medicines having been in use for more than 2000 years. The old Hindu book of medicine AYURVEDA contains the description of a large number of plant species with immense medicinal values. The nature has been an immense source of medicinal agents from the time immemorial and importance of herbs in the management of human ailments are well proven. Plants can act as herbal drugs, nutraceuticals, food supplements, folk medicine, pharmaceutical intermediates and new chemical entities for synthetic drugs, sweetness, fragrance and number of healthcare products (Hammer *et al*., 1999). Some plants have great medicinal properties depending on their phytochemical constituents that have great pharmacological significance. The use of natural resources like plants as medicine is practiced since ancient times in India. There are more than 3000 varieties of plants with very high medicinal and economical values which have been documented so far (Jain, 1983). Around the world Medicinal and Aromatic plants (MAPs) are used

by different groups of hominids and ethnic tribes. In the developing countries 80% of the population dependent upon the traditional medicines of which 85% comes in the form of medicinal plant extracts while 70% of the modern medicines are derived from natural products (Singhal and Agarwal, 2007; Bhatt *et al*., 2012) and more than 25% of pharmaceutical drugs are derived from the natural plants (Schmidt *et al*., 2008). All these facts have led to a high demand of traditional herbs in the last decade (Dubey *et al.*, 2004; Lubbe and Verpoorte, 2011). Considering the importance of traditional medicinal system and medicinal herbs in the pharmaceutical industry as source of bioactive secondary metabolites (Rout *et al*, 2000) organized exploration of such plants is required.

"Medicinal plants" are described as, plant species which possess healing properties due to the presence of specific beneficial elements in them. The branch that deals with studying about such plants is called Ethnobotany while all the analytical studies related to compounds contained in these plants, their use in drug development and treatment of patients is known as Ethnopharmacology. These methods are also used as tools to validate the use of medicinal plants in traditional healing practices (Anand *et al*., 2019).

Medicinal plants possess therapeutic properties due to the complex compounds of different composition they produce, these compounds are known as secondary metabolites and found in different parts of the plant. On the basis of their composition secondary metabolites have been classified in to various groups' viz. alkaloids, terpenoids, phenolics, flavonoids, quinones etc. Alkaloids are the leading group of these, and it includes some of the well-known drugs such as morphine and coccain (poppy), quinine (*Cinchona*), reserpine (*Rauwolfia*), aconitine (*Aconite*) and many others. Glycosides is one another key group among the secodanry metabolites having digoxin (Foxglove), barbolin (*Aloe*) etc. Some essential oils like peppermint and valerian kutch also have therapeutic significance and are used in the pharmaceutical industry (Zuhaib, 2016).

Human have been exploring the nature for their own benefits since beginning. In the process whenever they got ill they kept on searching for treatments from their vicinity (Pye *et al*., 2017). Thus they kept on identifying the utility plants and adding them to their knowledge. Such tendencies have led to development of therapeutics.

Phytochemicals have always been the mainstay for pharmaceutical industry for their research and development (R&D) sector, as they always search for some novel drugs (Newman and Cragg, 2016). Today almost 60% of anti-cancer drugs comes from natural sources either in direct use of indirectly as adjuvant to the main synthetic drugs or being a main structural component of the drug. Overall, near about 50% of modern drugs trace their origin from Natural products (Boucher *et al*., 2017). Innovation of a new therapeutics depends a lot upon the Natural products as the natural products are highly likely to be major source for a novel drug or a wonder drug that may come handy against various ailments (Rodrigues *et al*., 2016). Most of the nature depend therapies have come from two living traditions, Ayurveda: The Traditional Indian Medicine (TIM) and the Chinese Medicine System (Tan and Zhou, 2016). Both of these systems have their roots deeply going down into the nature and focused upon the use of plants and their products as drug. These system consist of a huge list of plants that can be used against various ailments and also description on making medicine out of the different plant part termed as phytomedicines (Patwardhan *et al*., 2005). Many pharma industry giants depends upon these lists of plants in order to develop newer drugs. The Chinsese scientists, researchers and medical fraternity is

already taking a lot of help from their Traditional Chinese Medicine for treating infectious diseases, similarly there are several instances where the Ayurveda based potential compounds are also under clinical trials (Butler *et al*., 2014). The herbal drugs are used in different forms and combinations in both of these traditional systems. These combinations and forms may be powders, tinctures, poultices, and teas. The form and combination of such raw drugs largely depends upon the type of disease. All such Herbal medicines play a great role still today in the world with 80% of world population dependent upon their traditional knowledge of healing both body and mind (Alves and Rosa, 2007).

## BIOPROSPECTING

A systematic approach towards searching a beneficial product from the natural resources which can be further developed for good cause of society and commercialization is termed as bioprospecting. Thus, it can be said that it is an assessment of life forms in search and development of novel compounds or biological molecules and entities with a clinical or economical utility. Screening plant extracts for antimicrobial, antioxidant and similar other activities, testing microorganisms for novel chemical compounds and using animal exudates for developing new drugs and therapies is a wide definition for Bioprospecting (Cox and King 2013). Screening microbes for their ability in catalyzing oil spills, analyzing their antifouling property to protect ship hulls, assessing novel bacterial strains resistant to high temperatures from hot springs and the search for new chemical compounds that may be of pharmaceutical use to inhibit a pathogen or treat a disease, all fall under Bioprospecting.

## BIODIVERSITY AND COMMERCIAL ASPECT

Often the term bioprospecting is considered analogous to extractive and destructive by the meida platforms which not really correct bioprospecting characterizes the search for a novel molecule, genome or structure that can become commercially viable (Cox and King, 2013). Such natural products are most of the time obtained from nature without creating any significant disturbance to the biological resources either consuming them or destroying them instead the scientist are always looking for and creating novel sustainable ideas in the process of creating a method to use certain resources. Thus it is a pejorative term that does not describe the resource being used to the nature but most of the time the use of such bio resources remain sustainable. All along the development of human civilization there have been many discoveries by the people from the nature whenever they require something as their need some of the important examples are the use of plants as herbicides and insecticides and other therapeutically valuable compounds those were utilized to treat animal's ailments. Thus. Though the term is new "Bioprspecting" was being unknowingly followed by peoples since ages and at places. Collecting a certain natural compound and using it for own benefit is the sole objective of Bioprospecting.

In the modern times with the advent of technologies scientists have created and innovated machines that can help one to understand the true nature of a certain plant by analyzing it to the molecular level and thereby understanding its Chemistry (Rosenberg, 1974). Understanding the structure of compound further may help one to develop similar compound in the lab so that further loss of natural resources can be checked (Thomke and Kuemmerle, 2002). A large focus of modern Bioprospecting have been the medicinal plant that have been the part of traditional medicinal system either oral or written or described in the folklores. Thus, bioprospecting to understand the true nature of a medicinal plant not only will

improve the efficacy of the drug obtained from that plant but also will help to check the irrational use of the plant thereby it can also help in plant conservation as well.

## EXPLORING MEDICINAL PLANTS FOR NOVEL METABOLITES

Medicinal plant analysis has been a part of human history for long, especially with respect to quality analysis of the plants. The most basic of these analyses starts with physical senses of taste, smell, and appearance also called organoleptic tests. With the evolution and further learning humans have come up more innovation and led on to more advanced sophisticated instrument based techniques (Fitzgerald *et al*., 2020). Different countries of world have developed their own medicinal practices over the race of civilization currently China publishes highest number of research papers related to analyzing medicinal plants for their therapeutic potential and then adding them to their respective pharmacopoeia. Such publications contained more of monographs containing methods and directions the kind of analysis to be done, as well as for herbal manufacturers. Over the past years, there have been developments in analytical techniques including advances in chromatography and spectrophotometry that led to deciphering the type of compounds contained in a plant and their respective structure (Atanasov *et al*., 2021). Further, the data analysis advancements using multivariate analysis software has given an edge to the present generation of researchers to study the metabolomics as well. This helps the researchers to understand variations in phytochemicals produced within medicinal plants. Such advancements not only assure us about the quality of the plant under study but shows route forward to the best of use one can have from that particular plant.

In the past few years there has been a constant rise in demand of herbal medicines as compared to the synthetic drugs, the advancements in extraction methodologies as well as faster and cheaper analytical methods have enabled us to understand the therapeutic values and possible uses of traditional medicinal plant. Major contributors to the medicinal plant based researches been China, India, USA and South Korea. Some of the East Asian countries like Japan, Taiwan, China, South Korea, have been sharing an immense 55% of total citations in researches related to bioprospecting from medicinal plants. The traditional medicine practice contributes about 40% of the medicine consumption in China and such systems are prevalent among rural populations of India, Japan, Pakistan, Sri Lanka and Thailand. The legumes such as Caesalpiniaceae, the Fabaceae, and the Mimosaceae are used in Thailand as herbal medicines. Japan has a huge demand of herbal pharmacy products as compared to any other nation world wide. The contribution of plants been remarkable in diverse sectors including fine nutraceuticals, cosmetics, pharmacy, chemical and other industry raw materials. Such plants prove to be instrumental whenever a novel drug or molecule is discovered or developed. In combating cancer like deadly diseases including the virus associated diseases viz. Hepatitis, AIDS etc., plants were found dynamic contributors. Deseridine, Vincristine, Vinblastin, Reserpine and Reseinnamine were among the top 100 hundres drugs that were produced by USA pharma market in the period of 1950-70 from different plants. Some other fresh medicines like Ginkgolides, Artemisinin, Lectinam. E-guggulsterone, Z-guggulsterone, Plaunotol, tenopiside, nabilone and ectoposide were launched in world market during 1971-1990. The pace of herbal pharmacy market was taken over by such researchers and they further propel it from the 2% presence of tptecan, gomishin, paclitaxel and irinotecan to higher levels with the development of strong herbal medicine manufacturing system. A new episode was added to the world of herbal medication in 1953 when serpentine was extracted and characterized from the Indian plant *Rauwolfia serpentina* This, drug

was obtained from the roots of the plant was found highly effective in treating the hypertension and lowering blood pressure. Vinblastine is an another herbal drug isolated from *Cataranthus roseus* used for treating various cancers like leukemia in children, testicular and neck carcinoma, Hodgkins choriocarinoma and non-Hodgkins lymphomas. Similarly, *Nothapodytes nimmoniana(Mapiafoetid*a) used to combat cervical cancer in Japan (Harrison, 1998; Jonas, 1998; Dar *et al*., 2017).

## PHYTOCHEMICALS OBTAINED FROM PLANTS

Plants produce some specific compounds which provides health benefits to the human beings in addition to the micro and macronutrients (Hasler *et al*., 1999). These naturally occurring chemical compounds with specific biological activity are called "Phytochemicals". Such phytochemicals provide resistance to the plant against the detrimental effects of environmental stresses like UV exposure, pollution, drought, salinity and pathogenic infections (Gibson *et al*., 1998, Mathai, 2000). These compounds also induce specific aroma, flavor and color to the plants. Humans have exploited such properties of plants to prevent themselves from pathogenic infections and for the health benefits. More than 4000 phytochemicals have been catalogued (American Cancer Society, 2000) till date out of which about 150 have been studied in detail.

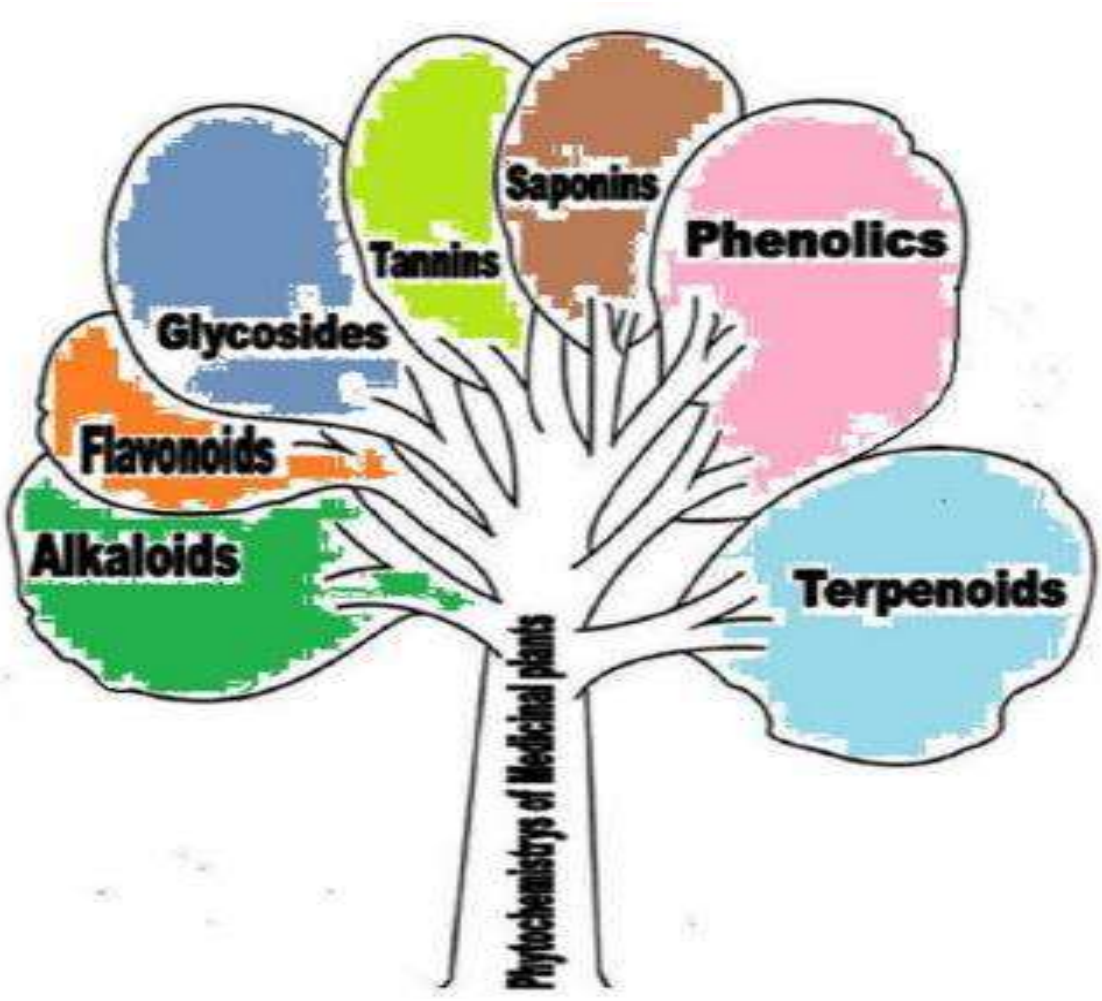


**Fig. 1.** Diagrammatic Representation of some important groups of phytochemicals produced in plants

All such compounds possess antimicrobial, immune system simulation, hormone modulation, antioxidative and anticancerous properties termed secondary metabolites (Rao, 2003). Compared to the synthetic medicines antioxidants and antibacterial or antimicrobial agents from natural sources are considered safe in terms of side effects and potent as well. The ancient Indian literature tells us, that each and every plant on earth hold some utility for humans or animals or another plant. The biochemical reactions that occurs persistently in the human body, require oxygen this leads to the production of reactive oxygen species as by products. These reactive oxygen species are freer radicals which have detrimental effects on the proteins, DNA or the other important part of cell (Bailey *et al*., 2001; Bailey and Davies, 2001b). Antioxidants are the compound which can protect cells form damaging effects of Reactive Oxygen Species (ROS) (Sies, 1997). The deleterious effects of ROS including superoxide anion ($O^{2-}$), hydroxyl free radical ($OH^{1-}$) and hydrogen peroxide may cause cancer, ageing, atherosclerosis and coronary heart diseases (Madhavi *et al*., 1995). Table 1 shows the biological functions of some important phytochemicals and their classification details.

**Table 1.** Bioactive metabolites in medicinal plants

| Class | Important compounds | Biological Function |
|---|---|---|
| NSA (Non-starch polyssacharides) | Cellulose, hemicellulose, gums, mucilages, pectins, lignins | Water holding capacity, delay in nutrient absorption, binding toxins and bile acids |
| Antibacterial and Antifungal | Terpenoids, alkaloids, phenolics | Inhibitors of micro-organisms, reduce the risk of fungal infection |
| Antioxidants | Polyphenolic compounds, flavonoids, carotenoids, tocopherols, ascorbic acid | Oxygen free radical quenching, inhibition of lipid peroxidation |
| Anticancer | Carotenoids, polyphenols, curcumine, Flavonoids | Inhibitors of tumor, inhibited development of lung cancer, anti-metastatic activity |
| Detoxifying agents | Reductive acids, tocopherols, phenols, indoles, aromatic isothiocyanates, coumarins, flavones, carotenoids, retinoids, cyanates, phytosterols | Inhibitors of procarcinogen activation, inducers of drug binding of carcinogens, inhibitors of tumourogenesis |
| Others | Alkaloids, terpenoids, volatile flavour compounds, biogenic amines | Neuropharmacological agents, anti- oxidants, cancer chemoprevention |

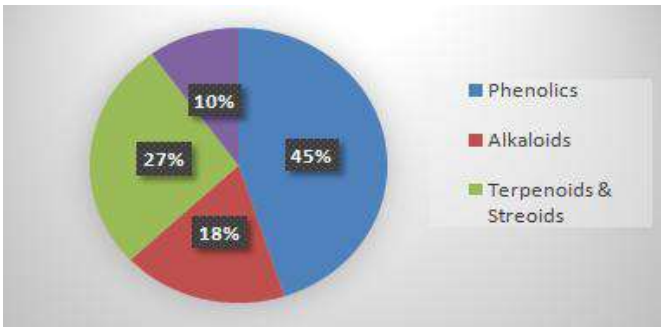


**Fig. 2.** Share % of major phytochemical groups among natural products

The biologically active compounds extracted from plants are mostly the secondary metabolites, which acts as natural shields for plants against external vulnerabilities. Resistance to various pathogenic infections and herbivores is an important ecological function of secondary metabolites. There are many compounds which are used by both plants and humans against various infections as fungal infection.

However, in most of the cases the secondary metabolites have altogether different effects on humans, for example, L-Dopa functions as an antifeedant for *Viccia faba,* and protects it from herbivory; but it is used to treat Parkinson's disease in humans (Simmonds and Grayer, 1999). Plants contains phenolic compounds which can prevent oxidative degradation of lipids and thus, improves the quality and nutritional value of the food which is beneficial for humans. Antioxidant capacity of plasma can be increased by consuming fruits and vegetables rich diets (Cao *et al*., 1998). Natural antioxidants obtained from several plants, induces resistance against ageing and diseases. Plant materials such as vegetables, fruits, leaves, oilseeds, cereal crops, barks and roots, spices, herbs and crude plant drugs have been investigated for the presence of antioxidant compounds.

For studying such wide variety of Chemical constituents from plants specific techniques are required, even the compounds cannot be analyzed with a single technique. Chromatographic techniques are widely used for metabolomic profiling of the plants. These chromatography techniques include Thin Layer Charomatography (TLC), HPTLC for separation of metabolites from crude extract while HPLC (High Performance Liquid Chromatography) used for identification and quantification of secondary metabolites (Talreja *et al.*, 2016).

## ANTIOXIDANTS

Antioxidants are the compounds that can inhibit the oxidation processes, preventing propagation chain reactions. They are also known as oxidation inhibitors (Pokorny *et al*., 2001).In a cell, the antioxidants can neutralize the free radicals by donating electrons and thus prohibiting the carbon-stealing reaction. Antioxidants acts as scavenger in order to prevent cell and tissue damage by free radicals. The different types of compounds whether they are of endogenous or exogenous origin acts as antioxidants (Jacob, 1995). The endogenous antioxidants include enzymatic antioxidants; metal binding proteins like ferritin, lactoferrin, albumin, ceruloplasmin and other phytoconstituents (Jacob, 1995).

## SOME IMPORTANT PLANTS

Ayurvedic medicine has greatly been used in India including many herbs such as turmeric since 1900 BC. The earliest Sanskrit writing including Atharva Veda and Rig Veda has got the detailed description of medicinal knowledge forming a base for Ayurvedic system of medicine. Some other herbs were later described by ancient Indian herbalists like Charaka and Sushruta during 1$^{st}$ millennium BC.

*Coleus forskohlii* is one of such plants that has been used since ancient times in Hindu and Ayurvedic medicine. According to Paul *et al*., (2013) *Coleus forskohlii* contains many diterpenes. The diterpenoids extracted from *C forskohlii* belongs to two groups viz. abietanediterpenoids (abietanoids) and 8, 13-epoxy-labd-14 en-11-one diterpenoids. The most investigated compound is forskolin. Initially it was named colenol, however, after the identification of other colenols and diterpenoids, it was renamed as forskolin (Saksena *et al*.,1985). Chemically it is 7β-acetoxy-8, 13-epoxy-1α, 6β, 9 α-trihydroxy-labd-14 en-11-one (Bhat et al., 1977; Saleem *et al*., 2006). Till now 20 constituents have been isolated from different parts of *Coleus forskohlii,* of which the forskolin and coleonols are found in the root part of the plant. Leaf extract of this plant have shown high amount of polyphenols, flavonols and flavones and high antioxidant activity. HPLC studies of leaf and stem tissues proved the presence of standard antioxidative

polyphenols and more potent antioxidative polyphenols which demonstrate that it can be used as an important source of phenolic compounds having high antioxidant activity. Tannins are also present in the leaf and stem portion of the *Coleus forksohlii* (Rasineni and Reddy, 2008; Khan *et al*., 2012). Two diterpenoidquinones were isolated from the chloroform extract of the *Coleus* leaves which are coleon S and coleon (Yao and Xu, 2001). Srivastava *et al*., (2002) carried out a detailed pharmacognostical study of roots procured from different geographical areas of India. All the samples showed similarity in macroscopic and microscopic characteristics. There was considerable variation in the content of forskolin, sugars, protein and starch in the various samples.These variations are attributed to genetic or climatic factors (Tandon *et al*., 1979).

The prevailing herbal medicine has descended from generation to generation for curing a simple ailment to a complex one. Present ethanobotanical studies has revealed the use of plant for various disease and ailments ranging from dysentery, cough, asthma, inflammation, body ache, wound healing, bronchitis , mouth ulcers, delivery, head ache, sore throat ,constipation , diarrhoea, menstrual disorders, malaria, jaundice, mental disorder and skin disease etc.

One among these plants is *Reinwardtia indica* commonly known as yellow flax or pyoli. This plant belongs to family Linaceae and genus Reinwardtia found in the Himalayas. Only two species of Reinwardtia are known that are native to Southern Asia namely *Reinwardtia indica* and *Reinwardtia sinensi*s. In India the genus is represented by only one species *R. indica*. Being a native of Himalayan foothills, this plant has many medicinal properties (Rawat *et al*., 2011).

*Adhatoda vasica* (*syn. Justicia adhatoda*), another important medicinal plant, also known as Malabar nut tree is a member of the family Acanthaceae. It is a common evergreen, perennial shrub distributed throughout India, especially in the lower Himalayan Region (up to 1300 m above sea level) also found in Nepal, Pakistan, Sri Lanka, Burma and Malaysia. In Ayurveda, the ancient system of Indian medicine it is commonly known as vasa (Singh *et al*., 1997). It grows to a height of 2-3 feet with leaves about 10-15 cm long and 5.0 cm wide flowers are white or purple and four-seeded fruits. The leaves are of dark green in color on adaxial and pale yellow on abaxial surface. Flowers are typical, white arranged in pendunculated spike. Leaves of *Adhatoda* are used extensively in Ayurvedic medicine for over 2000 years primarily for respiratory disorders. Wide range of phytochemical constituents isolated from the vasaka plants and its possesses various activities like antifungal, antiviral, hepatoprotective, antitussive, antibacterial, anti-inflammatory and antiulcer, abortifacient, thrombolytic, radiomodulation, cardiovascular protection, hypoglycaemic, antitubercular, antioxidant, antimutagenic, reproductive action (Claeson *et al*., 2000).

*Agretina adenophora*, commonly known as Crofton weed or sticky snakeroot, is a member of Asteraceae plant family. It is a toxic weed that causes damage to farmlands, pasture fields and forests as it has been observed that other plants were rarely found in the proximity as it suppresses the growth of other plants in its vicinity due to its allelopathy (Zhou and Xie, 1999). In addition to its strong adaptability under diverse environmental conditions, it is a perennial herbaceous shrub which may grow up to 1m height. It has opposite trowel-shaped serrated leaves that are 6-10 cm long and 3-6 cm in wide. It flowers during late spring and summer; the flowers are compound and are purple to white in color. It grows as weed on vast expanses in many parts of the world and is an attractive source of bioactive natural products. Various species of *A. ageratina* have been used in the traditional system of medicine in different parts of the world. The leaf juice of *A. adenophora* is used to stop bleeding of cut and wounds, forming clots. The oils

have antifungal and insecticidal qualities, being suggested for use in controlling aphids, ants and even weevils in stored grains. The oil has been considered for other uses, and even for xylitol production (Sarker *et al*., 2011).

*Terminalia chebula*, commonly known as black or chebulic myrobalan and harad . It is a species of Terminalia, and member of family Combretaceae. It is found throughout the South East Asia including India, Nepal, Bhutan, Vietnam, Thailand and Pakistan. In India it is found in the Sub Himalayan tracks from Ravi eastwards to West Bengal and Assam, ascending up to the altitude of 1500m in the Himalayas. *T. chebula* is a medium to large deciduous tree growing to 30m (98 ft) tall, with a trunk up to 1m in diameter (Saleem *et al*., 2002). The leaves are alternate to sub opposite in arrangement, oval, 7-8cm long and 4.5-10 cm broad with a 1-3 cm long petiole. The fruits are drupe–like, 2-4.5cm long and 1.2–2.5 cm broad, blackish, with five longitudinal ridges (Rathinamoorthy and Thilagavathi, 2014). The dull whites to yellow flowers are monoecious, and have a strong, unpleasant odour. The fruit of T.chebula is considered as the "king of medicines" by Tibetans and second to- none by Ayurvedic apothecaries. Terminalia consists of 250 species and widely distributed in tropical areas of the world (Gupta, 2012).

These are some specific examples of plants that have various medicinal properties and used by people worldwide especially in the Indian subcontinent. There are many more of the plants finding their description in the grand old book of medicine i.e. Ayurveda and all those still needed to be analyzed for their medicinal properties and therapeutic aspect.

## FUTURE OF MEDICINAL PLANTS AND BIOPROSPECTING

Looking at the current trend in world of medicine and healthcare it has been immensely tilted towards naturopathy and herbal medications, as the world been quite clever to understand the side effects caused by most of the synthetic medications (Urban, 2019). Further, with the advancements of analytical and extractive methods, it has become easier for researchers worldwide to carry on the extractive and analytical researches on the plants that have been ignored for long time now and can become important therapy tools in coming future (Urban, 2019). The World Health Organization (WHO) has also now recognized the importance of traditional medicines (WHO, 1993). They have come up with guidelines, standards and strategies for botanical medicines. Furthermore, in order to meet the growing demands of such plants as well as their conservation agro-industrial technologies need to be applied for the cultivation of all such recognized important plants (Hosseinzadeh *et al*., 2015). Many of the important medications of modern world are produces from medicinal plants and they are valuable resources for novel drugs.

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# ETHNOMEDICINAL PLANTS USED AGAINST OSTEOARTHRITIS BY THE RURAL POPULACE OF TEHSIL PAONTA SAHIB, DISTRICT SIRMOUR, HIMACHAL PRADESH, INDIA

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## ABSTRACT

Osteoarthritis is a severe condition affecting the mankind throughout the globe. An ethnobotanical survey was carried out and 32 plant species belonging to 24 families were reported to treat osteoarthritis in Paonta Sahib Tehsil of district Sirmour, Himachal Pradesh. Maximum plant species used were trees (34.37%), followed by herbs (28.12%), shrubs (25%), under shrubs (9.38%) and liana (3.13%). The main purpose of the study is to unfold the asset of traditional medicinal plants used by the rural populace against osteoarthritis and suitable measures should be taken to conserve these ethno medicinal species and practices also.

**Keywords**: Conservation, Sustainability, Folk Use, Survey and Traditional

## INTRODUCTION

Ethnobotany includes the use of plants by both tribal and non-tribal communities without any inference of ancient societies" (Wickens, 1990). While the term also refers to the study of the knowledge system pertaining to the multidimensional perception of life, culture, traditions as well as interaction of traditional human communities with their local flora (Ethnobotany) or fauna (Ethno zoology) (Pushpangadan, 1990) . Often, the interaction is wrongly interpreted to be exclusively concerning only the indigenous people with plants. But the nature and scope of the term ethno botany be widened to include all aspects like natural and direct relationship of people with plants, at any level of antiquity and primitiveness. Of late, the subject of ethno botany has been recognized as a rapidly expanding multidisciplinary natural science throughout the world with practical application of its data in areas such as conservation of plant species including varieties of crops and other forms of biological diversity, botanical inventories and assessments of the conservation status of species, sustainability in supplies of wild plant resources including non-timber products, enhanced food security, nutrition and healthcare, preservation, recovery and diffusion of local botanical knowledge and wisdom, reinforcement of ethnic and national identity, greater security of land tenure and resource ownership, assertion of the rights of local and indigenous people, agreements on the rights of communities in protected areas, identification and development of new economic products from plants, for instance crafts, foods, herbal medicines and horticultural plants and contributions to new drug development (Hamilton *et al*., 2003).

Traditionally indigenous societies worldwide are dependent largely on plants for their sustenance and livelihood. The harmony with nature is inherent in their culture and way of life of these societies. This

knowledge is not only "technical" in nature, but also incorporates integrative insights, wisdom, ideas, perceptions and innovative capabilities which pertain to ecological, biological, geographical and other physical phenomena (Mashelkar, 2001). The significance of traditional ethno botanical knowledge is now being increasingly accredited. However, the practice related to applying traditional culture to serve present day conservation and management systems needs to be elaborated (Aizhong *et al*., 1999).

Osteoarthritis is a musculoskeletal ailment which is very common and affecting large number of people. It is the oldest ailment and its predominance increases with age. Osteoarthritis is a degenerative and chronic joint condition which leads to narrowing of joint space and is also a major cause of disability. This condition occurs due to wear and tear of the protective cartilage which is a flexible tissue present at the end of the bones. It is the cartilage loss when cushion between the joints breaks down leading to acute pain, inflammation, stiffness and finally to the obliteration of joints (Singh, 2016). This disorder mainly affects knees, lower back, buttocks, fingers and feet. Osteoarthritis causes structural and functional failure of synovial joints due to which movement becomes difficult. In established arthritis, the synovial membrane becomes altered into inflammatory tissue, the pannus. This tissue invades and destroys adjacent cartilage and bone (Gautam *et al.*, 2013). The normal joint lining is very thin and it has a very few blood vessels in it but in the arthritic joints, the lining becomes very thick and crowded with the white blood cells (Kaur *et al*., 2012). Arthritis is associated with numerous genetic and environmental factors that contribute the phenotype in different combinations (Choudhary *et al.*, 2015).

Today's lifestyle is also responsible for this problem which includes unhealthy and improper diet, lack of exercise and yoga, long working hours and wrong posture during work. Synthetic drugs also minimize the arthritic pain but symptoms re-emerge after the discontinuation of medicines. Thus, herbal medicines are preferred over them because these have no side effects. The World Health Organization (WHO) suggested that as many as 80% of world's people depend on traditional medicine for their primary health care requirements (Prakash, 2014). Today about 65% of the Indian population depend on the traditional system of medicine (Uniyal and Shiva, 2005). Plants can be used in various forms to relieve pain and inflammation in the joints. Some medicinal plants contain certain active constituents which are used to relieve pain and inflammation of joints.

As the local people are settled far from cities, they are not able to take modern healthcare facilities so they are totally reliant on traditional medicinal practices for their primary health care. Plants play an imperative role in the treatment of diseases since primitive times and considered as one of the most important area of research in the world today. Traditional medicines are used in the maintenance of health, prevention of disease and improvement of physical and mental illness (Lone *et al*., 2015).

## MATERIALS AND METHODS

### Study Area

Tehsil Paonta Sahib, lies in outer Himalayas commonly known as Shivalik in Sirmour district of Himachal Pradesh (India). The district shares its boundaries with Shimla in north-east, Solan in north-west, Haryana to its west and south-west, Uttar Pradesh to its south-east and Uttarakhand to its east. Tehsil Paonta Sahib is located between 30.43$^{o}$N to 77.62$^{o}$E at an altitude of 400 - 1,300m and at a distance of 45 km from headquarter at Nahan. Yamuna, Giri and Bata are the rivers flowing through the Tehsil. 90% of the population is living in villages. Thus, due to traditional and ethnic lifestyle of the

people, the region possesses a rich floral and cultural diversity which is required to be conserved immediately.

## Methodology

To document first hand information pertaining to medicinal plants of Tehsil Paonta Sahib used for curing osteoarthritis, exhaustive field surveys were undertaken in its various villages in different seasons. A questionnaire format was also prepared in which vernacular name of the plant, area from where it was collected, morphology, folk uses and method of use of plant against osteoarthritis etc. were mentioned. The field surveys were planned in such a way so as to collect the plant species either in flowering or fruiting stage. The required information on osteoarthritis was collected through interviews from old experienced farmers, family heads, traditional practitioners, housewives, well-known elderly persons of the community, etc. The data thus collected were verified in different villages after showing the same plant specimen to various villagers. If at least three informants made similar comments about the uses then the ethno botanical lore is considered valid. The specimens were identified by comparing herbarium specimens at Forest Research Institute, Dehradun and after consulting with the experts. The voucher specimens were deposited at Department at Ethnobotany and Biodiversity lab, in the herbarium section of Botany, Himachal Pradesh University, Shimla (H.P).

## RESULTS AND DISCUSSION

During present study, it was found that 32 species belonging to 24 families are useful for the treatment of Osteoarthritis (Table 1).

**Table 1.** Anti Osteo arthritic Medicinal Plants of Tehsil Paonta Sahib, District Sirmour, Himachal Pradesh, India

| Botanical Name | Vernacular Name | Family | Parts Used | Folk Uses |
|---|---|---|---|---|
| *Amorphophallus paeoniifolius* (Dennst.) Nicolson | Zaminkand | Araceae | Corm (under-ground stem) | Poultice of corm used for curing arthritis. |
| *Argemone mexicana* L. | Bharbhara | Papaveraceae | Stem | One teaspoon stem juice massaged to check arthritic pains. |
| *Brassica juncea* (L.) Czern. | Sarson ki todia | Brassicaceae | Seeds | Warm poultice of its seeds along with single garlic clove applied on aching muscles. |
| *Cassia fistula* L. | Amaltas | Fabaceae | Fruit | Fruit pulp applied on painful arthritic joints for relief. |
| *Celastrus paniculatus* Willd. | Malkanghni | Celastraceae | Seeds | Seed oil massaged on arthritic and painful joints. |
| *Cinnamomum camphora* (L.) J.Presl | Kapur | Lauraceae | Wood, Stem and leaves | Camphor along with olive oil is massaged for rheumatic joints. |
| *Cordia dichotoma* G.Forst. | Lasura | Boraginaceae | Fruits | 4-5 of its ripe fruits consumed daily for 10-15 days for checking arthritic pain. |
| *Ficus benghalensis* L. | Bargad | Moraceae | Bark/ Fruits | 1/2 cup decoction of bark or 1/2 tsp powdered fruit given for 8-10 days once daily after meal for arthritis. |
| *Jasminum sambac* [Soland.] Hortus Kew. (W. Aiton) | Mogra | Oleaceae | Flowers and leaves | Poultice of flowers and leaves applied to heal arthritic joints and flowers also added to vegetables or curries for curing arthritis. |

| | | | | |
|---|---|---|---|---|
| *Madhuca longifolia* J.F.Macbr. | Mahua | Sapotaceae | Bark | Poultice of bark applied on arthritic joints. |
| *Mentha longifolia* Huds. | Jangli pudina/Safed Pudina | Lamiaceae | Leaves | Paste of leaves applied as poultice for painful arthritic joints. |
| *Mesua ferrea* L. | Nagkesar | Clusiaceae | Seeds | Seed oil massaged for pain in arthritic joints. |
| *Moringa oleifera* Lam. | Sahanjana | Moringaceae | Fruits, flowers and root | ½ tsp powdered fruits, flowers and one year old root of the plant in equal ratio combined with hot milk given once daily for 5-10 days to cure arthritic pains. |
| *Murraya koenigii* Spreng. | Curry patta | Rutaceae | Whole plant | 15-20ml decoction of the whole plant taken twice daily till cure for arthritic pains. |
| *Nyctanthes arbor-tristis* L. | Harsingar | Oleaceae | Leaves | 20-25ml decoction of leaves taken twice a day for 2-3 months for arthritis |
| *Pluchea lanceolata* Oliv. & Hiern | Raasna | Asteraceae | Whole plant | 10-15ml decoction of the plant given with hot water twice for three months to cure arthritis. |
| *Plumbago zeylanica* L. | Chitrak | Plumbaginaceae | Roots | Oil extracted from roots massaged on painful joints |
| *Populus deltoides* Bartram ex Marshall | Poplar | Salicaceae | Bark | Paste of bark applied as poultice for arthritic joints. |
| *Rauvolfia tetraphylla* L. | Bara-chandrika | Apocynaceae | Roots | Poultice of roots applied on painful joints to check pain. |
| *Ricinus communis* L. | Arand | Euphorbia-ceae | Leaves | Poultice of leaves also applied on arthritic joints, Also, castor oil massaged for relief from arthritic joints |
| *Sapindus saponaria* L. | Ritha | Sapindaceae | Leaves | Paste of leaves applied as poultice on aching joints. |
| *Senna obtusifolia* (L.) Roxb. | Panwad | Fabaceae | Seeds | 1/2g of powdered seeds taken once daily with milk for 15-20 days for arthritis. |
| *Senna occidentalis* (L.) Link | Kasondi/Kasmarda | Fabaceae | Seeds | ¼ tsp powdered seeds taken daily with honey for swollen joints and arthritis. |
| *Solanum americanum* Mill. | Makoi | Solanaceae | Whole plant | Poultice of plant applied on arthritic joints. |
| *Spilanthes acmella* Murray | Akarkara | Asteraceae | Leaves | Paste of leaves applied on arthritic joints. |
| *Stevia rebaudiana* (Bertoni) Bertoni | Madhupatri | Asteraceae | Leaves | Poultice of leaves applied on rheumatic joints. |
| *Terminalia bellirica* (Gaertn.) Roxb. | Bahera | Combreta-ceae | Fruits | Pulp of kernels applied as poultice on arthritic joints. |
| *Trigonella foenum-graecum* L. | Methi | Fabaceae | Seeds | 1tsp powder of seeds taken on empty stomach with lukewarm water for arthritis. |
| *Urtica dioica* L. | Bichhubooti | Urticaceae | Leaves | Decoction of young leaves consumed as tea for arthritis. |
| *Vitex negundo* L. | Nirgundi | Lamiaceae | Whole plant | Warm poultice of the plant applied on arthritic joints. |
| *Withania somnifera* | Ashwa-gandha | Solanaceae | Stem | Paste of tender shoots applied for arthritic joints. |
| *Wrightia antidysenterica* | Ramjau | Apocynaceae | Bark | 25-30ml decoction of bark prescribed daily till cure against arthritis. |

Predominant families are fabaceae and asteraceae. Out of these, 68.75% species are growing wild whereas 31.25% are cultivated. Trees were dominating with (34.37%) species as compared to herbs (28.12%), shrubs (25%), under shrubs (9.38%) and liana (3.13%) (Fig. 1).

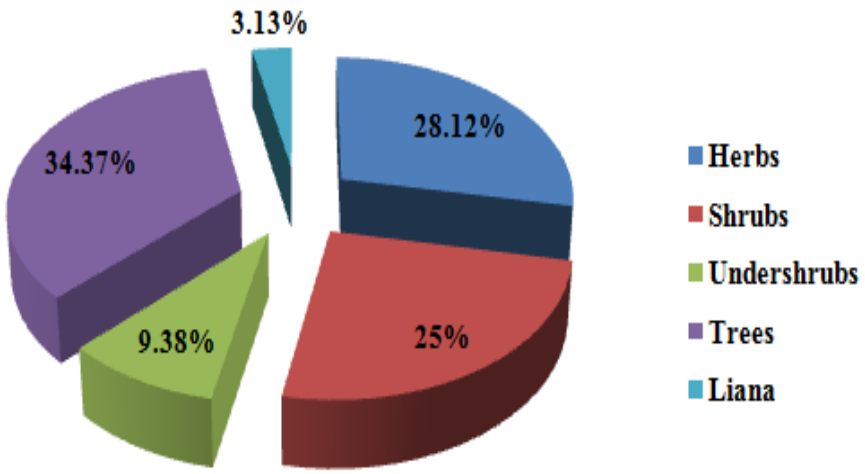


**Fig. 1.** Habit-wise distribution of plant species used for the treatment of Osteoarthritis in the study area

Variety of methods of preparation of herbal remedies practiced by the inhabitants has been reported. Maximum used method of preparation includes poultice which is s soft, moistened mass of herb or plant material wrapped in a cloth. Poultice/paste of 46.88% species (*Amorphophallus paeoniifolius, Brassica juncea, Cinnamomum camphora, Jasminum sambac, Madhuca longifolia, Mentha longifolia, Populus deltoids, Rauvolfia tetraphylla, Ricinus communis, Sapindus saponaria, Solanum americanum, Spilanthes acmella, Stevia rebaudiana, Terminalia bellirica, Vitex negundo*), followed by decoction of 15.62% species (*Ficus benghalensis, Murraya koenigii, Nyctanthes arbor-tristis, Pluchea lanceolata, Urtica dioica*) and powder of 15.62% species (*Ficus benghalensis, Moringa oleifera, Senna obtusifolia, Senna occidentalis, Trigonella foenum-graecum*), oil of 12.5% species (*Celastrus paniculatus, Mesua ferrea, Plumbago zeylanica, Ricinus communis*), juice/pulp of 6.25% species (*Argemone mexicana, Cassia fistula)* and 3.13% species are consumed as such (*Cordia dichotoma*).

Different plant parts such as leaves [21.62%] (*Cinnamomum camphora, Jasminum sambac, Mentha longifolia, Nyctanthes arbor-tristis, Ricinus communis, Sapindus saponaria, Spilanthes acmella, Stevia rebaudiana, Urtica dioica* ), seeds [16.22%] (*Brassica juncea, Celastrus paniculatus, Mesua ferrea, Senna obtusifolia, Senna occidentalis, Trigonella foenum-graecum* ), fruits [13.52%] (*Cassia fistula, Cordia dichotoma, Ficus benghalensis, Moringa oleifera, Terminalia bellirica*), bark [10.81%] (*Ficus benghalensis, Madhuca longifolia, Populus deltoids, Wrightia antidysenterica*), stem [10.81%] (*Amorphophallus paeoniifolius, Argemone mexicana, Cinnamomum camphora, Withania somnifera*), whole plant [10.81%] (*Pluchea lanceolata, Solanum americanum, Vitex negundo*), root [8.11] (*Moringa oleifera, Plumbago zeylanica, Rauvolfia tetraphylla*), flower [5.40] (*Jasminum sambac, Moringa oleifera), wood [2.70] (Cinnamomum camphora*) were used for the preparation of traditional medicine (Fig. 2).

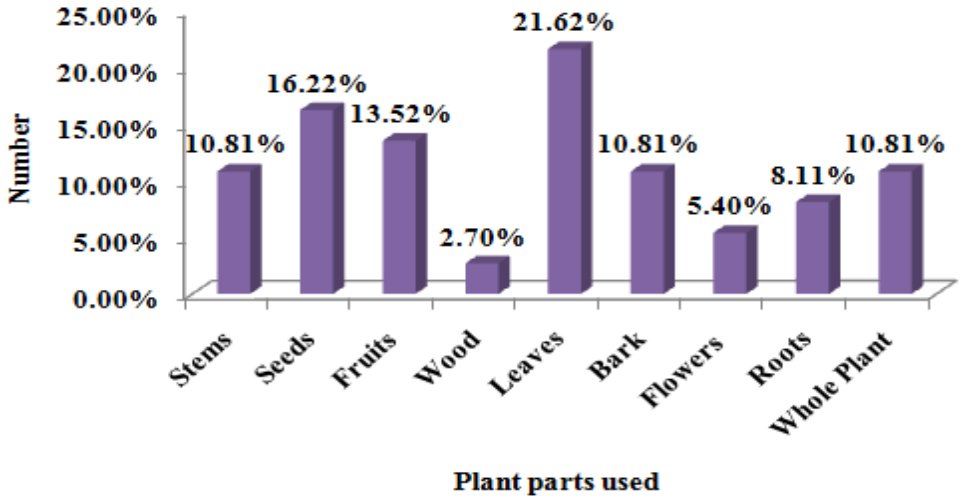


**Fig. 2.** Analysis of different plant parts used for curing Osteoarthritis by the inhabitants of Tehsil Paonta Sahib, District Sirmour, H.P.

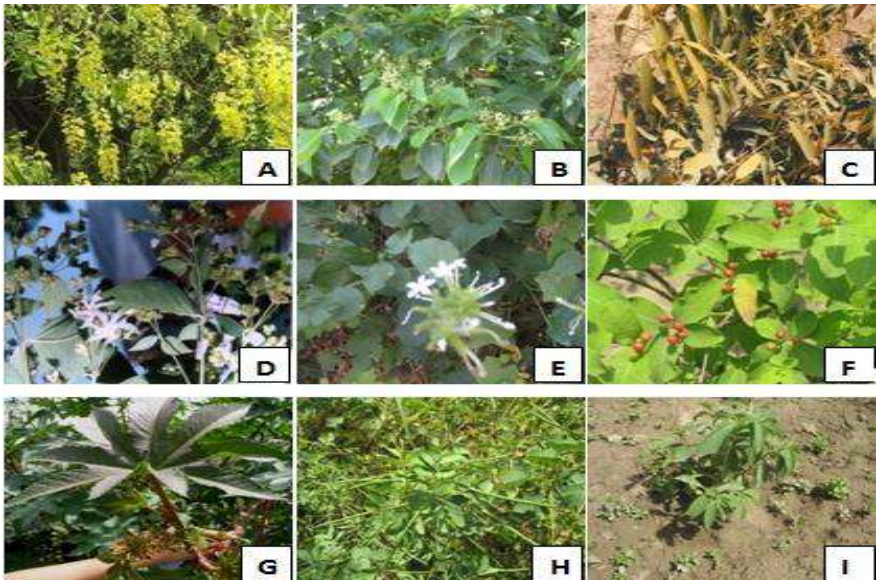


**Plate 1.** Selected Ethno medicinal plants used for Osteoarthritis by the rural populace of Tehsil Paonta Sahib of district Sirmour, Himachal Pradesh (India). **A.** *Cassia fistula* **B.** *Cinnamomum camphora* **C.** *Mesua ferrea* **D.** *Nyctanthes arbor-tristis* **E.** *Plumbago zeylanica* **F.** *Rauvolfia tetraphylla* **G.** *Ricinus communis* **H.** *Senna obtusifolia* **I.** *Stevia rebaudiana*

## CONCLUSION

The use of ethno-medicinal plants by the villagers of Tehsil Paonta Sahib plays a very important role for the cure of osteoarthritis in the region. Plants are the richest source of herbal medicines with wide acceptance. Traditionally used medicinal plants have been a source of relief for arthritic patients in the study area. It is evident from the present study that the inhabitants have an independent subsistence lifestyle. Due to the prevalence of osteoarthritis and large number of people affected by this ailment, a comprehensive effort is necessary for effective planning to discover the traditional knowledge based anti-arthritic drugs with minimal side effects and low costs. The potential value of these traditional remedies for curing the ailment needs to be popularized worldwide. By adopting conservation oriented practices, all these species should be conserved.

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# TIME TO SAFEGUARD INDIAN *EPHEDRA*: THE SOMA PLANT

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*Ephedra*, the Indian Soma Plant, is an interesting genus of the highly evolved order of gymnosperms, Ephedrales. Unique features like double fertilization, advanced anatomical features and entemophyllous pollination in a few species, further add to the antiquity of this plant. Ephedra may be treated as closest relative of the flowering plants. Importance of Ephedra in Indian Ayurveda is well recognized. Earlier reports indicate that the ancient Aryans discovered Ephedra or Soma plant as an energizer-cum-euphoriant. Use of *Ephedra* juice for longevity was a part of ancient Indian Aryans custom mentioned in the Rigveda (the oldest of sacred Sanskrit Vedas) and followed even by ancient Romans (Mahdihassan and Mehdi, 1989). Traditionally *Ephedra* was made as a fermented drink and was used ceremonially by Vedic and Zoroastrian priests. Use of Soma plant by ancient people is documented in Indian Ayurvedic literature in the treatment of common cold, cough, and fever, headache, as nasal decongestion and as bronchodilator in the treatment of asthma. This is an important constituent in all major cough and cold herbal decoctions and medicines. Not only in India, but in China also *Ephedra* (Ma Huang) is referred as TCM (traditional Chinese Medicine) is being used for asthma and other ailments since 5000 years. In Japan this plant is used in several kampo (Sino-japanese) preparations. Moreover, a new usage of *Ephedra* different from traditional direction had been widespread in the United States. Focusing on thermogenic and lypolytic effects of Ephedra, dietary supplements containing *Ephedra* extracts have been commercially promoted and are used for weight reduction and energy enhancement (Josefson, 1996, Boozer *et al*., 2001). All these factors are leading to a heavy consumption of this drug plant at a very higher rate. Main producer and supplier of *Ephedra* to the whole world has been China. However, disturbed condition in China by Sino-Japanese war nearly 100 years back and damaging of wild habitat due to desertification, industrialization and climate change in recent years led to the search of *Ephedra* from other parts of the world like India and Pakistan (Kakiuchi *et al*., 2007).

Medicinal property of *Ephedra* is due to the presence of active alkaloids l-ephedrine (E) and d-pseudoephedrine (PE). These active alkaloids constitute 0.5 to 2.5 % of total mass, and are referred to as ephedrine type alkaloids. Other optically active alkaloids occurring in Ephedra species are (-)-N-methylephedrine, (+)-N-methylpseudoephedrine, (-) – norephedrine and (+) – norpsuedoephedrine. Ephedrine is the principal alkaloidal constituent of the plant *E. sinica* Stapf. Besides it, *E. gerardiana* and *E. nebrodensis* also contain ephedrine in quantities equal to or even superior to those found in *E. sinica*. *E. intermedia* also contain ephedrine but the main alkaloidal content is pseudoephedrine, which, however, is also valued as drug (Sahni, 1990).

In 1983, the world consumption of d-pseudoephedrine alone was estimated as 250,000kg. It is estimated that as many as two to three billion doses are consumed every year in the United States. According to the report of GAO (1999), the present annual consumption of the *Ephedra* as a crude drug form is a little below 1000 tons in Pakistan. In Japan, *Ephedra* plants are consumed at a rate of some 300 tons a year. The excessive use of *Ephedra*, is creating a heavy pressure onto natural habitat of this medicinal species.

In view of this, methods of conservation of gene pool of such species and sustainable utilization of the land resources need to be carried out involving suitable measures (Porwal *et al*., 2003).

There are about 68 species of *Ephedra* spreading worldwide in Europe, temperate Asia, South America and Afghanistan to Bhutan (2400-5000m) adapted to semiarid and desert environment (Sharma and Dhiman, 2010). These are widely distributed in both Eastern as well as Western Hemisphere (Fig.1).

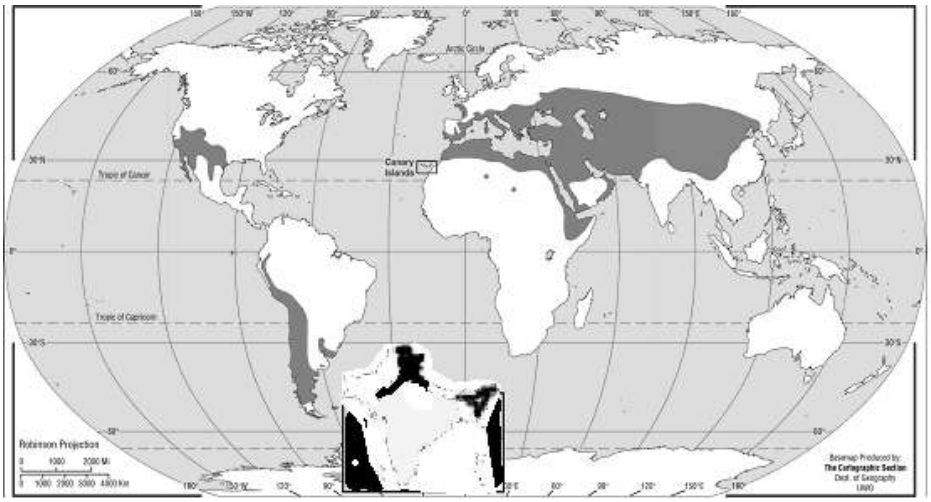


**Fig.1.** Worldwide distribution map of *Ephedra*. Inset shows distribution in India. (Modified from Caveney *et al.*, 2001).

In India, *Ephedra* is represented by eight species namely *Ephedra foliata*, *Ephedra gerardiana, Ephedra intermedia, Ephedra nebrodensis, Ephedra regeliana, Ephedra saxatilis, Ephedra pachyclada* and *Ephedra przewalskii*. Sharma and Uniyal discovered a new species, Ephedra sumlingensis, from Sumling, Spiti district of Himachal Pradesh in India. Ephedra gerardiana was reported from present day Uttarakhand from dry Southern exposure of Deoban Ridge Jaunsar (8000 to 9500 feet) and in Gidikhad below Karamba peak (Fig. 2A).

It is also found to occur in temperate and alpine Himalayas from Kashmeer to Sikkim in Pangi, Lahul, Spiti, Chini and Kilba-Kailash ranges of Kanawar, Shali hills (north of Shimla), Kashmir, and Ladakh (Kanjilal, 1927).

*Ephedra* resembles with Equisetum in morphology (Fig. 2B). The internodes are longitudinally ridged and the ridges on the successive internodes alternate. The leaves are in whorls of three (sometimes four) at each node. There are determinate branches which are borne in the axil of some of the leaves of indeterminate branches showing opposite and decussate pairs of leaves. The leaves are small, scaly and thin and are fused into a basal sheath. They are green when young but turn brown at maturity and are shed. Accessory buds arise below at the base of axillary shoots. Since the leaves are scaly and reduced, the photosynthesis is done through the green stem.

*Ephedra* is typically dioecious. The male and female strobili are borne in the axils of leaves of determinate shoots and also in whorls on the nodes of older branches. The male plants (Fig. 2C) bear male strobilus consisting of a central axis and a few opposite and decussately arranged bracts. Each bract bears a microsporangiate "flower" in its axil-except the lowest pair which is usually sterile. Each "flower" consists of an unbranched sporangioiphore, bearing at its tip 2-6 bilobed, sessile, microsporangia. The sporangiophore is enclosed in a pair of perianth leaves and it grows out of the later during maturation of the sporangia. The female plants (See Fig. 2D) bear female strobilus consists of four to seven pairs of

opposite and decussate green bracts, fused at the base forming a cup-like structure. In the axil of each of the uppermost pair of bracts, there is an ovule. Each ovule consists of two envelopes. The inner envelope, or the integument, is thin and fused with the nucellus except in the upper region which protrudes to form a long micropylar tube. The outer envelope is thicker and completely free from the integument. The two subtending bract of megasporangiate strobilus form the outer fleshy covering of the mature seed. This is red in colour in *E. gerardiana* .

Published literature on medicinal plants of the Himalayan region does not provide evidences of any systematic attempt to document past and present distribution of genetic diversity of most of the pharmacopoeial plants. Much of the information on frequency or distribution, therefore, comes from reports of botanical explorations in the region. There are, however, successive losses in population numbers and also changes in distribution ranges over a period of time. Based on these reports, *Ephedra gerardiana* is listed as an endangered species (Gupta and Sethi 1983) Similarly, Badola and Pal 2002 specified prioritization of endangered medicinal plant species of Himachal Pradesh for ex-situ conservation. They categorized *Ephedra gerardiana* based upon knowledge, cultivation prospect and marketing into IV ranked plant of cold-desert zone and classified it as an endangered species both nationally and internationally.

Natural habitat of *Ephedra gerardiana* in Chakrata Jaunsar region of Uttarakhand were explored to study its population. Only a few plants were found on a single ridge of Deoban (Fig. 1 A & B). The only located area was discovered at Khadamba Road from Chakrata in Deoban compartment, Kanasar Range at about 8750 feet (2625mt) msl. This clearly indicates loss of natural habitat of E. gerardiana in its area of earlier occurrence.

In view of the conservation strategy of this plant, High Altitude Medicinal Plant Nursery of Chakrata Forest division is attempting to grow the plant in Nursery beds. Following the exploration by authors, the department has shown more interest in development of conservation strategy through macropropagation of *Ephedra gerardiana*. However, the High Altitude Herbal Garden of Chakrata (Research Station of FRI, Dehradun) is already taking steps to grow these plants. The Uttarakhand Forest Department has already banned the collection of this plant for general or commercial use.


**Fig. 2. A.** Deoban ridge showing natural habitat of *Ephedra gerardiana* in Chakrata forest division.**B**. Plants of *Ephedra gerardiana* occurring at cervices of rocks in the ridge. **C.** Male plants of *Ephedra gerardiana* **D.** Fruits

The biotechnological tool implying micropropagation technology can be the best method to propagate and conserve this medicinal plant of ancient Indian medicinal system (Dhiman *et al*., 1998). However, the true application will be successful only if micropropagated plants are rehabilitated in affected area.

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# NUTRITIONAL AND PHARMACOLOGICAL ACTIVITIES OF *MACROTYLOMA UNIFLORUM* AN UNDERUTILIZED LEGUME OF IHR- A MINI REVIEW

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**ABSTRACT**

Legumes hold a promising place in human nutrition and gaining popularity around the world as they are rich source of protein, fiber, mineral and vitamins. Despite the fact many edible legumesare still underutilized and given less economic importance including *Macrotylom auniflorum*. It is rich source of proteins, fats, fiber, ash, vitamins, micronutrients and carbohydrates. Additionally, it also contains several bioactive compounds or anti-nutrients such as phenols, tannins, phytic acid and flatulence-causing oligosaccharides which have various health promoting effects. It has been used as traditional medicine since times immemorial in the cure of kidney and bladder stones as well as in piles, asthma, bronchitis, heart diseases, and leucoderma. Moreover, it also possesses various pharmacological properties such as anti-oxidant, anti-microbial, anti-hypercholestrolemic, anti-helminthic, anti-inflammatory and antidiabetic activity. Based on the various published scientific sources, the present review is an attempt to highlight its nutritional, anti-nutritional and pharmacological properties.

**Keywords:** *Macrotyloma uniflorum*, Underutilized, Orphan legume**,** Nutritional and Pharmacological activities

## INTRODUCTION

The Indian Himalayan Region (IHR) is well known as the hub of vast agricultural diversity and it is the home to many legumes including *Marcrotyloma uniflorum*. It is commonly known as horsegram in English and locally as gaheth, muthira, hurali, and kulthi or madras gram is a drought resilient legume of North-Western Himalayan region of India. It is a self-pollinated crop of the family fabaceae. Horsegram is native to Southeast Asia, Tropical Africa and India is considered as its center of origin where it is cultivated as food and feed. Among the total 240 species of horsegram all over the world, 30 species are found in India. It is an annual semi-erect, diploid herbaceous climbing herb attaining a height of 60 cm having 2n= 20, 22, 24 chromosome numbers. The leaves are compound, alternate and trifoliate having an approximate length of 3-7 cm and width of 2-4 cm. Its flowers are usually creamy-yellowish in color with a purple blot in auxillary racemes (Mehra and Upadhaya, 2013). Seeds are borne in hairy pods of 4.5-6 cm long and 4-5 mm wide, usually 6-7 seeds in a pod. Seeds are of varying color as shown in Fig. 1 having length of approximately 4-6 mm and width of 3-5 mm. The most characteristic feature of the crop

is its capacity to enhance the fertility of soil by adding nitrogen content in soil due to the presence of root nodules. This crop grows well in low rainfall and resistant to various biotic and abiotic factors. It can be grown near sea level to 1800 meters in both summers and winters (Chahota *et al*., 2013). However, it can be grown near sea level up to 1200 meters in Uttarakhand (Mehra and Upadhyaya, 2013). In India, it is sown in the month of June or July and matures in a time period of approximately 120-180 days. It can be grown in a wide array of soil type apart from the alkaline soil and best grows at the soil pH range of 5.5 to 8. It needs rainfall of 200-1000 mm and best suited at a temperature of 25-35℃ (Mehra and Upadhaya, 2013). The crop is an excellent source of proteins, carbohydrate, vitamins, minerals, fiber, fat and several essential amino acids. Besides having high nutritional value it also possesses certain antinutrients like phytic acid, flatulence factors, phenolic compounds and enzyme inhibitors which are now considered as potential antioxidants and used as traditional medicine in the cure of many ailments like kidney stones, common cold, fever, urinary disorders, throat infection, piles etc (Prasad and Singh, 2015). Moreover, researchers have reported many pharmacological properties like anti-calcifying, anti-hyperlipidemic, anti-diabetic, anti-carcinogenic, anti-obesity, anti-hypercholestrolemic, anti-histamic, anti-choliolithic, hepatoprotective and anti-oxidative (Rlds and Erhss, 2017). Furthermore, in hilly areas of Uttarakhand it is also used in various culinary preparations locally famous as gaheth ke parathe, gaheth dal ke phanu, gaheth ke dubke, gaheth ki gathwari, gaheth ka soup and gaheth ki bari etc. So, it is an ideal future pulse crop having both nutritional and remedial properties.

## CULTIVATION OF HORSEGRAM

Horsegram is cultivated in many countries for food and feed such as in India, Australia, Nepal, Sri Lanka, Africa, Myanmar, Malaysia and Mauritius (Asha *et al.*, 2006). However, its center of origin is regarded as India and cultivated in many states like Uttarakhand, Himachal Pradesh, Madhya Pradesh, Tamil Nadu, Bihar, Jharkhand, Andhra Pradesh, West Bengal, Karnataka and Chhattisgarh. In Uttarakhand, the total land area under horsegram cultivation is 12.13 thousand hectares. Here it is cultivated as mixed crop with maize or finger millets in both the divisions. Various crop improvement methods have been implemented to improve the horsegram cultivar and there are two recommended improved varieties of horsegram for the state Uttarakhand i.e. VL-8 and VL-10.

**Fig. 1.** Different germplasm of horsegram

## NUTRITIONAL COMPOSITION OF HORSEGRAM

Horsegram is the richest source of many dietary compounds such as proteins, carbohydrates, fats,dietary fiber etc. as shown in Table 1. These dietary constituents such as the non-digestible carbohydrates in horsegram play a significant role in maintaining the blood sugar level thus helpsin diabetes management. In addition to this, the presence of fats is responsible for sound and healthy nervous system. Fats like linoleic acid are used in the treatment of diabetes and cardiovascular diseases. However, linoleic acid with α-linolenic acid helps in the prevention of Alzheimer's and Parkinson's diseases (Mishra and Pathan, 2011).

**Table 1.** Nutritional composition of horsegram

| S. No | Constituents | Parameters | Composition | References |
|---|---|---|---|---|
| **1.** | Proteins | High lysine | 22-24% | Gopalan *et al*., 1971 |
| **2.** | Carbohydrates | Monosaccharide<br>Oligosaccharide<br>Polysaccharide | 37.15% | Bravo *et al*., 1999 |
| **3.** | Fats<br>a) Saturated | Palmitic acid | 21.97% | Mishra and Pathan,2011 |
| | | Arachidic acid | 2.85% | |
| | | Stearic acid | 2.32% | |
| | | Myristic acid | 0.36% | |
| | b) Unsaturated | Linoleic acid | 42.78% | |
| | | Oleic acid | 16.15% | |
| | | Linolenic acid | 13.56% | |
| **4.** | Minerals<br>a) Macroelements | Ca, Mg, P, S, K | 5.0-95 g | Morris *et al*., 2013 |
| | b) Microelements | Cu, Fe, Mn, Ni, Zn | 1.0-95.0 µg | |
| **5.** | Amino acids | Arg, Cys, His, Ile, Lys,Met, Phe, Thr, Trp, Val | 50.1% | Rlds and Erhss, 2017 |
| **6.** | Moisture | Harvesting time | 18-25% | Mohan *et al*., 2011 |
| | | Storage period | 9-12% | |
| **7.** | Ash | Whole seeds | 3.0-3.8% | Sudha *et al*., 1995 |
| **8.** | Dietary Fiber | Insoluble | 27.82% | Khatoon and Prakash, 2004 |
| | | Soluble | 1.13% | |
| **9.** | Vitamins (per 100 gm dry matter) | Thiamine | 0.4 mg | Rlds and Erhss, 2017 |
| | | Riboflavin | 0.2 mg | |
| | | Niacin | 1.5 mg | |

## ANTINUTRITIONAL FACTORS IN HORSEGRAM

Apart from the high nutritional value of horsegram there are several organic compounds formed by secondary metabolism which are not involved directly in the growth and development of plants rather protects them from different biotic and Abiotic stresses. Among the organic compounds some are toxic and hinder the normal digestion thus, termed as anti-nutrients or anti- nutritional factors.

The anti-nutritional factors present in horsegram are trypsin inhibitors, oligosaccharides, phytic acid and several polyphenols as shown in Table 2. However, some of these anti-

nutitional factors are now considered as potential antioxidants (Bhartiya *et al*., 2015) Antioxidants are free- radical scavengers which have potent role in delaying cancer, diabetes, brain disorders and also minimize the chances of ageing by maintaining a handsome amount of antioxidants. Hence, the presence of outstanding anti nutritional factors or antioxidants in horsegram makes it an exceptional legume having nutritional and remedial properties.

**Table 2.** Antinutritional factors in horsegram

| S.No | Antinutients | Composition* | Functions | References |
|---|---|---|---|---|
| **1.** | Trypsin inhibitors (TIU/g) | 9246±18 | Acts as anti-carcinogenic, anti-diabetic and anti-inflammatory | Roy *et al*., 2010 |
| **2.** | Phytic acid (mg/g) | 10.2±0.4 | Reduce the risk of cancer, diabetes mellitus,coronary heart disease, and renal stones | Kumar *et al*., 2010 |
| **3.** | Polyphenols (mg GA/g) | 14.3±0.4 | Acts as anti-inflammatory, anti-HIV, cicatrizant and also protects plant frombiotic and Abiotic stresses | Furlan *et al*., 2011 |
| **4.** | Oligosaccharides mg/g<br>a. Raffinose | 7.1±0.0 | Balances the bifidobacterium in intestine | Alles *et al*., 1999 |
| | b. Stachylose | 15.6±0.4 | | |
| | c. Verbascose | 4.1±0.0 | | |

*Composition – Sreerama *et al*., 2012

## PHARMACOLOGICAL ACTIVITIES OF HORSEGRAM

Different parts of horsegram such as seeds and whole dried plant have shown good antimicrobial activities against *B. subtilis*, *E. coli*, *S. aureus*, *P. aeruginosa*, *Serretiasp*, *Klebseillasp*, *Proteus sp*. and *S. paratyphi*. The ethanol and methanol extract of whole plant have shown potent anticancer activity against human osteosarcoma cell line MG63. The leaf powder have also reported hypocholestrolemic effect by reducing the cholesterol effect, low density lipoproteins(LDL), very low density lipoprotein (VLDL) and the high density lipoprotein(HDL). Different extract have also shown various other pharmacological activities such as antidiabetic, hypercholestrolemic, anti-inflammatory, anti-urolithiatic and diuretic (Table 3).

## Table 3. Pharmacological activities of horsegram

| S. No. | Pharmacological activity | Part used | Solvent/extract | Response | References |
|---|---|---|---|---|---|
| **1.** | Antimicrobial | Seeds | Dichloromethane, Ethyl-acetate, 1-butanol and watery concentrates | Ethyl acetate extract was effective against *B. subtilis*, *E. coli*, *S. aureus* and *P. aeruginosa* | Gupta *et al.*, 2005 |
| | | Whole plant | Methanol and ethanol | Methanol extract showed potent activity against *P. aeruginosa*, *Serretiasp*, *Klebseillasp* and *Proteus sp*. | Chakraborty and Abraham, 2016 |
| | | Seeds | Alcohol and aqueous extract | Alcoholic extract showed better antibacterial activity against, *S.paratyphi* and *E. coli* | Parvathiraj *et al.*, 2015 |
| **2.** | Antidiabetic | Seeds | Physiological saline | Reduced the mouse pancreatic and human salivary α-amylase | Gupta *et al.*, 2011 |
| **3.** | Antioxidant | Seeds | Methanol and 70% acetone | 70% acetone showed highest radical scavenging activity | Siddhuraju and Manian, 2007 |
| | | Whole plant | Methanol | Protective action against high fat diet induced oxidative stress in tissues of rabbit | Muthu *et al.*, 2006 |
| **4.** | Antiobesity | Leaf and seed | Ethanol | Decreased the weight of high fat diet fed mouse | Vadivelu *et al.*, 2019 |
| **5.** | Hypercholestrolemic | Leaf powder | Petroleum ether, chloroform, ethanol, distilled water | Consumption of ethanol and water extract of horsegram reduced total cholesterol, LDL, VLDL and increased HDL. | Kumar, 2013 |
| **6.** | Anti-inflammatory | Seeds | Aqueous | Inhibited the human secretory phospholipase induced in mouse. | Giresha *et al.*, 2015 |

| | | | | | |
|---|---|---|---|---|---|
| **7.** | Anti-urolithiatic | Seeds | n-butanol | Decreased the level of promoters of urolithiasis | Patel and Acharya, 2020 |
| **8.** | Hepatoprotective | Seeds | Hydroalcoholic | Showed Hepatoprotective effect in induced liver damage mouse by increasing antioxidants and inhibiting lipid peroxidation in liver | Panda, 2015 |
| **9.** | Anticancer | Whole plant | Ethanol and Methanol | Anticancer activity of both extractwas reported against MG 63 | Chakraborty and Abraham, 2016 |
| **10.** | Anti-histaminic | Seeds | Ethanol | Lowered the histamine induced contractions in goat | Suralkar and Sanjay, 2013 |
| **11.** | Diuretic | Seeds | Ethanol | Diuretic effect was observed in experimental albino rats | Ravishankar and Priya, 2012 |

## CONCLUSION

From the extensive review of the various scientific sources on the nutritional, anti-nutritional and pharmacological activities of horsegram, it can be concluded that they are the treasure house of various nutritional constituents like proteins, fiber, fats, vitamins, carbohydrates etc. Furthermore, they possess a variety of non- nutritional bioactive compounds which acts as potentantioxidants in the cure of various ailments. Horsegram has been used since times as traditional medicine in the cure of kidney or bladder stones, cough, cold *etc.* thus possesses many pharmacological properties like antimicrobial, anti-inflammatory, anti-diabetic and many more. Despite of having such an impressive nutritional and bioactive profile, the crop is still unexplored as very limited work has been done in this area. So, keeping in view its nutritional and medicinal value, further research work needs to be done to explore its nutritional and remedial properties for more utilization and production.

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# MORPHOLOGICAL DIFFERENCES BETWEEN FLORAL CHARACTERS OF RED AND WHITE FLOWERS OF *RHODODENDRON ARBOREUM*- THE FIRST COMPARATIVE STUDY IN INDIA

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## ABSTRACT

*Rhododendron arboreum* (Sm.) is widely known for its multi-purpose use as well as the ecological adaptability it shows encountering different environmental conditions. It is amongst the important *taxa* of the Indian Himalayan region (IHR). However, being one of the most extensively studied species yet there are many loop areas which are still unexplored particularly for Uttarakhand, India. For instance, there are no records of the number of sub-species and varieties for the genus in the entire Uttarakhand state. Additionally, no emphasis is laid on the study of factors that are responsible for such wide morphological variations in the species. There are no published account highlighting and comparing these variations for entire North-Western Himalayan region. The present paper deals with one such character-the white flowered variant of *Rhododendron arboreum* (Sm.) which has been not reported from the entire North-western Himalaya region in India, also, it is the first morphological comparative study of both flowers (red and white) of *Rhododendron arboreum* (Sm.) in India.

**Keywords:** *Rhododendron arboreum*, White-flower and Indian Himalayan region

## INTRODUCTION

Genus *Rhododendron* (L.) has been described as the largest genera of the family Ericaceae (Cullen and Chamberlain, 1978). It is one of the important floral *taxa* in the Himalayan ecosystem. This is well illustrated from the fact that besides representation by more than 1000 species across the globe (Chamberlain *et al.*, 1996; Fang *et al*., 2005) it has well established itself in the temperate regions of the Himalayan ecosystem (Fang *et al*., 2005; Bhattacharya, 2011). Rhododendrons show a wide range of distribution and habitats, covering almost all continents of the world except Africa and Central and South America (Bhattacharya and Sanjappa, 2008). In India, the genus is represented by nearly 87 species 12 sub-species and 8 varieties (Sekar and Srivastav, 2010) with maximum species being reported from Arunachal Pradesh followed by Sikkim (Bhattacharya and Sanjappa, 2008) indicating the North-Eastern dominancy for its occurrence and settlement. As far as North-Western Himalaya (Uttarakhand in particular) is concerned, the genus is represented by 6 species, *Rhododendron arboreum* (Sm.), *Rhododendron barbatum* (Wall.), *Rhododendron campanulatum* (Don), *Rhododendron*

*lepidotum* (Wall.), *Rhododendron anthopogon* (Don) and *Rhododendron nivale* (Hook.). The focal species of this paper is *Rhododendron arboreum* (Sm.).

*Rhododendron arboreum* (Sm.) is so engraved in the lifestyle of the local inhabitants of the Himalayan ecosystem that it has been crowned with respective titles like National flower of Nepal, State Tree of Uttarakhand and State Flower of Nagaland. Particularly, if Indian Himalayan Region (IHR) is discussed, the local people are dependent on the species for fulfilling their various needs and requirements Bhattacharya (2011). Many authors have regarded it as the cultural and ecological keystone species (Paine, 1969; Garibaldi and Turner, 2004; Cristancho and Vining, 2004). This species is also a treasure hunt for researchers, ethnobotany to phytochemistry, taxonomy to ecology, pharmacology to climate change (Jain *et al*., 2000; Verma *et al*., 2010; Srivastav, 2012; Ranjitkar, 2013; Sharma and Kala, 2016; Mamgain *et al*., 2017; Malsawmkima and Sahoo 2020) *Rhododendron arboreum* (Sm.).

The species holds a special place in the Himalayan ecosystem but studies are rare and fragmented,. We report and highlight the white flower variant of *Rhododendron arboreum* (Sm.) that has been not reported from the entire North-Western Himalayan region (Jammu and Kashmir, Himachal Pradesh and Uttarakhand) till date. We also describe the morphological characters in detail.

## MATERIAL AND METHODS

During the field survey for identifying occurrence of different species of genus *Rhododendron* (L.) in Kumaun Himalaya, Uttarakhand, two individual trees of white flowered variant of *Rhododendron arboreum* (Sm.) were reported from two different locations in the region. The specimens were collected from the field for morphological examination and construction of herbaria. The prepared herbaria have been deposited at G. B. Pant National Institute of Himalayan Environment, Almora, Uttarakhand. Botanical Survey of India (BSI), Northern Circle, Dehradun and Forest Research Institute (FRI), Dehradun were visited for investigating existing records (if any) for the collected sample. During herbaria review, two records were found both collected from Garhwal region of Uttarakhand. The first sample was collected from Badrinath in the year 1914 by B. D. Kalia, the specimen was without flower and has been labelled as ‘safed burans’ preserved at FRI, Dehradun, whereas the second sample was collected from Kukinakhal in the year 1967 by U. C. Bhattacharya, the specimen had flower and has been described as *R. arboreum* (Sm.) f. album (Buch-Nain. Ex. D. Don Wall) but it did not mentioned anything about the colour of corolla of the specimen. This sample was preserved at BSI, Dehradun. These two records do not provide any significant evidence for the white flowered variant of *Rhododendron arboreum* (Sm.) also there were no published data found which accounted for the support of these locations. Apart from this no other record was found for entire North-Western Himalayan region.

The identification for the collected sample was done with the help of available literature (Davidian, 1989; Grierson and Long, 1991; Fang *et al*., 2005) and the anatomical studies were done using compound light microscope and digital camera (MC, 170 HD, Leica Microsystems). The present paper describes comparative morphological characters of the white and red flowers of Rhododendron arboreum (Sm.) that has been mentioned in Table 1 and shown in Fig. 1 with illustration in Fig. 2.

**Table 1.**. Morphological comparison between red and white flowers of *R. arboreum* (Sm.)

| Character | *R. arboreum* (Red Flowered) | *R. arboreum* (White Flowered) |
|---|---|---|
| Habit | Tree | Tree |
| Bark | Pinkish Brown | Pinkish Brown |
| Leaf | | |
| Shape | Lanceolate, oblong-lanceolate, oblanceolate, rarely oblong | Lanceolate, oblong-lanceolate, acute apex |
| Petiole surface | Glabarous | Glabarous |
| Length (cm) | 7.5- 15 | 7.9- 15 |
| Width (cm) | 2.5- 5 | 2.1- 4.1 |
| Adaxial side | Dark green or olive green | Dark green |
| Abaxial side | Shiny white, silvery, fawn, glabarous | Shiny white, silvery, fawn, glabarous |
| Flower | | |
| Status | Complete | Complete |
| Inflorescence | Raceme umbel | Raceme umbel |
| Compact length (cm) | 9 | 8.7 |
| Compact width (cm) | 8.7 | 8.8 |
| Flowers in each cluster | 18- 20 | 18- 20 |
| Bracts | Hairy | Hairy |
| Nectar pouches | Present (5) | Present (5) |
| Pedicel length (cm) for single flower | 0.5- 1 | 0.4- 0.9 |
| Calyx | | |
| Shape | Triangular to ovate | Triangular to ovate |
| Lobes | 5 | 5 |
| Color | Yellowish- green | Yellowish- green |
| Corolla | | |
| Shape | Tubular campanulate or open campanulate | Tubular campanulate |
| Tube length (cm) | 2.3- 2.8 | 2.3- 2.7 |
| Tube width (cm) | 2.1- 2.5 | 1.2- 1.7 |
| Color | Red, inner spots may be present or absent | White, inner spots may be present or absent |
| Lobes | 5 | 5 |
| Androecium | | |
| Stamen | 10 (4+6) | 10 (4+6) |
| Stamen length (cm) | 2 (smallest)<br>3.6 (largest) | 2.3 (smallest)<br>3.7 (largest) |
| Anther | Hard, dark brown-maroon | Hard, dark brown |
| Filament | White colour | White colour; filament was observed to be thinner as compared to the filament of red flowered *R. arboreum* (Sm.) |
| Gynoecium | | |
| Length (cm) | 4.2- 4.9 | 3.5- 4.7 |
| Stigma | Dark maroon colour | Yellow colour |
| Style | Red to Maroon-pinkish in colour | White to light greenish in colour |
| Ovary surface | Hairy | Hairy |
| Ovary | Superior | Superior |
| Ovary length (cm) | 0.5- 0.7 | 0.5: Length was observed to be smaller |

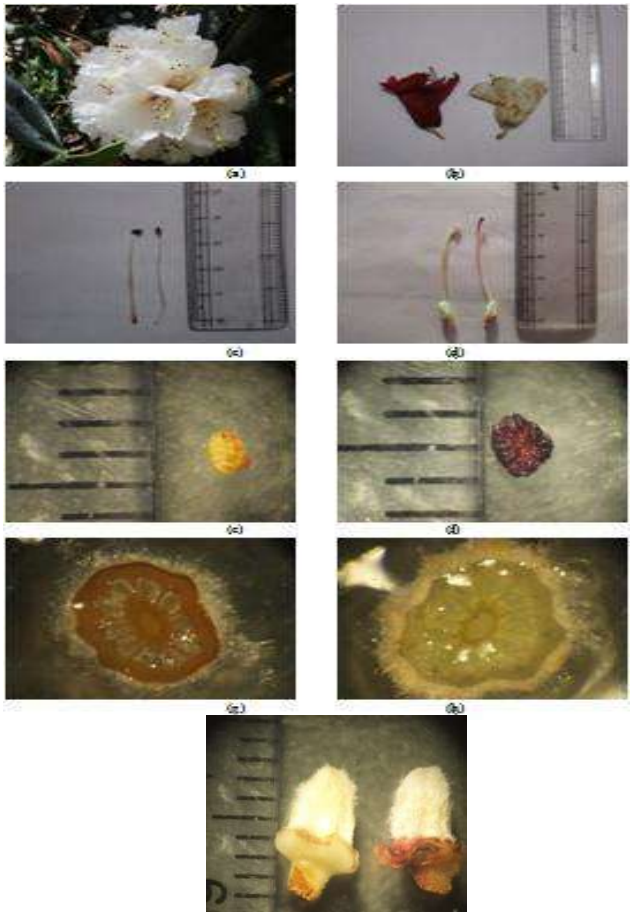

**Fig. 1.** Various morphological characters of red and white flowered *R. arboreum* (Sm.) (a) White flowered variant of *R. arboreum* (Sm.) (b) Complete compact-red and white flower. (c) Androecium for both flowers (left-red flower; right-white flower). (d) Gynoecium for both flowers (left-white flower; right- red flower). (e) Stigma of white flowered variant *R. arboreum* (Sm.) (f) Stigma of red flowered *R. arboreum* (Sm.) (g) T. S. of ovary of white flowered variant R. arboreum(h) T. S. of ovary of of red flowered *R. arboreum* (Sm.) (i) Ovary of both flowers (left-white flower; right-red flower).

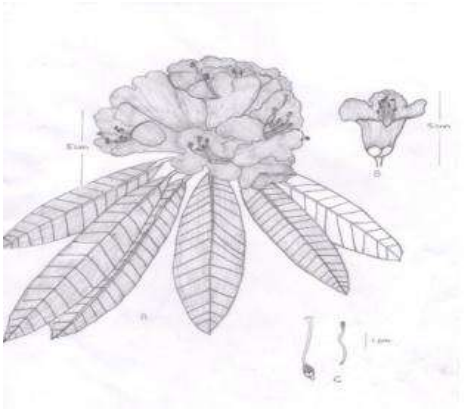

**Fig. 2**. *Rhododendron arboreum* (Sm.) White flowered (a) Flowering branch (b) Single flower with calyx (c) Androecium and Gynoecium**.**

## RESULTS AND DISCUSSIONS

The white flowered variant of *Rhododendron arboreum* (Sm.) was first discovered from Nepal Himalayan region by Dr. Francis Buchanan- Hamilton in 1803 (Davidian, 1989), there are

reports of the specimen being recorded from Sikkim (Sastry and Hajra, 2010) but the only available authentic data is from Kalapokhri, Darjeeling in West Bengal, described in the Fascicles of Flora of India: Fascicle 25, Ericaceae by BSI (2014). Apart from this there is very scarce knowledge about its distribution in the Indian Himalayan region (IHR).

The present specimens of white flowered variant of *Rhododendron arboreum* (Sm.) was recorded from Nainital district of Uttarakhand, India, from two different locations, represented by one tree at each location at altitudes 2030 and 2231 m respectively. The comparative study between the two flowers showed that there were 5 character differences between the two flowers: leaf shape, colour of corolla, width of anther filament, colour of stigma and length of gynoecium, which has been highlighted in Table 1. It was also observed that no published records were found which mentioned about the colour of stigma, length of style, anther filament length and width this is quite surprising since these characters are prominent and easily distinguishable and can serve as an important criterion for identification between species, sub-species and varieties for genus *Rhododendron* (L.). The present paper is the first description of gynoecium and androecium in detail for *Rhododendron arboreum* (Sm.). This certainly demands for extensive field surveys and collection of samples for construction of herbaria with proper photographs for maintaining the records for *Rhododendron arboreum* (Sm.) diversity in the state. Literature review and herbaria review clearly concludes that there is no published data available from entire North-western Himalayan region so far for the occurrence of white flower in *Rhododendron arboreum* (Sm.).

More research is required to answer the following : Why there is so less representation of white flowered variety in the population of *Rhododendron arboreum* (Sm.)? What factors are responsible for the corolla pigmentation variation? Generally, it has been observed that with rise in altitude the colour of the corolla of *Rhododendron arboreum* (Sm.) changes from red to light pink hence, is it the influence of abiotic factors (precipitation, temperature, elevation etc.) responsible for the change in the colour of corolla? Does the colour of stigma of *Rhododendron arboreum* (Sm.) is dependent on the colour of corolla? Since, the morphology of stigma is yet another important character in differentiating the two flowers. Another issue which needs to be highlighted is the conservation and protection of the specimen trees, since local inhabitants are dependent on *Rhododendron arboreum* (Sm.) for various needs (wood, fodder, temple offerings, juice preparation, other ethno-botanical and commercial uses) so it is very important to make people aware about this rare variety so that they don't unknowingly harm the trees. A comparative study with the specimen reported from West Bengal should also be done at both morphological and molecular level so as to establish the ecological and taxonomic similarities and differences between the two varieties.

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# PHYSICO-CHEMICAL CHARACTERISTICS AND DIURNAL TEMPERATURE VARIATIONS IN HOT SPRINGS OF DIRANG, ARUNACHAL HIMALAYA

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## ABSTRACT

Hot springs are of tourism, cultural and medicinal importance in the Himalayan region. The present study was aimed at the physicochemical characteristics and temperature variation in two distinct hot springs under West Kameng district, Arunachal Pradesh, where one of them is facing anthropogenic disturbances. The hot spring with anthropogenic disturbances at location $D_2$ was found alkaline (69.77 mg/L) compared to undisturbed hot spring at location $D_1$(28.06 mg/L). However, the pH for both the hot springs was within the permissible limit (6.5 to 8.5). Further, EC and TDS were higher for hot spring at location $D_1$. The total hardness (TH) and $Cl^-$ were also higher at $D_1$. The temperature increased from 06:00 hrs to 14:00 hrs with highest at 14:00 hrs and after that the temperature decreased. The temperature was maximum at the source and decreased away from the source with respect to the increased distance (0-5 meters) for both the hot spring. However, the water quality of both the hot springs was found excellent in spite of variation in physico-chemical parameters. The present study improved the existing information on the hot spring of Arunachal Pradesh. However, a further detailed study on various parameters is required for the entire analysis of ecosystem these springs.

**Keywords:** Natural spring, Groundwater, Water quality, North-East India and Eastern Himalaya

## INTRODUCTION

Hot springs are natural groundwater discharges with higher temperatures concerning their surroundings. The primary hot springs originating from magmatic waters change during the rise to the surface. The secondary hot springs are shallow fluids generally coming from the primary fluids, which can further be categorized into several types, viz. chlorinated, sulfated acid, or carbonated fluids, etc. The hot springs located around the world make a great diversity of geophysical, geochemical, and biological properties depending on the area and the origin of the waters. Due to various processes such as cationic exchange, hydrolysis, boiling, cooling, and leaching with rocks, the water goes under compositional changes during the rise to the surface (Kaasalainen and Stefansson, 2012; Marais and Walter, 2019). In India, hot springs have been utilized for religious and medicinal purposes before 2000 BC. Though medical

science has advanced over the few decades, many people and ailing patients have still utilized hot springs for their medical treatment. Hot springs are scattered and occur either solitarily or in groups up to 3000 m above sea level in India. The hot water bodies, are often famous as tourist destinations, are getting polluted due to the influx of tourists and poor maintenance & management in and around the hot water springs (Sherpa *et al*., 2013).

Indian Himalayan Region (IHR), known for cold and snow caped lakes, also possess unique hot springs at high elevations in the Western and Eastern Himalayas (Sherpa *et al*., 2013, Sahay *et al*., 2017). The geology and some physico-chemical characteristics of hot springs situated in Arunachal Pradesh were studied by earlier researchers (Sinha, 1980, Bora *et al*., 2006). The two different hot springs located on the bank of the Dirang river in the West Kameng district of Arunachal Pradesh have great values among the local communities. One of the hot springs is popular amongst the tourist and is disturbed due to anthropogenic activities. Since these hot springs are of tourist, cultural and medicinal significance, the present study aimed to analyze the physico-chemical characteristics and diurnal variation in temperature of these hot springs.

## MATERIAL AND METHODS

### Study site

The study was conducted in the Dirang area under the West Kameng District, Arunachal Pradesh. The survey was conducted at different hot springs, where the hot spring at location $D_1$ (27°22'34.69" N, 92°14'11.84" E) is locally known as '*Goga Kshi'*, while the second location $D_2$ (27°22'40.60" N, 92°13'58.55" E), is known as '*Garampani*'. The location $D_2$ is one of the well-known tourist attraction sites in the Dirang area, where hot spring source is channelized into cemented bathing/swimming tanks, and is subjected to anthropogenic disturbances (Fig. 1).

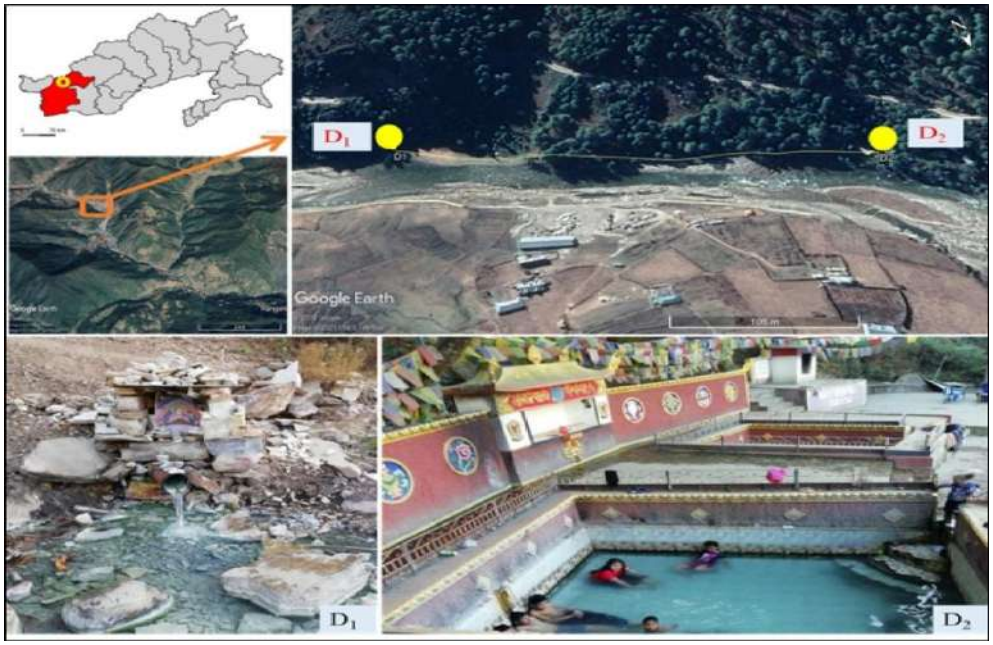


**Fig.1.** Location map and sites of two hot springs in Dirang, Arunachal Pradesh

## Sample collection and physicochemical analysis

The samples were collected in clean glass bottles from both the sites at the outlet of the designed channel of the hot springs (Fig. 1) and brought to the laboratory for physico-chemical analysis. The pH and electrical conductivity (EC) were measured at the sampling site using AQUASOL, AM-AL-01 (Rakiro), while sodium and potassium were measured using a flame photometer (Systronics 128). The parameters including alkalinity, chloride, magnesium, calcium, and total hardness was measured using the titration method. The total solids and dissolved solids were measured using the Gravimetry method. The chemical analysis was conducted using standard protocols following Tripathi and Govil (2001) methodology and guidelines of Bureau of Indian Standards (IS 3025-1964), Government of India. The temperature was measured at regular intervals (2hrs) from 6:00 hrs to18:00 hrs using AQUASOL, AM-AL-01 (Rakiro) at the outlet of the source (i.e., 0 meter) and at various distances viz. 1, 2, and 5 meters from the source. The data were interpreted and analysed using Microsoft Excel (2019).

## Water quality index

The present study utilized the ten water quality parameters viz. pH, EC, TDS, alkalinity, total hardness, $Ca^{2+}$, $Mg^{2+}$, $Cl^{-}$, $K^{+}$, $Na^{+}$ for analyzing the WQI of both the hot springs. The WQI calculations were done based on the BIS (2012) standards for all the parameters except EC and Na (Table 1).

**Table 1.** Weightage of each parameter

| Parameters | Acceptable limit | Maximum permissible limit (Si) | 1/Si | K | Weight (Wi) |
|---|---|---|---|---|---|
| pH | 6.5-8.5 | 8.5 | 0.1176 | 1.1205 | 0.13182 |
| EC (mS/cm) | - | 1.5* | 0.6667 | | 0.74698 |
| TDS (mg/L) | 500 | 2000 | 0.0005 | | 0.00056 |
| Alkalinity as $CaCO_3$ (mg/L) | 200 | 600 | 0.0017 | | 0.00187 |
| Total Hardness as $CaCO_3$(mg/L) | 200 | 600 | 0.0017 | | 0.00187 |
| Calcium (mg/L) | 75 | 200 | 0.0050 | | 0.00560 |
| Magnesium (mg/L) | 30 | 100 | 0.0100 | | 0.01120 |
| Chloride (mg/L) | 250 | 1000 | 0.0010 | | 0.00112 |
| Potassium (mg/L) | - | 12 | 0.0833 | | 0.09337 |
| Sodium (mg/L) | - | 200* | 0.0050 | | 0.00560 |

As per the BIS standards (2012), *WHO guidelines 2017.

The weighted arithmetic water quality index method is the most commonly measured water quality parameter and is calculated (eq. i) as follows

$$\mathrm{WQI} = \frac{\sum W_i Q_i}{\sum W_i} \qquad \text{eq.(i)}$$

Where Qi is the quality rating scale, representing the relative value of water quality specific to each parameter, Wi is the relative weight of every parameter, and;i denotes the number of parameters considered. Qi is calculated (eq. ii) as follows

$$Q_i = \frac{(V_i - V_o)}{(S_i - V_0)} \qquad \text{eq.(ii)}$$

Where, Vi is the estimated value of the $i^{th}$ parameter, $V_0$ is the ideal value of that particular parameter in pure water. $V_0$ is 0, except pH=7.0 and DO= 14.6 mg/l. Si is recommended standard value (permissible limit) of the $i^{th}$ parameter. The unit weight (Wi) for each water quality parameter is calculated in eq.(iii).

$$W_i = \frac{K}{S_i} \qquad \text{eq.(iii)}$$

Where K is proportionality constant and calculated by using the following equation (eq. iv)

$$K = \frac{1}{\sum(1/S_i)} \qquad \text{eq.(iv)}$$

## RESULT AND DISCUSSION

### Physico-chemical characteristics

The pH for both the hot springs was under the permission limit (pH- 6.5 to 7.5) and safe for drinking purposes. The pH at $D_1$ (6.62±0.02) were slightly acidic than at $D_2$ (7.28±0.05). The pH measures the balance between the concentration of hydrogen ions and hydroxyl ions in water (Prasanth *et al*., 2012). The alkalinity (AL) was higherfor hot spring at $D_2$ (69.77±3.05 mg/L) than hot spring at $D_1$ (28.06±1.16 mg/L) (Table 2).

**Table 2.** Physico-chemical characteristics of different hot springs from Dirang area

| **Hot springs at different locations** | | |
|---|---|---|
| **Parameters** | **$D_1$** | **$D_2$** |
| pH | 6.62±0.02 | 7.28±0.05 |
| EC (mS/cm) | 5.52±0.06 | 2.20±0.01 |
| TDS (mg/L) | 3.76±0.04 | 1.28±0.02 |
| TS (mg/L) | 3.84±0.03 | 1.30±0.01 |
| Alkalinity (mg/L) | 28.06±1.16 | 69.77±3.05 |
| Total Hardness (mg/L) | 370.00±2.01 | 153.33±5.03 |
| Calcium (mg/L) | 114.36±2.58 | 86.57±9.24 |
| Magnesium (mg/L) | 62.12±1.05 | 16.22±1.03 |
| Chloride (mg/L) | 661.48±5.42 | 159.75±3.55 |
| Potassium (mg/L) | 7.50±0.2 | 5.07±0.06 |

| | | |
|---|---|---|
| Sodium (mg/L) | 53.33±1.4 | 19.33±0.15 |

*As per the Bureau of Indian Standard for Drinking Water- revised specification (ISO 10500: 2012)

The conductivity was recorded higher (5.52±0.06 ms/cm) for hot spring at $D_1$, signifying that it has a higher concentration of ions than in hot spring at location $D_2$. The most desirable limit of EC in drinking water is prescribed as 1.5 mS/cm. The enrichment of salts in the groundwater is also an indicator of higher EC, an approximate index of the total content of the dissolved substances in water. The effect of pH may also increase the dissolution process, which eventually increases the EC value (Prasanth *et al.*, 2012). Total dissolved solids (TDS) were also higher for hot spring at (3.76±0.04 mg/L). There was a similar increase in the EC and TDS for both the hot springs, which shows a relationship between TDS and EC in the present study. The composition of ions also influences the relationship between EC and TDS. Although the conductivity depend entirely on ionic charges, the non-iodized substance also contributes to TDS while not to EC. In addition, sodium, potassium, calcium, magnesium, chloride, etc., also influence the TDS (Taylor *et al*., 2018). There was a strong correlation among the ions & EC which apparently influences the conductivity. However, EC have shown a strong negative correlation with pH and AL. The total hardness was higher at undisturbed sites ($D_1$), while lower in hot spring at $D_2$ with some anthropogenic disturbances. The overall higher calcium and magnesium content at natural springs may also be the reason for higher total hardness at the undisturbed hot springs (Cotruvo and Bartram, 2009). The chloride content was higher at $D_1$ while lower at $D_2$. Chloride as a free ion is one of the major inorganic anions in water and wastewater and produces a salty taste in water. The potassium and sodium content were also higher at $D_1$. The strong positive correlation between the TH and Ca & Mg ions also validates the role of calcium and magnesium influencing the hardness of the water. The major source of potassium and sodium in unpolluted and natural water is due to weathering of rocks. Sodium within the standard limit from water and food isn't harmful to humans but is a cause of concern for the heart, kidney, and insomnia patients. Potassium is vital in maintaining the water level, blood pressure, neural transmission, and contraction of the muscle in the body (Banerjee and Prasad, 2020). The study revealed that the sodium and potassium content is well within the permissible limit of the World Health Organization (WHO, 2017). The variation in the physicochemical characteristics of the hot springs at both the sites ($D_1$&$D_2$) may be due to the various processes and responsible anthropogenic factors.

**Diurnal temperature variation**

The temperature at $D_1$ source increased from 23.9 °C at 6:00 hrs to 31.0 °C at 14:00 hrs, and after that, it decreased to 25.6 °C at 18:00 hrs. However, the temperature at $D_2$ was higher and varied from 33.2 °C to 40.4 °C. The temperature of the hot springs at a distance of 1 meter varied from 22.8 to 30.4 °C at $D_1$ while 32.9 to 39.5 °C at $D_2$. Whereas at 2 meters, the temperature varied from 21.5 to 30.5 °C for hot spring at $D_1$ and 32.1 to 37.5 °C for hot spring at $D_2$. Similarly, the temperature at 5 meters varied from 20.7 to 28.4 °C for hot spring at $D_1$ and 29.7 to 34.5 °C for hot spring at $D_2$. The temperature of both the hot springs was highest at the source and decrease with increase in distance from the source (Fig. 2).

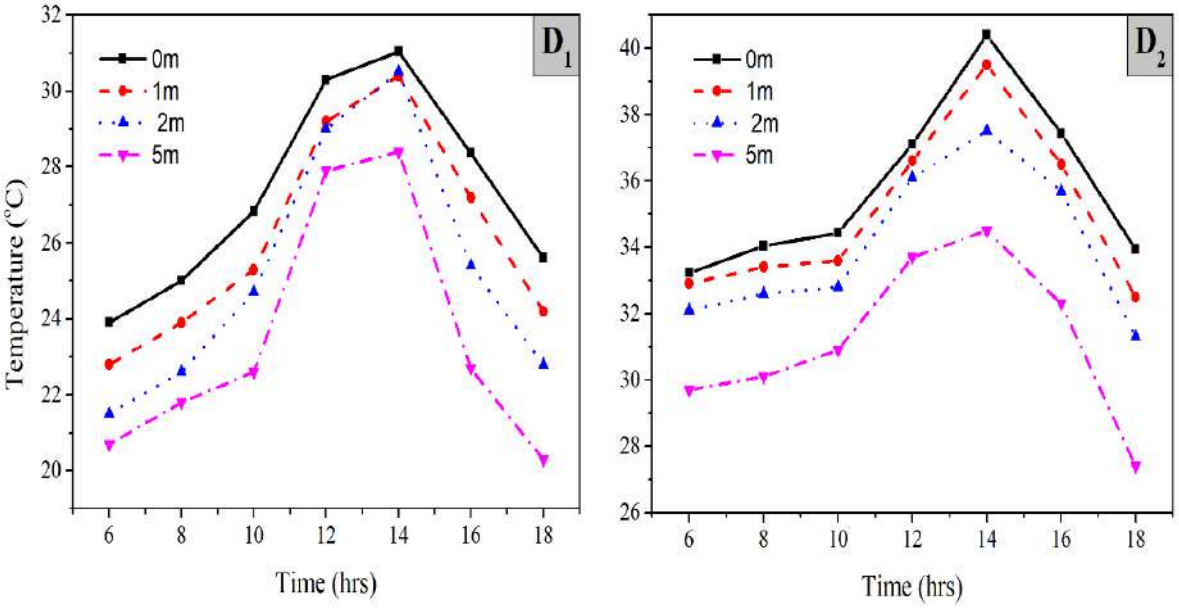


**Fig. 2.** Diurnal temperature variation in different hot springs with distances from its source

The highest temperatures at 14:00 hrs maybe because of the highest intensity of the sun during the peak hours (12:00-14:00 hrs). The undisturbed hot springs at $D_1$ have shown moderately lower temperatures than disturbed hot springs ($D_2$). Though the undisturbed spring show a Lukewarm temperature, the sites of the spring are in close proximity to the river, and the climatic conditions of the Dirang is also very cold. Since the sampling was done in November and considering the factor of very low surrounding temperature (5-12 °C), the temperature of both the spring in other season may be on the higher side compared to the present study. The thermal regimes of water are impacted by the surface exchange of heat with the atmosphere through various processes such as radiation, evaporation, convection, turbulent mixing, etc. Anthropogenic changes are the usual local factors that disturb the processes and nature of zones which influences the thermal characteristics of the water (Graf, 2019). Therefore, the air temperature and anthropogenic factors might be the influencing factors for variation in the temperature of hot springs.

**Water quality index**

The water quality index (WQI) is an effective technique to describe the combined impact of individual parameters on the overall quality of water. It is challenging to decide the overall quality of water for human consumption based on a particular water quality variable. The bulk of the information on different water quality parameters has been reduced to a single value through the WQI (Tyagi *et al*., 2013). WQI values lie in the range of 0 to 100, signifying the quality of water (table 3). The WQI values for hot spring at $D_1$were 2.79, while 1.16 for hot spring at $D_2$. The results revealed that the WQI values of hot springs for both the locations were <25 and considered as excellent water quality (Mishra and Patel, 2001)

## CONCLUSION

The study provided detailed information on the physicochemical parameters of the hot springs. The varied difference in pH, EC, TDS, alkalinity, total hardness, and other parameters for the hot spring at the $D_2$ site might be due to anthropogenic disturbances. The water quality index of hot springs at both the locations was found to be excellent. The diurnal variation in temperature at different distances from the source of hot springs at both the sites is conducted first time. The present study improved the existing information on the physicochemical characteristics of the hot springs located in Arunachal Pradesh. However, a further detailed study is required for elemental analysis, bioprospecting values, and other parameters for the ecosystem analysis of these hot springs.

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# TRANSITION FROM WATER SCARCITY TO WATER SUFFICIENCY THROUGH STORAGE OF SPRING FLOW: A SUCCESS STORY OF WATER CONSERVATION FROM AYAL VILLAGE, PAURI

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## INTRODUCTION

In the early 21st century, a flagship programme in the rural drinking water sector, Swajaldhara was initiated by the Government of India (GoI) where communities were made central in decision making, planning, implementation, and management of water resource schemes. Several case studies from various parts of India, however, portray a conflicting picture, with the notion of community ownership being delivered through a top-down bureaucratic procedure. Swajaldhara encountered policy reversals while being intended to be a demand-side bottom-up strategy; instead, it got ingrained in a top-down style of service delivery (Srivastava, 2012; Cullet, 2009). After almost two decades, a very recent initiative of GoI, under Jal Jeevan Mission (JJM), aims to provide all rural Indian homes adequate water at their doorstep. The mission by the year 2024 promises to ensure water through 'functional' tap connection for other stakeholders also like schools, wealth centers etc., as well as plans to empower local volunteers for catchment protection and related activities to ensure the sustainability of water supply system. Even though the nature of problems has comprehensively changed over the past couple of decades, however, the mission becomes doubly difficult in the physiographic region of the Indian Himalaya. This is due to widely reported diminishing discharge in springs and streams, maintenance of long lengths of pipelines through rugged topography which connects the source to the supply and threatening anthropogenic activities like recurrent forest fire, road construction etc. resulting due to weakened links in Human-Nature relationships.

Springs have been an uncredited backbone for remote villages since ages and their importance of it is recently being realized when most of the villages are seeing their springs drying up. Since the early 1980s, reports have indicated a decline in springflow and headwater stream discharge throughout the Himalayan range (Rawat *et al*., 2016; Aayog, N.I.T.I., 2018**).** The underlying complex causes could be associated to decline in monsoon as well as decreased winter rainfall, landuse change (Tarafdar *et al*., 2019) and forest degradation and overuse causing less options for rainfall infiltration ( Qazi *et al*., 2017). The transformation in the land use pattern either due to climate change or caused by out-migration of workforces could have played an important role in the depletion of the water resources. Land-use change has direct and indirect impacts on the amount of evapotranspiration, surface runoff, alteration of physical soil characteristics and groundwater recharge. These interconnected processes control the water budget on the surface and subsurface groundwater aquifers, and so govern the overall basin water dynamics (Bormann and Klaassen, 2008).

One of the most urgent concerns facing the world is to ensure that there is enough freshwater available to maintain human health and well-being as well as to sustain the ecosystems in which they live (Damkjaer and Taylor, 2017). But fresh water availability can not be assured if the SW monsoon is getting deficient year after year causing frequent multi-year droughts of moderate to severe intensity (Preethi *et al*., 2019). The prevalent seasonal water scarcity in India is alarming (Mekonnen and Hoekstra, 2016**)** and the crucial role of the vulnerable mountain towers as a source for water supply and storage for its inhabitants and the downstream ecosystem and society is not fully realized **(**Viviroli *et al*., 2011, Immerzeel *et al*., 2020**)**. Hence, the need for mountain-specific conservation and appropriate climate change adaptation strategies to safeguard the susceptible mountain communities and the ecosystems are strongly recommended (Immerzeel *et al*., 2020). With rising expectations for conservation under precarious time, efficient water management could play a fundamental role in the water-scarce hilly areas of the middle Himalaya for sustainably managing and adapting to climate change (McCartney and Smakhtin, 2010). Water storage and accumulating when it's available in plenty could be one of the most effective measures for its security and productivity (Tarafdar, 2013).

This study brings into light a case study of bringing together the policy and practice on spring flow conservation that was carried out in the Ayal village of the Pauri block of Pauri district. The spring has a high water discharge not only during the monsoon period but also during the summer lean period and acts as a reliable fresh water source for meeting the daily water needs of all the households and livestock in the village. The multi-institution effort on water conservation resulted in solving the prevalent lean period water scarcity and needs replication in other regions of the Indian Himalaya by strengthening the role of small storage.

## STUDY AREA

Ayal, a small village with a coverage area of around 1.7 $km^2$ is located in the south direction of Pauri, the district headquarter of the Pauri district. Spatially, it lies between 30° 04' 26'' to 30°03' 42'' North latitude and 78° 47' 10'', 78° 47' 57'' East longitude. The minimum height above the mean sea level is 1350m which represents the valley portion while the observed maximum height above the mean sea level is 1700m located at the ridge tops bounding the micro watershed. The village lies within the Paidul microwatershed which falls within the Irgad sub watershed which is a part of the Paschimi Nayar river sub-basin. Figure 1 shows the study area map with the locations of the central stream, spring, tank and solar panels for the spring pumping project (Fig. 1). Five villages are located in the micro watershed of an area of 8 $km^2$ which are dependent on springs, streams and hand pumps for water demand whereas the central stream act meets the agriculture demand through small gul systems. The pipe water supply exists but becomes highly irregular during the lean summer months. Either side of the Paidul Gad has moderate to gentle slope with the majority of the land use as terraced agricultural land and the outskirts regions are occupied with open pine forest (*Pinus roxburghi*) or barren land. The middle slopes covered by forested areas vary from a moderate gradient to high gradient with 30° to 51° slopes in the southern part of the village. The air temperatures vary from approximately 1°C minimum temperature in winter to a maximum of 36°C in the summer season. The monsoon season contributes almost 80% of the rainfall with a reported long-term average of 1280mm rainfall (Tarafdar, 2016). However, the region in recent times

record deficient monsoon rainfall with delayed summer monsoon. Very deep coarse textured soil overlies the metamorphic rock types of quartzite and foliated phyllite in the spring catchment area of Ayal.

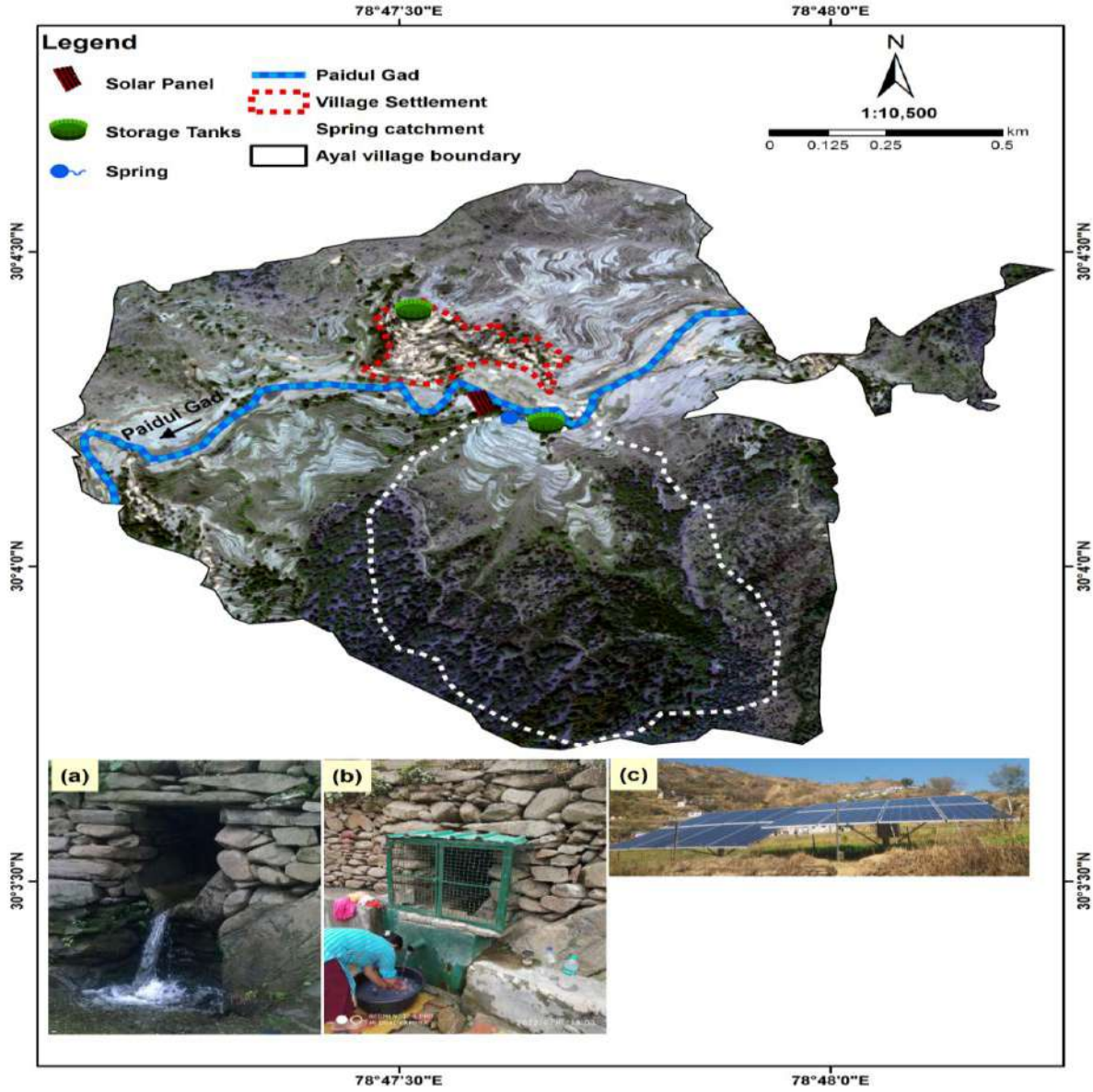


**Fig. 1.** Study area map with location of Ayal spring and its catchment area with pre unconserved state of springflow (a) and post-conservation photograph (b) with solar panel(c).

## DATA ACQUISITION AND METHODOLOGY

### GIS based dataset acquisition:

High resolution Rapid-Eye satellite imagery with a spatial resolution of 1.8 meters (Pan: 450-800 nm, Blue: 450-510 nm, Green: 510-580 nm, Red: 655-690 nm, Near IR: 780-920 nm) was acquired from NRSC, Hyderabad. ALOS-Palsar digital elevation model with a spatial resolution of 12.5 meters for the entire Irgad catchment was downloaded from Earthdata, NASA's data hub (https://search.asf.alaska.edu/#/?dataset=ALOS). Further basic population

data for population statistics of the Pauri block was downloaded from the "District Census Handbook (DCHB)", the official census records, accessible from the official website of the "Census of India" (https://censusindia.gov.in/2011census/dchb/DCHB.html). The data was processed and further tabulated to find the variation in the population trend of the block and district over the decade.

**Field based survey**

A community survey of the Ayal village was undertaken for collecting the information regarding the supply of water to each household through the stand post for pipe water supply and the availability criteria on a per day basis. The dependency on the Ayal spring was also assessed during the field survey as the spring is being used as a drinking and domestic water supply source since long time. The post assessment of water availability after the commissioning of newly developed spring water pumping project during 2021 in the village was also done through stakeholder consultation. GPS location which includes latitude, longitude and altitude of the spring and seeps were taken using a hand held GPS device.

**Remote Sensing and GIS based analysis**

High-resolution satellite image LISS-IV and Rapid-Eye for the period of 2010 and 2017 and SoI toposheet were used for mapping and to analyze the changes in the landuse. The satellite data were georeferenced and projected to UTM projection with WGS 1984 datum. For understanding the extent of the village boundary and the past landuse of Ayal village, revenue maps were collected from the tehsil office and digitized for mapping the past landuse for the year 1966. The other thematic maps like drainage, slope, and aspect maps were generated using satellite data. The DEM was used for demarcation of catchment boundaries of the micro watershed.

**RESULTS AND DISCUSSIONS**

**Demography of the Pauri block and the Ayal village**

Out-migration for a better livelihood and employment has turned many villages in Pauri into ghost villages. Pauri block had a total population of 30482 in the year 2001 which reduced to 29287 in the year 2011, which accounts for a decline by 5.8% over a decade. As the rural areas are mostly dependent on agriculture and in the past ten years also, the agriculture sector too showed a significant decline in the agricultural workers by 59% in the Pauri block (6556 in 2001 to 2774 in 2011). The change map (Fig. 2) clearly highlights that almost 54% of the total villages are experiencing a negative trend with 25 villages having turned into ghost villages in the Pauri block. Ayal village located in Pauri block has also shown a negative trend in terms of the population over the decade between 2001 and 2011. The total population of Ayal in the year 2001 was 467 which got reduced to 390 in 2011 which marked an overall decline of 16.5% in the past decade. Water scarcity and wildlife are some of the issues for such a regional pattern of decline in population in the block and district as a whole.

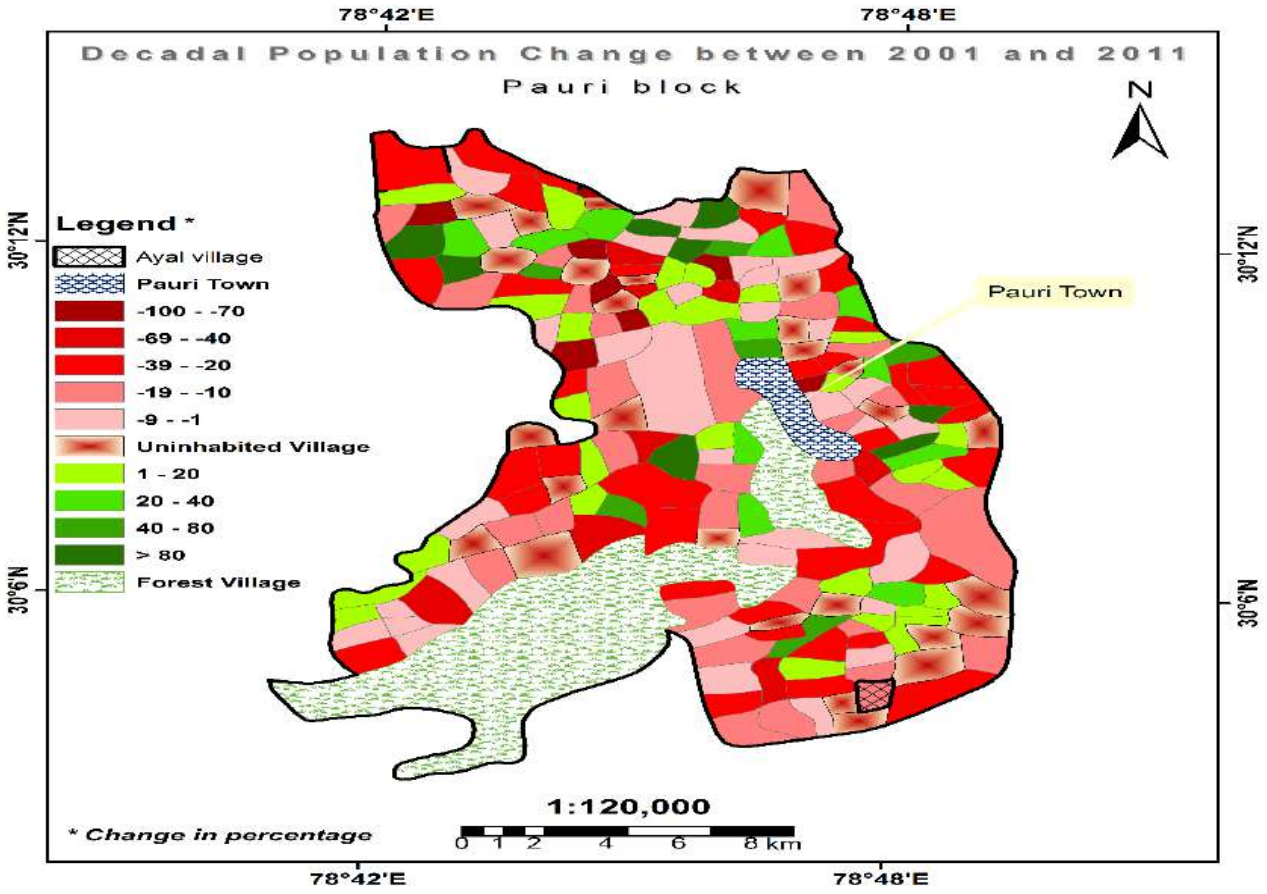


**Fig. 2.** Net change in decadal population in Pauri block reflecting a dominance of declining population in village with shades of red colour.

## Land use Land cover change

The high resolution Rapid-eye and LISS-IV satellite imagery was visual interpreted with field verification for generation of detailed land use land cover of the Ayal village. The maps in fig. 3 and table1 demonstrate the pattern of the land use distribution in the entire village. In the short span of seven years, a very dominant change can be observed in agricultural and forest cover, with agriculture reducing radically from 40% of the total land occupancy in the year 2010 to only 18% in the year 2017. The majority of the agricultural land is converted to barren and permanent fallow land. The agricultural land abandonment in not only observed in the rain-fed middle and high terraced agricultural land but also in the adjoining regions of streams which used to be irrigated with wet rice. The forest cover which is mainly dominated by pine forest and minor patches of oak covers 27% of the area in 2010 and has increased by nearly 10% in 2017. The barren land and fallow land have increased by 5-6% over seven years. This study reflects not only the local specific picture of the region surrounding a specific village but a regional picture of overall landuse transformation happening in the Pauri district. With the alteration in rainfall characteristics as well as delay in monsoon rainfall in the past years, the agricultural activity of the region is greatly impacted.

**Table 1.** Area distribution and percentage of each landuse landcover class in 2010 and 2017

| 2010 | Area ($km^2$) | percentage |
|---|---|---|
| Agricultural Land | 0.702 | 39.6 |
| Barren Land | 0.088 | 4.96 |
| Pine Forest | 0.44 | 24.8 |
| Oak Forest | 0.045 | 2.53 |
| Fallow Land | 0.453 | 25.5 |
| Settlement | 0.044 | 2.48 |
| Pasture Land | 0.014 | 0.80 |

| 2017 | Area ($km^2$) | percentage |
|---|---|---|
| Agricultural Land | 0.31 | 17.8 |
| Barren Land | 0.184 | 10.6 |
| Pine Forest | 0.602 | 34.7 |
| Oak Forest | 0.045 | 2.59 |
| Fallow Land | 0.533 | 30.7 |
| Settlement | 0.044 | 2.54 |
| Pasture Land | 0.014 | 0.80 |

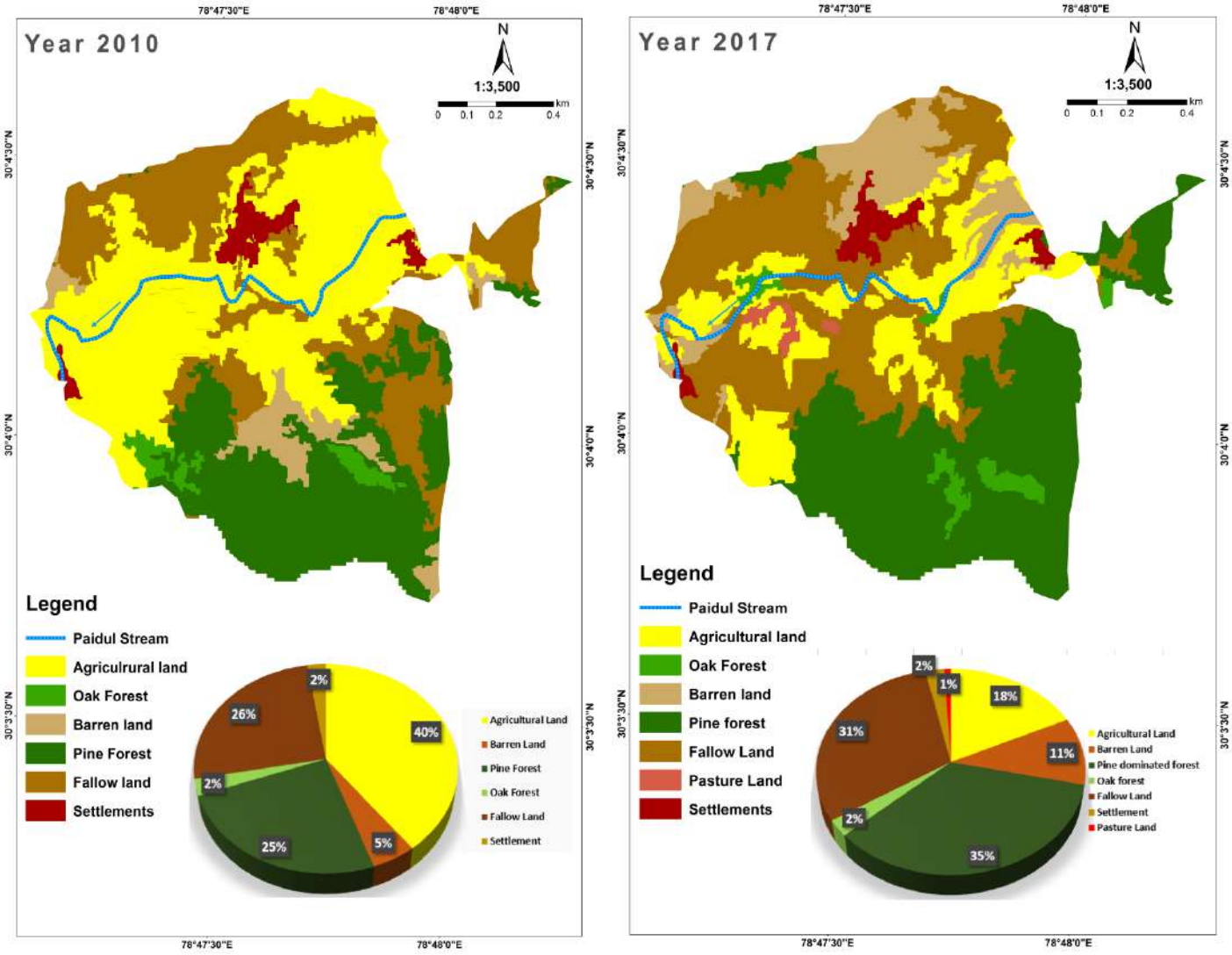


**Fig. 3** Land use land cover map in the administrative boundary of the Ayal village showing clearly a major reduction in agricultural practices between year 2010 and 2017.

### The spring flow storage and pumping project in the Ayal village: a real Jal Jeevan Mission

The experimental micro watershed and the Ayal village became a part of the study in the year 2012 from international support under the small grant mission of the South Asian Water Initiative (SAWI) with collaboration from partners of Nepal and ICIMOD. Since then, the

long- term study site is supported by many agencies which include funding from SAC, ISRO, Ahmadabad and National Mission for Himalayan Studies, MoEF &CC and GBPNIHE. The experimental micro watershed of 8 $km^2$ was instrumented with water level recorders, rain gauges, as well as several springs monitored daily by involving local stakeholders for the generation of baseline database. Several sensitization and awareness programmes were organized in the same experimental micro watershed with basic training and demonstration on monitoring of water resources. The Ayal spring outflow monitoring results over five years (2012-2017) range from maximum flow of more than 500 lpm during the monsoon period to as low as 5 lpm during the summer low-flow period and has an average annual flow of 90 lpm. Due to deficient rainfall year after year the spring flow has declined from 10 lpm discharge to only 5 lpm discharge during the lean period. The spring outflow lacked storage and the village population was facing a serious water scarcity issue, with very infrequent pipe water supply during the lean summer months.

In the year 2020, the local community with the active participation of the gram pradhan of Ayal village, Himmothan-Tata Trust and State water department came together for this replicable water conservation initiative. The project started by constructing a tank in the immediate vicinity of the spring with a storage capacity of 40 thousand liters. The tank stores the water and is connected to two tanks which are located near the Ayal village on the hill top on the right-hand side of the catchment with a storage capacity of 20 thousand liters. Water is pumped twice a day through the long pipeline of nearly 800 meters using either an electric pump or a submersible pumped supported by 16 solar panels. A total of 146 families are getting benefited from this project. A post-assessment through community survey revealed that adequate water is being supplied to each household in Ayal village and could completely solve the summer season water scarcity issue in the village. A single household in the village utilizes up to 200 to 300 liters of water a single day. The livestock consumes around 15 to 30 liters a day, while per capita consumption is around 50 to 60 liters a day. The springflow conservation and pumping project now fulfills the water demands of the once water deficit village of Ayal and now is a role model village on water conservation.

## CONCLUSION

Managing water in the 21st century in the heterogeneous sloping landscape of middle Himalaya will be a more daunting task under the changing land and socio-economic transformation as well as recurrent drought and high-intensity rainfall. Storage of surplus water and simple runoff storage in the hydrologically sensitive areas (HSA) through appropriate soil and water conservation measures provide an opportunity to buffer the impact from vagaries of rainfall uncertainty. Source area protection and storage are the two key measures for long-term water resource sustainability.

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# IMPACT OF AGRICULTURAL PRACTICES ON RIVERINE WATER QUALITY OF TAWI RIVER BASIN, WESTERN HIMALAYAS, J&K

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## ABSTRACT

Agriculture is the main occupation in the Union Territory of Jammu and Kashmir with rice, wheat and maize as the major crops grown. These three food crops accounts for 70% of the total cultivated area.The irrigational requirements are fulfilled by the Himalayan river called "Tawi or Surya Putri" which flows through the Union Territory of Jammu and Kashmir and forms an important part of the Indus river water system. The cultivated lands are stretched along both the banks of the river draining the river with chemical fertilizers, pesticides, and organic pollutants throughout its course. The agricultural practices mainly involve the use of chemical fertilizers. Growing concern calls for detailed scientific investigations on riverine water quality in terms of agricultural discharge from irrigated areas and surface runoff to provide guidance and data base for regional water management and sustainable agricultural development. Therefore, the present study is intended to account the limited availability of water quality data and approximation of the probable anthropogenic influence on water quality of Tawi river. For this, field sampling was executed at basin scale at 15 sampling locations during pre and post monsoon season and measured physical and chemical parameters along with the minerals and nutrient status as per standard procedures to assess the extent to which these parameters were regulated by anthropogenic activities particularly agricultural practices. The results showed pH of water is alkaline having elevated levels of phosphate, nitrate and sulphate indicating contamination from fertilizers and manure runoff.The maximum levels of sulphate and nitrate were found in downstream (JSW-8, 5 & 4). The streams in the downstream of the basin receives more organic load as the area is experiencing intense anthropogenic stress and receives agricultural runoff from paddy fields mainly.The findings recommend water management for riverine ecosystems in the Tawi river basin and potentially for the whole of the Western Himalayas. There is need to further enhance the knowledge base on organic farming and resource management for bringing the yield at par with the conventional agricultural methods.

**Keywords:** Tawi river, Agricultural runoff, Chemical fertilizers and Organic farming

## INTRODUCTION

Himalayas, called the "Water tower of Asia" host numerous glaciers and are home to emergence of great rivers and contribute to the major river water systems of India. The Himalayan Union Territory (UT) of Jammu and Kashmir (J&K) is blessed with ample of rivers, streams and lakes which built up the socioeconomic status of the UT.The most significant rivers in the UT, with headwaters in the Himalayan mountain range, are the Indus, Jhelum, Tawi, Chenab, Ravi, and Kishenganga. Agriculture, irrigation, horticulture,

hydroelectricity, and tourism are the main industries in the UT of J&K that are directly reliant on water resources (Shukla and Ali, 2018). However, the water quality is degrading as a result of the heavy use of pesticides and fertilisers in agriculture fields during the growing seasons (Rashid and Romshoo, 2013).

Among the major rivers flowing through the UT of J&K, Tawi river is important to residents of Jammu as they are exclusively dependent on the river for drinking and irrigational requirements. It is the important tributary of river Chenab and confluences on its left bank which in turn is a most important tributary of the Indus river water system. The river also receives untreated sewage, unabated municipal waste disposal and agricultural activities involving use of chemical fertilizers and pesticides and organic pollutants (Kour *et al*., 2021). Growing concern calls for detailed scientific investigations on riverine water quality in terms of agricultural discharge from irrigated areas and surface runoff to provide guidance and data base for regional water management and sustainable agricultural development.

## MATERIAL AND METHODS

To account the limited availability of water quality data and approximation of the probable anthropogenic influence on water quality in Western Himalayas, we executed field sampling at basin scale at 15 sampling locations during pre and post monsoon season for the year 2021 and measured physical and chemical parameters along with the minerals and nutrient status as per standard procedures to assess how these were regulated by anthropogenic activities particularly agricultural practices. The samples were collected upstream (sampling IDs: CSW-8, CSW-7, CSW-6 and CSW-5 [marking the region between Basantgarh to Chennani]; mid stream (USW-5 [Udhampur], RSW-2 & RSW-7 [Ramnagar], DSW-7 and DSW-5 [Domel region]) and downstream (JSW-1 to 5 & JSW-8 [Jammu]).

## STUDY AREA

River Tawi, also known as Surya Putri, finds its origin in the Kali Kundi glacier and the nearby areas located on the south west of Doda district of J&K and converge with Chenab river in Pakistan. Majority of the river basin (95%) falls in the J&K UT of India (in Jammu, Udhampur and a smaller portion in Doda, Reasi and Samba district) and 5% in Pakistan.The Tawi river basin in the Indian territory (Fig. 1) has a basin area of 2342.6 km sq. and the total length of the main channel is 174.5 kms. The river is drained by about 5293 streams in the entire basin. The main channel is surrounded by agricultural fields on both the banks.

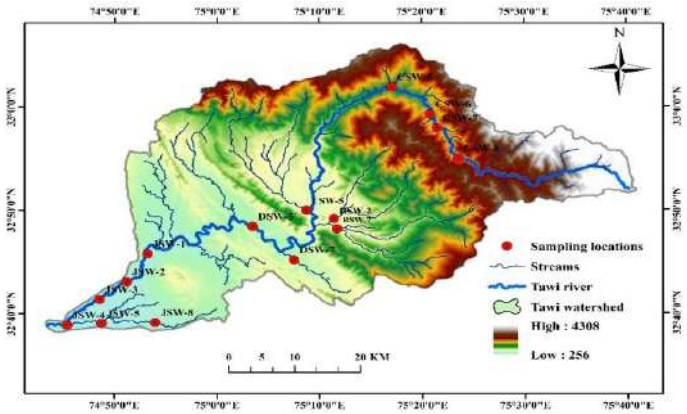


**Fig.1.** Tawi river basin

## Soil type

Soil forms the back bone of agriculture and the type of soil determines the type of crop grown in a particular region (ENVIS, Soils types of Jammu & Kashmir, 2015). The soil types found in the entire Tawi river basin is mainly alluvial type. Brown forest soil is found in Udhampur and is silt loam to clayey in texture, moderately alkaline with a water holding capacity of 40% and has good carbon to nitrogen ratio. This soil is good for crops like maize, wheat, pear. Red and yellow podzolic soil is also found in the district of Udhampur having a water holding capacity of 40% and is course grain size. The type of soil found on the slopes of forest hills of Jammu and Udhampur is Lithosol with a water holding capacity of about 38% and 0.2 to 0.6% organic carbon.

## Agricultural activities

Agriculture is the main occupation in the UT of J&K. Rice, wheat and maize are the major crops grown and accounts for 70% of the total cultivated area. Wheat is mainly grown in regions of Jammu and Udhampur district. It is a Rabi crop and is mainly grown in autumn. Maize is the major crop in terms of land under cultivation in J&K and is cultivated in Kandi, Karewa, and plain areas primarily in kharif season. Many rice varieties are cultivated in the entire basin. Jammu district is famous for Basmati rice cultivation. The other crops grown in the entire basin are pulses, oil seeds, fodder, bajra, and vegetables. The agricultural practices involve the use of chemical fertilizers.

## RESULTS AND DISCUSSIONS

The result of the physico-chemical parameters for the entire basin is shown in Table 1. The pH of water is alkaline having elevated levels of phosphate, nitrate and sulphate indicate contamination from fertilizers and manure runoff. The maximum levels of sulphate and nitrate is found in downstream (JSW-8, 5 & 4). The streams in the downstream of the basin receives more organic load as the area is experiencing intense anthropogenic stress and receives agricultural runoff from paddy fields mainly.

**Table 1.** Physico-chemical analysis data of all the sampling sites during two seasons

| Parameters | | Pre-Monsoon | | | Post-Monsoon | | |
|---|---|---|---|---|---|---|---|
| | | **Minimum value** | **Maximum value** | **Mean value** | **Minimum value** | **Maximum value** | **Mean value** |
| Physico-chemical | pH | 7.6 | 9.4 | 8.3 | 7.6 | 8.7 | 8.3 |
| | Conductivity (mS) | 0.04 | 1.18 | 0.32 | 0.14 | 0.8 | 0.35 |
| | TDS (ppm) | 27 | 587 | 159.20 | 82 | 448 | 187.27 |
| | DO (mg/L) | 4.83 | 10.47 | 7.82 | 1.4 | 10.07 | 7.14 |
| | Hardness (mg/L) | 42 | 352 | 136.40 | 100 | 370 | 190.67 |
| Nutrients | Calcium (mg/L) | 10.93 | 51.30 | 26.41 | 33.64 | 95.04 | 54.72 |
| | Magnesium (mg/L) | 2.55 | 72.81 | 17.13 | 0.83 | 32.26 | 13.13 |
| | Sodium (mg/L) | 1 | 58.53 | 10.83 | 1 | 48.26 | 16.80 |
| | Potassium (mg/L) | 1 | 10 | 8.38 | 1 | 9.90 | 3.09 |
| | Nitrate (mg/L) | 0.38 | 4.35 | 1.40 | 1.05 | 3.30 | 0.75 |
| | Phosphate (mg/L) | 1.92 | 25.78 | 6.09 | 1.73 | 4.08 | 2.87 |
| | Sulphate (mg/L) | 5.78 | 45.52 | 16 | 9.24 | 31.90 | 16.11 |

**Measures to control surface water pollution from agricultural runoff**

Organic farming is considered as a best alternative to curb the environmental menace associated with modern agricultural practices. It is based on sound ecological principles which encourage use of organic waste. It integrates sustainable farming methods like use of biofertilizers and biopesticides. Mixed cropping of legumes with non-legume crops such as wheat can provide for the nitrogen demand of the plants and reduce use of commercial fertilizers. “Soil Health Card” scheme is also beneficial for assessing the nutrient status of the field and helps in avoiding the excess nutrient loss from the agricultural fields during runoff.

## CONCLUSION

From our findings, we recommend water management for riverine ecosystems in the Tawi river basin and potentially for the whole of the Western Himalayas. There is need to further enhance the knowledge base on organic farming and resource management for bringing the yield at par with the conventional agricultural methods.

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# Revised Author Guideline for ENVIS Bulletin Himalayan Ecology
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Abstract must reflect important findings of the paper. It should be brief within 400 words.

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# ENVIS BULLETIN
# HIMALAYAN ECOLOGY

**G.B. Pant National Institute of Himalayan Environment**
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**State Name:** Sikkim
**Common Name:** Noble orchid
**Scientific Name:** *Cymbidium goeringii*

**State Name:** Arunachal Pradesh
**Common Name:** foxtail orchid
**Scientific Name:** *Rhynchostylis retusa*

**State Name:** Nagaland
**Common Name:** Rhododendron
**Scientific Name:** *Rhododendron arboreum*

**State Name:** Manipur
**Common Name:** Siroi lily
**Scientific Name:** *Lilium mackliniae*

**State Name:** Mizoram
**Common Name:** Red Vanda
**Scientific Name:** *Renanthera imschootiana*

**State Name:** Tripura
**Common Name:** Nag Kesar
**Scientific Name:** *Mesua ferrea*

**State Name:** Meghalaya
**Common Name:** Gambar
**Scientific Name:** *Cypripedioideae*

**State Name:** Assam
**Common Name:** Foxtail Orchid
**Scientific Name:** *Rhynchostylis retusa*

**State Name:** West Bengal
**Common Name:** Night flowering jasmine
**Scientific Name:** *Nyctanthes arbor-tristis*

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