

Impact of Parbati Hydroelectric Power Project Stage-II on the Interdependence of Ethno-Botanical Resources and the Inhabitants of the Parbati Valley in Kullu District of Himachal Pradesh

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Abstract The aim of the present study is to document ethno-botanical bio-diversity of Parbati Valley in Kullu district of Himachal Pradesh, interdependence of local communities with these resources and impact of Parbati Hydroelectric Project stage-II on both. The Parbati H.E. Project stage-II is a run of the river scheme proposed to harness hydro potential of lower reaches of the river Parbati with an installed capacity of 800 MW. The Parbati H.E. Project is part of the 2013 MW Parbati project, Asia's biggest hydroelectric power project on Parbati river. During field trips to the study area between September 2017 and October 2018, a total of 218 plant species were inventoried belonging to 178 genera and 74 families used by the indigenous communities for life sustenance. Out of these, there are 166 medicinal plant species, consisting of 94 herbs, 47 shrubs and 25 trees, which are used by local people for treatment of various diseases and ailments. During survey, plants species like *Arnebia euchroma*, *Aconitum chasmanthum*, *Ajuga bracteosa*, *Dactylorhiza hatagirea*, *Picorhiza kurrooa* and *Atropa acuminata*, *Aconitum heterophyllum*, *Arnebia benthami*, *Fritillaria roylei*, *Angelica glauca* have been found to be critically endangered due to construction of hydro-electric dam and allied activities. A perception survey was conducted in five sample adjoining villages namely Tosh, Tulga, Pulga, Sheela and Nakhtan with a population of 1826 villagers from 414 households to ascertain the impact of Parbati H.E. Project on their lives and biodiversity.

Keywords: hydroelectric power projects, medicinal plants, interdependence, indigenous knowledge, Himachal Pradesh, species diversity

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1. Introduction

The Indian Himalayan Region (IHR) covers a geographical area of 5,33,604 km². A review of existing biodiversity information of IHR reveals that there are approximately 18,440. Out of these, the most prevalent species include 1748 medicinal plants 3,675 wild edibles 4,279 fodder species, 155 sacred plants and 118 essential oil plants with medicinal values [1-7]. The Kullu district is centrally located in Himachal Pradesh. Physiographically, the forests of Kullu district are rich in endemic ethno-botanical resources [8]. Since ages the native communities of Kullu have depended on the plant resources of the region for medicine, fuel, fodder, timber for house construction, furniture, charcoal, flavoring agent, dye, narcotics, agricultural tools, aromatic and religious purposes etc. For example, *Cedrus deodara* (*deoda*), *Abies pindrow*, *Pinus*

roxburghii, *Picea smithiana* and *Taxus wallichiana* are widely used as timber for their durable wood quality for furniture and house construction. These communities have medical practitioners locally called as 'Vaidis' who are the custodians of the traditional indigenous knowledge of ethno-botanical medicinal herb plants for the treatment of various ailments and chronic diseases. Since ages, the native tribes like the *Gaddies* and *Kulluvians* have lived in complete harmony with mother-nature. Many plant species are part of their folklore, religious beliefs and value system.

The development of hydro-electric power projects has created a negative impact on the rich ethno-botanically repositories of the Himalayan region [9-12]. The 800 MW Parbati Project stage-II is part of the 2013 MW Parbati Project on Parbati river. The Parbati river is proposed to be diverted with a concrete gravity dam at Pulga village in Parbati Valley through a 31.52 km head race tunnel and produce 3160.66 million units of electricity every year.

This study aims to document the ethno botanically important plant species in the Parbati Valley and examine the impact of the Parbati H.E. Project stage-II on the interdependence of local communities with plant resources, especially the traditional knowledge about their medicinal properties.

2. Study Area

The study area is located between 31°20'25'' to 32°25'0'' N latitude and 76 0 56'30'' to 77°52'20''E longitude in Kullu district of Himachal Pradesh covering a geographical area of 5503 sq. km (Figure 1). Kullu district is bound by Mandi district in the south-west, Kangra district in the north-west, Lahaul and Spiti district in the North and by Shimla district in the South. The climate of the study area is typically temperate, sub-tropical, alpine and sub-alpine [13]. Because of its varying altitudinal gradient (1100-5500 m) and climatic conditions, the Parbati Valley harbors a variety of endemic plant species. The reserve forests spread over an area of 15618 ha, while the protected forests constitute 193,495 ha of land.

Unclassified forests account for 146,580 ha [14].

3. Materials and Methods

The flora of the project area was inventoried in three seasons: October-December 2017 (winter season), May- June 2018 (summer season) and July-September 2018 (heavy rainfall). The plants were recorded in quadrats along transects. A total of 35 randomly selected 10 × 10 m quadrats, covering the impacted area of the Parbati H.E. Project stage-II, were positioned along the target area to capture plant distribution in forest types. Quadrat size was determined using the species area curve method [15]. Transects of length 150m and width 5m were established between quadrats. Five villages named Tulga, Sheela, Pulga, Tosh and Nakhtan located in close vicinity of Parbati H.E. Project stage-II were identified to document primary data based on perception survey about the impact of the project on their lives. Participatory methods and Rapid Rural Appraisal (RRA) were used to collate, confirm, and validate ethno-botanical information during the field visits [16].

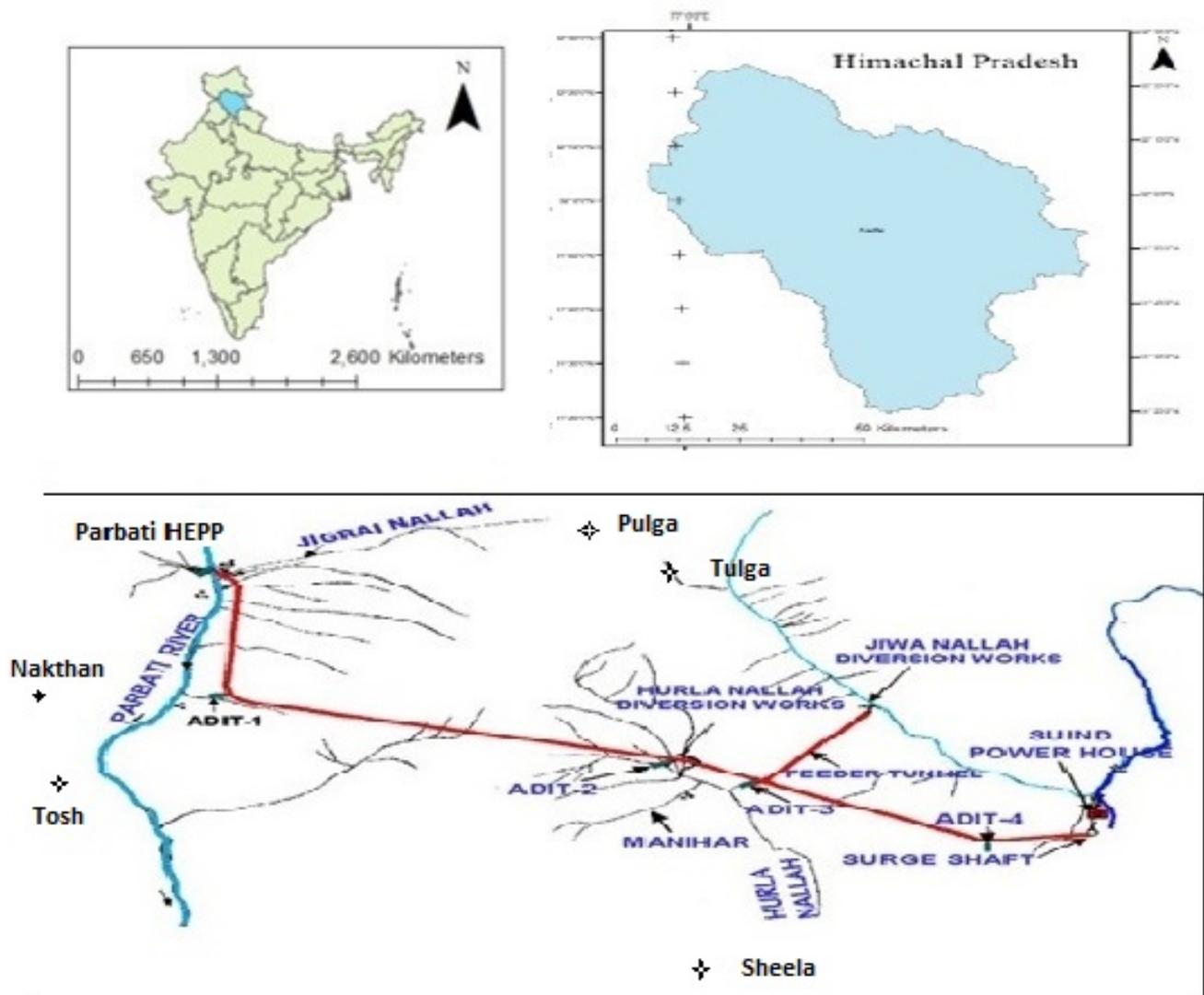


Figure 1. Map depicting Study Area

A total of 136 key persons were interviewed from these villages to collect data through semi-structured questionnaires, descriptive methods, on-spot interviews and informal group discussions. The information on traditional knowledge about medicinal plants was gathered from local healers. Their perceived threats were then discussed with the officials of the Divisional Forest Officer [17,18]. During the study, photographs and field notes were prepared to verify and analyze the raw information. The specimens having medicinal properties were identified with the help of reference collections and expert knowledge [19-30]. The secondary data was generated from secondary (desk) reviews from existing literature on the phyto-diversity distribution in Parbati Valley on use of plant resources as medicine and various other purposes. Important medicinal plants have been arranged in botanical alphabetical order followed by ailment treated and their mode of application.

4. Status of Commonly Used Bio-Diversity by Local Communities of Parbati Valley

On the basis of field survey of study area during different seasons of the year 2017-2018, a total of 218 plant species were identified belonging to 74 families and 178 genera. Classification of plant species was carried out as per their usage by the local communities for medicinal purposes (121 species), timber (23), fodder (17), essential oil (12), fuel/charcoal (11), wild edibles (10), aromatic (09), dye/coloring agent (07) and other purposes namely ornamental/religious purpose (08). Percentage-wise distribution of ethno-botanical resources as per their utility is shown at Figure 2. It is seen that 55% of these plant species are used for medicinal purpose, 10% each as timber, 8% as fodder, 6% as essential oils, 5% as charcoal, 4% as wild edibles and aromatics each, 3% as coloring agent and various other purposes each.

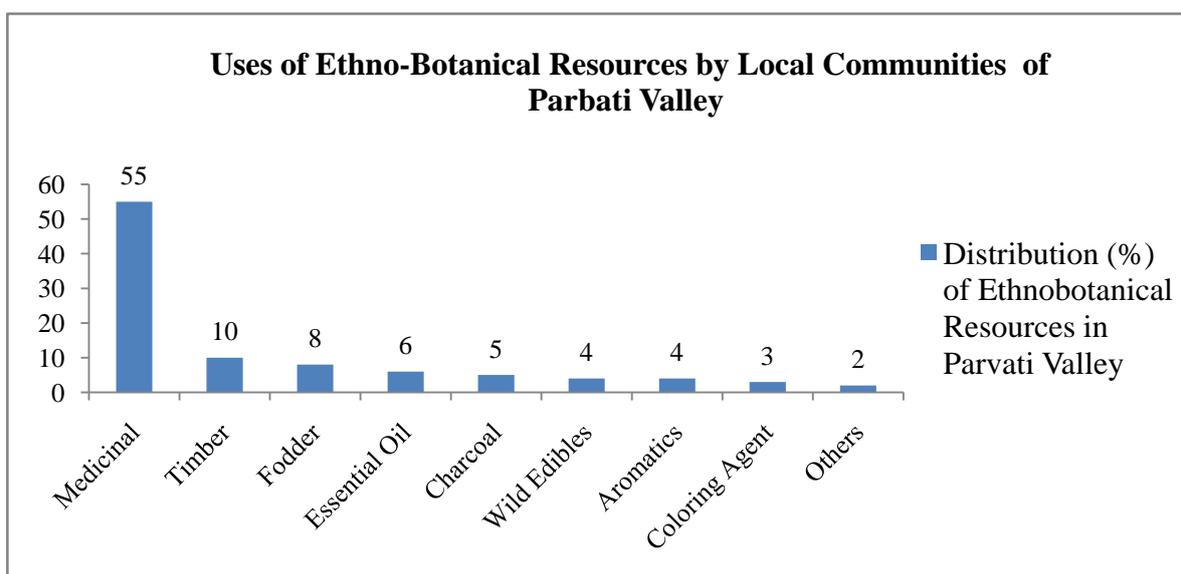


Figure 2. Percentage- wise distribution of botanical resources as per their utility

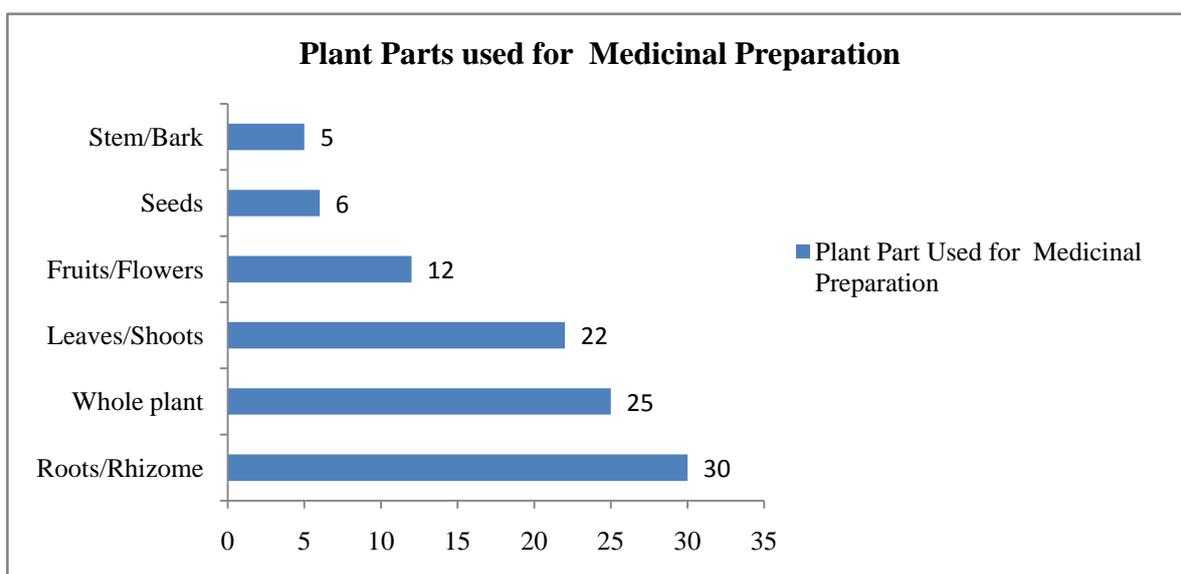


Figure 3. Percentage-wise distribution of Ethno-plant parts used for medicinal purposes

5. Ethno-botanical Resources used for Medicinal Purposes by the Local Communities of Parbati Valley

The natives of Parbati Valley depend largely on natural plant resources for treatment of various diseases and ailments by the local medical practitioners called Vaidis, who are custodians of traditional knowledge. These sacred groves are rich in rare and endemic species which are protected by the local people due to their belief in the deities of the forests [31]. Out of the total of 218 widely used plant

species identified in the survey area, 121 plant species are used for treatment of various diseases and ailments. These plants have been categorized as trees (23), herbs (67) and shrubs (31). On the basis of usage of plant part, it was found that 30% plants are used for their roots and rhizome, 25% are used as whole plant, 22% for their leaves, 12% for fruits& flowers, 6% for seeds and 5% for their stem and bark (Figure 3). These plant parts are used to prepare decoction, herbal oil, crushed leaf paste. Other methods include grinding, extraction to make powder and aromatic essence. Some of the widely used plant species, along with their mode of application, are listed in Table 1 below:

Table 1. Some of the widely used plant species by the local communities for medicinal purposes and their mode of application

Sr. No.	Name	Ailment/Disease Treated	Mode of Application
1.	<i>Abies pindrow</i>	Asthma, Cough, Bronchitis, Anxiety, Pain, Constipation	Decoction made from juice of leaves is used to cure cough and bronchitis. Sedative/ethanolic extract prepared from the leaves is mixed with milk and water to cure pain and anxiety. The inner bark is used to cure constipation & paste of leaves has antiseptic properties.
2.	<i>Arnebia euchroma</i>	Measles, Eczema, Pregnancy issues	The Arnebia roots are crushed to obtain rubericine which has bactericidal properties. Its fruit is used to prepare a post pregnancy liquid recipe called 'Sik'.
3.	<i>Aesculus indica</i>	Blood cancer	Leaves, roots, seeds and flowers of the plant are used to prepare decoction to cure blood cancer.
4.	<i>Alnus nepalensis</i>	Burns, Inflammation	The leaves are used for anti-inflammatory purpose. The juice of the bark is boiled and the gelatinous liquid is applied to burns.
5.	<i>Anemone rivularis</i>	Cough & cold, Stomach ache	The juice of the leaf is mixed with water which is inhaled through nostrils to treat sinusitis and stomach ache.
6.	<i>Acer acuminatum</i>	Cough and cold	The leaves are used as a tea to cure cough and cold.
7.	<i>Acorus calamus</i>	Cold, Inflammation Dysentery, Diarrhea, Respiratory issues	Leaf decoction is prepared to treat dysentery and diarrhea. The rhizome, when chewed, is used to treat cough and respiratory issues. It also helps to reduce inflammation.
9.	<i>Aconitum chasmanthum</i>	Respiratory issues, Asthma, Pulmonary, Lung diseases	The dried root is analgesic, anti-pyretic, anti-rheumatic and sedative. The roots are tied in a piece of cloth and dipped in cow's urine for three days and dried in sunlight. Purified roots are dried and preserved to treat these diseases.
11.	<i>Atropa acuminata</i>	Menstruation issues, Asthma, Parkinson's disease	The roots and leaves are used as anodyne, diuretic, narcotic and sedative purposes. It has properties to cure Parkinson's disease. It is used to treat sun strokes and painful menstruation.
12.	<i>Asparagus filicinus</i>	Tuberculosis,, Leprosy, Fatigue	The roots are used to cure diarrhea, diabetes, skin diseases and tuberculosis. It is antipyretic, vermifuge and expectorant.
14.	<i>Aconitum heterophyllum</i>	Snake/scorpion bite, Fever, Dyspepsia	Dried roots are taken orally as powder to cure stomach ache and fever. They are used against poisoning due to scorpion or snake bite and to cure fever
15.	<i>Abies spectabilis</i>	Cough and cold, Lungs, Throat, Fracture	The infusion of the leaf helps open the lungs and throat. It removes the mucus and clears blockages. Relieves cough and cold.
16.	<i>Achillea millefolium</i>	Gastrointestinal, Nose Bleeding, Clotting	The flower parts cure hay fever and reduce inflammation by chest rubs. The leaf decoction is used for clotting and nasal bleeding. The aerial parts improve digestion.
17.	<i>Achyranthes Bidentata</i>	Cardiovascular diseases, Pus formation, Menstruation	Paste of the root is applied on swollen parts of the body. Decoction of the root mixed with Safflower and Akebia vine stalk is used for treatment of menstruation related problems, pus formation and cardiovascular diseases.
18.	<i>Ajuga bracteosa</i>	Rheumatism, Palsy	Decoction of leaf powder is used to cure cases of rheumatism and palsy.
19.	<i>Arctium lappa</i>	Pancreas, Skin diseases,	The seed compounds possess anti-inflammatory properties for tumors such as pancreatic carcicoma. The leaf extracts can inhibit growth of micro-organisms.
20.	<i>Arisaema tortuosum</i>	Snake bites, Collic ailments.	The dried powder of root is used for snake bites. Seeds mixed with salt are used to treat collic ailments in cattle.
21.	<i>Anemone obtusiloba</i>	Rheumatism, Concussions, Spasmodic and nerve diseases	The plant is ametic, sedative, nervine, anti-spasmodic, anti-rheumatic. Roots are mixed with milk in treatment of convulsions. They are used externally as blistering agent. The root juice is ophthalmic.
22.	<i>Artemisia roxburghiana</i>	Skin infections, Stomach ailments, Allergies	Whole plant extract is used in fever, diabetes. Decoction of leaves is used for stomach ailments, worms and to cure allergies.

Sr. No.	Name	Ailment/Disease Treated	Mode of Application
23	<i>Aconitum balfourii</i>	Rheumatism, Fever, Leprosy, Paralysis, Arthritis, Inflammation	The tuber and root are analgesic, anti-inflammatory, anti-rheumatic and vermifuge. It is used in the treatment of pain and inflammation from gout to arthritis, worms or micro-organisms, amnesia, leprosy and paralysis.
24.	<i>Betula utilis</i>	Obesity, Leprosy, Convulsions, Bronchitis, Ear problems	The bark is anti-septic and carminative. The plant possesses antimicrobial, anti-inflammatory, anti-cancer, antioxidant and anti-HIV properties. The bark is used for the treatment of bronchitis, convulsions, leprosy and ear problems.
25.	<i>Betula alnoides</i>	Fractures, Snake bites	The plant has been used as an antidote in the treatment of snake bite. The decoction of the bark is used to treat dis-located bones.
26.	<i>Bergenia ciliata</i>	Diarrhea, Spleen enlargement	Kidney stones can be removed by the intake of root decoction. It is also used for various renal disorders.
27.	<i>Berberis aristata</i>	Fever, Eye diseases, Cholera	The plant has alkaloids, palmatine, columbamine properties. The dry stems are used as tonic for fever, cholera and eye diseases.
28.	<i>Bistorta affinis</i>	Diarrhea, Cough/Cold, Tonsillitis	Roots, leaves and flowers are used as an astringent and is useful for curing diarrhea, cough, cold and throat ailments.
29.	<i>Bistorta amplexicaulis</i>	Bleeding gums, Dysentery, Diarrhea	Root stock contains a drug called anjubar used as Ayurvedic and Unani medicines to treat bleeding gums, dysentery and diarrhea.
30.	<i>Bupleurum candolli</i>	Bleeding wounds, injuries.	The paste and decoction made from this plant is used as anti-coagulant.
31.	<i>Cannabis sativa</i>	Paralysis Joint pains, Piles, Epilepsy, Brain ailments	Oil extracted from dry seeds is applied to cure paralysis & joint pains. It is also applied to cure fever caused by severe cold. Concentrated and dried sap extracted from the leaves is mixed with mustard oil, both internally and externally to cure piles and brain ailments.
32.	<i>Cyathula capitata</i>	Hormonal ailments Snake bites, Rheumatism	A decoction of leaves is used for rheumatism, snakebite and thoracic pains.
33.	<i>Codnopsis ovate</i>	Wound, Ulcers Bruises	Roots and leaves are used for ulcers, bruises and wounds.
34.	<i>Cyathula tomentosa</i>	Dysentery Skin diseases	Decoction is used to cure dysentery and skin diseases.
35.	<i>Cedrus deodara</i>	Ulcers, Skin diseases, Leprosy,	The bark is used for diuretic, carminative and diaphoretic purpose. The tar is used in chronic skin diseases and leprosy. Also applied for external ulcers.
36.	<i>Chenopodium foliolosum</i>	Intestinal parasites	Plant is anthelmintic. The oil extracted is used for various medicines for intestinal parasites.
37.	<i>Caltha palustris</i>	Urinary infections Cough, Inflammation.	Aqueous extract of root and shoot is diuretic and used in cough. Roots are used in urinary infection. Flowers are used in inflammation.
38.	<i>Coryadalis govannianum</i>	Inflammation, Hot flushes	The root possesses properties to reduce inflammation when used externally. It is supposed to have cooling effect.
39.	<i>Capsella bursa-pastoris</i>	Diarrhorea, Internal bleeding, Urinary problems	Tea made from the whole plant is used as an astringent, stimulant, to treat internal/external bleeding and diarrhea.
40.	<i>Cassiope fastigata</i>	Herpes, Viral fever	Dried and powdered properties are used to cure skin problems and severe viral fever.
41.	<i>Cissampelos pareira</i>	Chronic ulcers, sinus, Cold/cough, Poisonous bites	Seeds are used in the treatment of chronic ulcers and sinuses. It is also used for the treatment of chronic skin diseases and in cases of poisonous bites.
42.	<i>Dactylorhiza hatagirea</i>	Diarrhea, Dysentery, Chronic fevers, Seminal debility	The decoction and plant extract mixed with sugarcane juice is applied on cuts/wounds. Tonic made from the plant is known to cure dysentery, fever, and diarrhea and also have aphrodisiac properties.
43.	<i>Desmodium tiliaefolium</i>	Bilious ailments, General weakness	Roots are used as carminative, have diuretic effect and also taken as tonic.
44.	<i>Delphinium vestitum</i>	Cardiac/Respiratory Intestinal worms.	Decoction made from roots and leaves is used to treat diseases related to heart and lungs. It treats intestinal worms.
45.	<i>Eleegnus parviflora</i>	Dysentery & Cancer.	Unripe fruit of the plant is used as astringent in treatment of dysentery. It is also used to cure cancer.
46.	<i>Elscholtzia strobilifera</i>	Choleric diarrhea, Headache, Cold.	Leaves are used to extract oil for choleric diarrhea, headache, cold and arthritis.
47.	<i>Euphorbia cognate</i>	Common sores	Leaves are used as fistular sores.
48.	<i>Elscholtzia fruticosa</i>	Bruises, Dysentery Constipation,	The seeds and root of the plant are carminative, diuretic and astringent.

Sr. No.	Name	Ailment/Disease Treated	Mode of Application
49.	<i>Fritillaria cirrhosa</i>	Tuberculosis, Asthma, Bronchitis	Dried corns are used for asthma, bronchitis and Tuberculosis.
50.	<i>Fritillari aroylei</i>	Asthma, Dry Skin Tuberculosis,	The bulbs contain alkaloids-peimine and peiminine. It is antipyretic, expectorant, and lactagogue. It is used in almost eighty different diseases.
51.	<i>Fagopyrum esclentum</i>	Blood pressure, Gout	Reduces capillary permeability. Decoction of dry leaves and roots is used as an acrid and astringent.
52.	<i>Fragaria vesca</i>	Cancer, Cardio-vascular system, Arthritis	The fruits called wild straw-berries are consumed raw and fresh. Its roots have anti bacterial, astringent and angio-protective properties. Leaves are used as laxatives astringent and diuretic.
53.	<i>Ficus palmata</i>	Constipation, Lungs bladder warts	Fruit is demulcent, emollient, laxative and poultice. Unripe fruit is cooked as vegetable and used as part of diet.
54.	<i>Girardinia diversifolia</i>	Gonorrhoea, Eczema, Joint effusion	Leaf juice, whole plant and roots are used for anti-allergy, anti-rheumatic, diuretic effect
55.	<i>Geranium wallichianum</i>	Eye troubles, Toothaches	Root stock of the plant is used to cure diseases like eye and tooth problems
56.	<i>Geum elatum</i>	Dysentery, Fever	The whole plant especially the root is anodyne, astringent, and febrifuge and cures fever in infants.
57.	<i>Geranium refractum</i>	Edema, Eczema, Fungal infections	Plant is known to have laxative, diuretic, anti inflammatory and purgative properties.
58.	<i>Gentiana kurooa royle</i>	Gastric ailments, Fever, Urinary problems.	Bitter tonic made is used for improving appetite and to stimulate gastric secretion. The root stock is administered in fever and urinary complaints.
59.	<i>Geranium falcate</i>	Skin, Kidney, Digestion, Menstrual pain	It has anti-septic, anti-bacterial, anti-fungal properties. A decoction taken as tea and extracted oil, relieves stress, menstrual pain and digestive/ kidney disorders.
60.	<i>Girardinia heterophylla</i>	Diabetes, Heart problems	The leaves of the plant have lipid lowering and anti-oxidant potential.
61.	<i>Hippophaer hamnoides</i>	Kidney & Heart issues, Dermatitis	The oil prepared from the pulp of the plant is used for skin problems. The fruit part is used for kidney and heart diseases.
62.	<i>Hedychium spicatum</i>	Swelling, Gingivitis, Oral cavities, Respiratory-tract	The paste made from the plant is applied on joints to cure swelling and pain. The tooth powder prepared is used to cure gingivitis. Concoction with honey is given to treat respiratory tract.
63.	<i>Heracleum candicans</i>	Leucoderma, Sun burns	The roots are sweet smelling and contain coumarins. It is used to prepare sun-tan lotions and anti-leucodermal purposes.
64.	<i>Habenaria intermedia</i>	General tonic	Tender leaves are boiled and eaten as a vegetable. The extract is used as tonic. It is also used in preparation of Chywanprasha (Tonic).
65.	<i>Hedychium acuminatum</i>	Stomach ache, Dyspepsia, Tonic	The root stock is used to treat stomach ache, dyspepsia and is also used as a tonic.
66.	<i>Habenaria pectinata</i>	Snake bite	Tubers are used to relieve the effect of snake bite.
67.	<i>Hypericum choisianum</i>	Ulcers, Rheumatism, Sores	Oil prepared from the plant is used for sores and ulcers and to treat rheumatism.
68.	<i>Indigofera cassioides</i>	Cough & cold, Pain in chest.	The root is used to make decoction and also dried and powdered for external application. The flowers of the plant are eaten as vegetable to cure cough and cold.
69.	<i>Juglans regia</i>	Skin ailments, Chronic Asthma, Dyspepsia, Anti-cancer	The leaves are anthelmintic, anti-inflammatory, astringent and depurative. The seeds are anti-lithic, diuretic, and stimulant. The paste of leaves is used to treat eczema, skin problems and other dermatitis purposes. Extract from the plant is known to be anti-cancer.
70.	<i>Juniperus macrpoda</i>	Joint pains, Paralysis Ring worms, Nervous disorders,	Its berries and resin are used to treat indigestion, piles, joint pains and paralysis.
71.	<i>Jasminum officinale</i>	Frigidity, Menstrual, Depression	The leaf juice is applied to corns and ear discharge. The root is used to treat ring worms. The flowers are aphrodisiac, antiseptic. The oil is used for aromatherapy to cure depression, impotence, frigidity and menstrual disorders
72.	<i>Jurinea dolomiaaea</i>	Boils, Fever, Skin eruptions.	Decoction made from the root is given for the treatment of colic and puerperal fever. The juice of the root is used for the treatment of fevers. The bruised root is used in the treatment of eruptions.
73.	<i>Juniperus communis</i>	Digestive issues, Kidney, Cystitis, Joint pain, Gout.	The fruit is antiseptic, digestive, carminative, diaphoretic, diuretic. It is used raw or boiled as tea. Extracted oil is applied externally on skin and joints.
74.	<i>Leucas lanata</i>	Round worms, Dermatitis, Sores of Eyes & nose	The crushed leaves of plant are applied on wounds and sores of eyes, nose. The decoction prepared from the plant is useful for round-worms among children.
75.	<i>Miconopsis aculeta</i>	Sedative, Relaxant,	Roots are used as narcotics for muscle relaxing.

Sr. No.	Name	Ailment/Disease Treated	Mode of Application
76.	<i>Malva verticillata</i>	Skin disorders, Whooping cough,	The root is used for whooping cough and the ash of dried leaves is used for scabies.
77.	<i>Nasturtium officinale</i>	Asthma, bronchitis	The chopped leaves are used in the treatment of asthma and bronchitis
78.	<i>Nardostachys grandiflora</i>	Spasmodic disorder	The roots contain essential oil. Roots are considered as tonic, stimulant anti-spasmodic and laxative.
79.	<i>Nicandra physaloides</i>	Gastro-intestinal, lice killer	The plant is diuretic & anthelmintic. The decoction of leaves is used for treatment of lice problem.
80.	<i>Morchella esculenta</i>	Bronchi-muscular problems, Inflammation, Muscle pain Fever,	The plant stalk and cap have aphrodisiac properties and are used as tonic and stimulant. The methanol extract is useful in treatment of pain and inflammation.
81.	<i>Oxalis corniculata</i>	Scurvy, Skin/ Eye disorders, Stomach ache	The leaves are boiled with buttermilk to prepare a decoction that treats stomach disorders. The infusion of the leaves cure scurvy and fever. Drops of juice of leaves cool the eyes and opacity of cornea.
82.	<i>Origanum vulgare</i>	Muscular & Respiratory issues, Toothaches	Externally it is used to treat bronchitis, asthma, arthritis and muscular pain. Essential oil distilled from the flowering plant cures toothache.
83.	<i>Pinus roxburghii</i>	Skin/ Bone issues, Kidney-Bladder disorders	The green needles and extracted sap are used to increase flow of urine. Leaves boiled in water cure skin problems.
84.	<i>Paris polyphyla</i>	Abscess, Appendicitis, Cuts/wounds, Dysentery	The roots of the plant have antibacterial action against dysentery. A paste of the roots is used to treat cuts and wounds. The juice of the roots is anthelmintic and analgesic.
85.	<i>Phytolacca acinosa</i>	Odema, Urinary disorders	A decoction of the root juice is known to have antifungal, antibacterial, laxative, vermifuge and diuretic properties.
86.	<i>Picorhiza kurrooa</i>	Fever & Joint pain	The fresh, as well as, dry roots/rhizomes are ground with water to prepare paste to cure joint pain and fever.
87.	<i>Plantago major</i>	Diarrhea, Dysentery, Indigestion	The plant seeds are useful in diarrhea, dysentery and indigestion. The root and seed extract is antibacterial, anti-inflammation, antiviral.
88.	<i>Plantago depressa</i>	Cough, Asthma, Pulmonary issues.	The leaves and roots are used to treat cough, asthma and pulmonary diseases.
89.	<i>Pistacia integerrima</i>	Cough, Dysentery, Liver disorders, Snake bite	The plant parts have been utilized for treatment of cough, dysentery, liver disorders and snake bite.
90.	<i>Polygonum plebeium</i>	Dysentery	The plant is crushed and eaten for dysentery.
91.	<i>Polygonum amplexicaulis</i>	Eyes-wounds	Root sap is extracted and applied to cure fresh wound in the eyes.
92.	<i>Prunella vulgaris</i>	Sore throat, Internal bleeding, Burns/Mouth ulcers	A decoction of the leaves is used to treat mouth ulcers, sores and bruises, also for anti-inflammatory and anti-allergic effect.
93.	<i>Princepia utilis</i>	Antidote for poison	Root paste obtained after heating it at low temperature in an earthen pot is applied to head to treat poisoning.
94.	<i>Punica granatum</i>	Anemia, Jaundice, Appetizer, Weakness	The seed juice of this plant is highly nutritious and is taken to treat jaundice and anemia. The seeds are eaten in general weakness also. The juice acts as a cooling agent and as an appetizer.
95.	<i>Populus ciliata</i>	Blood purifier, Inflammations, Menstrual cramps	The bark is used as a blood purifier and tonic stimulant. It is effective as anti-inflammatory, febrifuge and is used to relieve menstrual cramps.
96.	<i>Prunus armeniaca</i>	Constipation, Indigestion, Poisoning, Inflammation	The inner bark and roots are used to treat poisoning. The decoction made from the plant is used to cure constipation and inflammation. The seeds are anthelmintic, demulcent, sedative and vulnerary.
97.	<i>Ranunculus arvensis</i>	Rheumatic, Sores Muscular pain.	The whole plant is analgesic and rubefacient. The leaves are chewed to relieve pain from sores, muscular aches, and rheumatic pain.
98.	<i>Rhododendron anthopogon</i>	General weakness, Fever, Appetite Lung disorders, Digestive & Skin issues	The stems and leaves of the shrub are used for digestive problems, skin disorder, cough and lack of appetite. They are used as febrifuge and tonic to treat inflammation, lung disorders and general weakness.
99.	<i>Ricinus communis</i>	Constipation, Scorpion sting, Inflammation	The plant is diuretic, larvicidal, anti-cholestatic and anti-amoebic. Seed is hepato-protective and antidote for scorpion sting. Root juice is analgesic and seed is used to cure constipation.
100.	<i>Rheum australe</i>	Stomach ache, Cuts/Wounds, Muscular swelling	The plant parts are crushed to make a poultice of cotton cloth. The same is then applied to affected parts for healing. The roots are used in stomach ache, wounds, cuts, and muscular swelling.

Sr. No.	Name	Ailment/Disease Treated	Mode of Application
101.	<i>Rumex nepalensis</i>	Cuts, Wounds, Sores, Joint pains, Muscle relaxant	Root extract is applied in joint pain, wounds, and sores. Methanol extract significantly possesses the hypotensive effect and shows the property of muscle relaxant/tranquilizer.
102.	<i>Salvia nubicola</i>	Skin disorders	A decoction of leaves and flowers yields an essential oil useful for skin disorders.
103.	<i>Sarcococca saligna</i>	Cardio-vascular diseases, Muscle relaxant	The aqueous-methanol properties of the roots are used for cardio-suppressant, vasodilator and relaxant activities.
104.	<i>Skimmia laureola</i>	Diarrhea, Smallpox	Leaves are used in the treatment of smallpox and diarrhea. The smoke produced by burning them is said to purify the air.
105.	<i>Saussurea lappa</i>	Asthma, Joints, Stomach ache	Root extract is used to heal wounds, asthma, joint pains, stomach ache and dysentery.
106.	<i>Swertia chirata</i>	Fever, Malaria, Diarrhea, Intestinal worms	A tonic is prepared from this plant to improve general weakness during convalescence. The infusion of the herb is mixed with cloves and cinnamon to treat intestinal worms. The root part is mixed with honey in cases of vomiting, fever, malaria & diarrhea.
107.	<i>Selinum tenuifolium</i>	Skin ailments, Swelling	Drops of filtered concoction are given to children against skin infection. Root is powdered and mixed with mustard oil to cure swelling.
108.	<i>Salix acutofloia</i>	Pain, Fever, Bloating	The fresh bark contains salicin which is used as anodyne, febrifuge and cures bloating.
109.	<i>Saussurea gossypiphora</i>	Cuts & wounds	Parts of this herb (leaves, roots, stem) are used as application on cuts and bleeding.
110.	<i>Saussurea obvallata</i>	Cough & Cold, Urinary tract, Body ache	The flowers, rhizomes and leaves are used to treat cough, urinary infections and body ache.
111.	<i>Selinum vaginatum</i>	Epilepsy, Hysteria, Convulsions	The roots and rhizome parts of the plant are used to treat convulsions, epilepsy and hysteria.
112.	<i>Thymus serphyllum</i>	Skin diseases, Whooping cough, Intestinal ulcers	Pure extract obtained from the herb is used in combination with vinegar and honey to treat whooping cough, intestinal ulcer. Paste of leaves is applied to cure skin diseases.
113.	<i>Taraxacum officinale</i>	Blood purifier, Kidney, Liver/bladder issues, Boils & Sprains, Swelling	Leaves are diuretic. The roots are used as a blood-purifier and for kidney, liver & bladder ailments. It also acts as laxative and improves appetite and digestion. The leaves are used to cure swelling, boils and sprains.
114.	<i>Tanacetum longifolium</i>	Skin ailments	The plant has anti-fungal properties that cure skin ailments
115.	<i>Thalictrum foliolosum</i>	Stomach ache Gastric problems	The dried root powder mixed with thymus linearis is used to cure stomach ache and gastric troubles.
116.	<i>Urtica dioica</i>	Sprains, Fractures, Blood pressure Gastric problems	The stem has healing properties for sprains fractures. The root juice is given for gastric problems and blood pressure. The aqueous extract is antioxidant, analgesic, anti viral, diuretic with hypotensive properties to cures sprains and fractures.
117.	<i>Valeriana jatamansi</i>	Stomach ache, Menstrual cramps, Insomnia, Headache Nervous tension	The valerian roots and its decoction act as tranquilizer and used for relieving nervous tension, insomnia and headache. It is useful in treating bowel syndrome, stomach and menstrual cramps.
118.	<i>Withania somnifera</i>	Rheumatism, Cough, Dropsy,	The decoction made from extract and leaves also improves fertility among males. Treats cough, dropsy & rheumatism
119.	<i>Xanthium strumarium</i>	Stomach & Ear ache, Inflammation , Dysentery, Skin issues	Plant extract is antitussive, antibacterial, antifungal, antimalarial, hypoglycemic. The fruits are anti-inflammatory. The seed powder is useful in ear-ache, dysentery and skin disease.
120.	<i>Zehneria umbellata</i>	Skin inflammation, Spermatorrhoea.	The root is used in conditions of spermatorrhoea. The paste of leaves is applied for skin inflammation.
121.	<i>Zanthoxylum armatum</i>	Cough & Cold, Tonsillitis.	The bark is removed from the stem. The small piece of bark is chewed for 4-5 minutes to cure cough and tonsillitis.

5.1. Use of Plant Species as Timber, Fodder, Fuel and Other Purposes for Life Sustenance by Local Communities of Parbati Valley

The preferred species used by the local people as timber are *Abies pindrow*, *Aesculus indica*, *Alnus nepalensis*, *Betula utilis*, *Rhododendron arboretum*, *Rhus succedanea*, *R. wallichii*, *Cedrus deodara*, *Celtis australis*, *Cupressus torulosa*, *Fraxinus floribunda*, *Juglans regia*,

Pinus roxburghii, *Quercus dilatata*, *Q. leucotrichophora*, *Q. semecarpifolia*, *Q. semecarpifolia*, *Toona serrata* etc. These are used to make farm implements, kitchen ware, furniture items, wooden handicraft, handlooms etc.

During the survey, it was found that out of total of 414 houses, 307 houses (75%) have used timber as a main component for house building, 17% households used timber/mud blocks and stones and 6% of the houses have been constructed using timber/concrete and steel. Only 2% of the houses were made of concrete (Figure 4 & Figure 5).

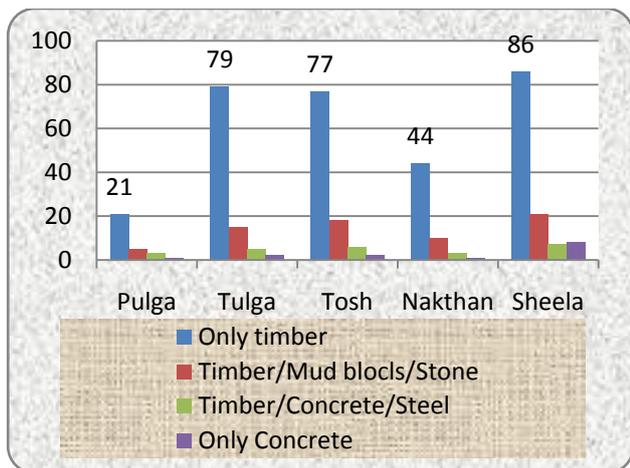


Figure 4. Village-wise status of material used for household construction

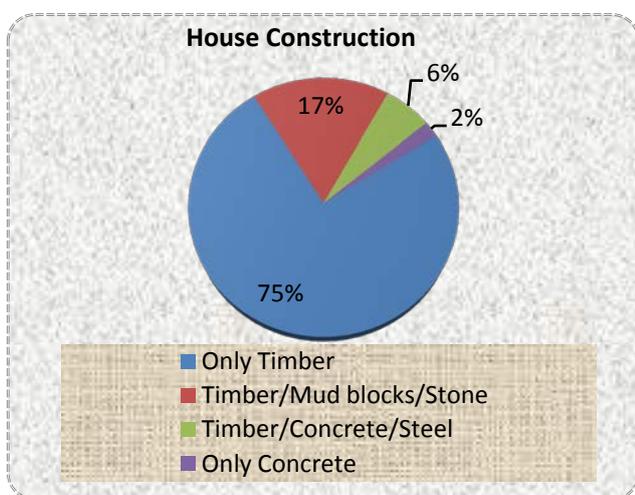


Figure 5. Percentage-wise distribution of construction material used for house construction

The villagers use traditional knowledge to make charcoal from *Trema orientalis* of the *Cannabaceae* family of plants found in the forests. The predominant source of energy for 78% households is charcoal/fuel wood, 12% households rely on solar energy, 7% households are dependent on kerosene and only 3% rely on LPG (Figure 6 and Figure 7).

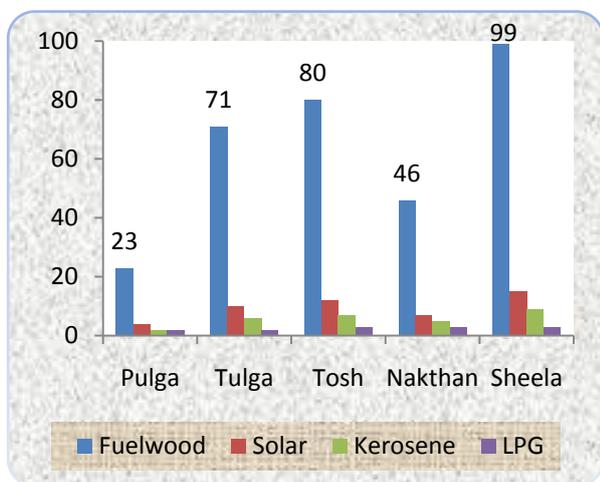


Figure 6. Data on use of energy sources for domestic purposes in sample villages

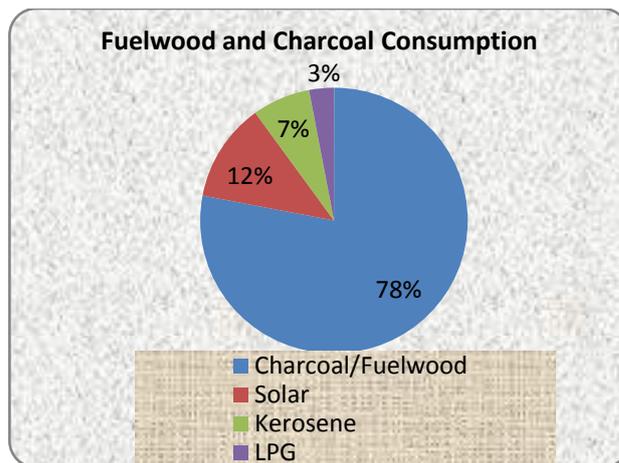


Figure 7. Percentage-wise distribution of energy in sample villages

The most common species of plants used as fodder for livestock is *Aesculus indica* (Khanor), *Acer caesium*, *Kydia calycina*, *Ehretia laevis*, *Bombax ceiba*. The artisans of Kullu Valley are known for handloom products and wood crafts like warm local tweeds, *pattus*, muflars, slippers of grass, straw carpets, mattresses, woollen quilts, hand knitted woolens, baskets called 'Kilta' made from *Thamnocalamus sparsiflorus*, holy rope called 'Band', *Bzetas* (also a type of rope) made from *Giradinia diversiflora*. Fiber extraction from *Populus deltoids* is used to make long threads called 'Niwar'. The study reveals that 26% households are engaged in small scale/medium scale handloom work and wooden handicraft.

6. Impact of Parbati Hydroelectric Project Stage-II on Bio-diversity and lives of Local Communities

6.1. Impact on the Bio-diversity

During construction of Parbati HE project a total of 11281 trees were affected by projects activities in Sainj, Malana and Parbati areas. Out of these, 8124 trees were felled/damaged during Parbati H.E. Project stage-II. The highest number of felled trees/damaged species was for *Populus ciliate* 36% (2927), followed by *Malus pumilus* 31.6% (2564) and *Cedrus deodara* 5.1% (416). The other adversely affected species included, *Abies pindrow*, *Acer cappadocium*, *Aesculus indica*, *Betula alnoids*, *Cornus macrophylla*, *Juglan regia*, *Lonicera angustifolia*, *Lyonia ovalifolia*, *Morus serrata*, *Olea ferrugenea*, *Persea duthiei*, *Picea smithiana*, *Pinus roxburghii*, *Pistacia integerrima*, *Pyrus pashia*, *Quercus floribunda*, *Quercus glauca*, *Quercus leucotrichophora*, *Rhododendron arboretum*, *Rhus cotinus*, *Rhus javanica*, *Robinia pseudoacacia*, *Salix tetrasperma*, *Symplocos chinensis*, *Taxus baccata* and *Ulmus wallichiana* [32].

During the perception survey among 414 households consisting of 1826 people in five sample villages of Tosh, Tulga, Pulga, Sheela and Nakthan, it was found that a number of water sources which formed a network of perennial water source for the local communities, have now dried up. With the diversion of *Nallahs* for the

project the traditional system of wheat grinding locally called, 'Haat Gharat' located near Pulga and Tulga villages have now become dysfunctional. Another region specific edible plant species *Morchella esculenta* (locally called *Gucchi*) has become almost inaccessible. The yield of major seasonal crops like maize, apples, wheat, apricot, plums and khumanis reduced considerably with change in the fertility of the soil.

7. Recommendations

Wild edible plant resources play a crucial role in providing local people with a number of vital nutritional elements such as vitamins, amino acids and minerals that are required to maintain good health and promote immunity against infection under harsh environment conditions [33]. In this context, to minimize the degradation to bio-diversity with the construction of HE projects, it is recommended that Cumulative Assessment Groups drawn from autonomous independent bodies such as Indian Institute of Technology (IIT), Wildlife Institute of India, National Green Tribunal (NGT), Indian Institute of Soil Science should be constituted to ensure proper implementation of Memorandum of Understanding (MOU) governing these projects. At the embryo stage, focus groups drawn from local communities should be formed and their views must be embedded in the project document. The degraded sites of the H.E. Projects areas should be rejuvenated through plantation of tussock-forming grasses initially and later on through plantation of seedlings and plantlets of species. Bio-diversity Management Committees (BMCs) at local level should be formed. People's Bio-diversity Registers (PBRs) at village level, Panchayat level, and Block level should be prepared in the surrounding areas of the project.

8. Conclusion

In many countries of the world particularly in Asia, Central/South America and Africa, efforts have been made to replace traditional biomass energy with hydro potential for the socio-economic development of the people. In our country, Himachal Pradesh has hydro-power potential of 23000 MW which is about 15.83 per cent of our nation's total hydro-power potential. However the construction of hydro-power projects cause serious degradation to the bio-diversity and ecological balance of the region due to construction related activities. The traditional knowledge of the local communities about ethno-botanical resources and their use for life sustenance is under threat. It is imperative that degradation to the plant resources during the construction of hydro-electric projects is minimized and the affected zones are rejuvenated to safeguard the interests of local communities.

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