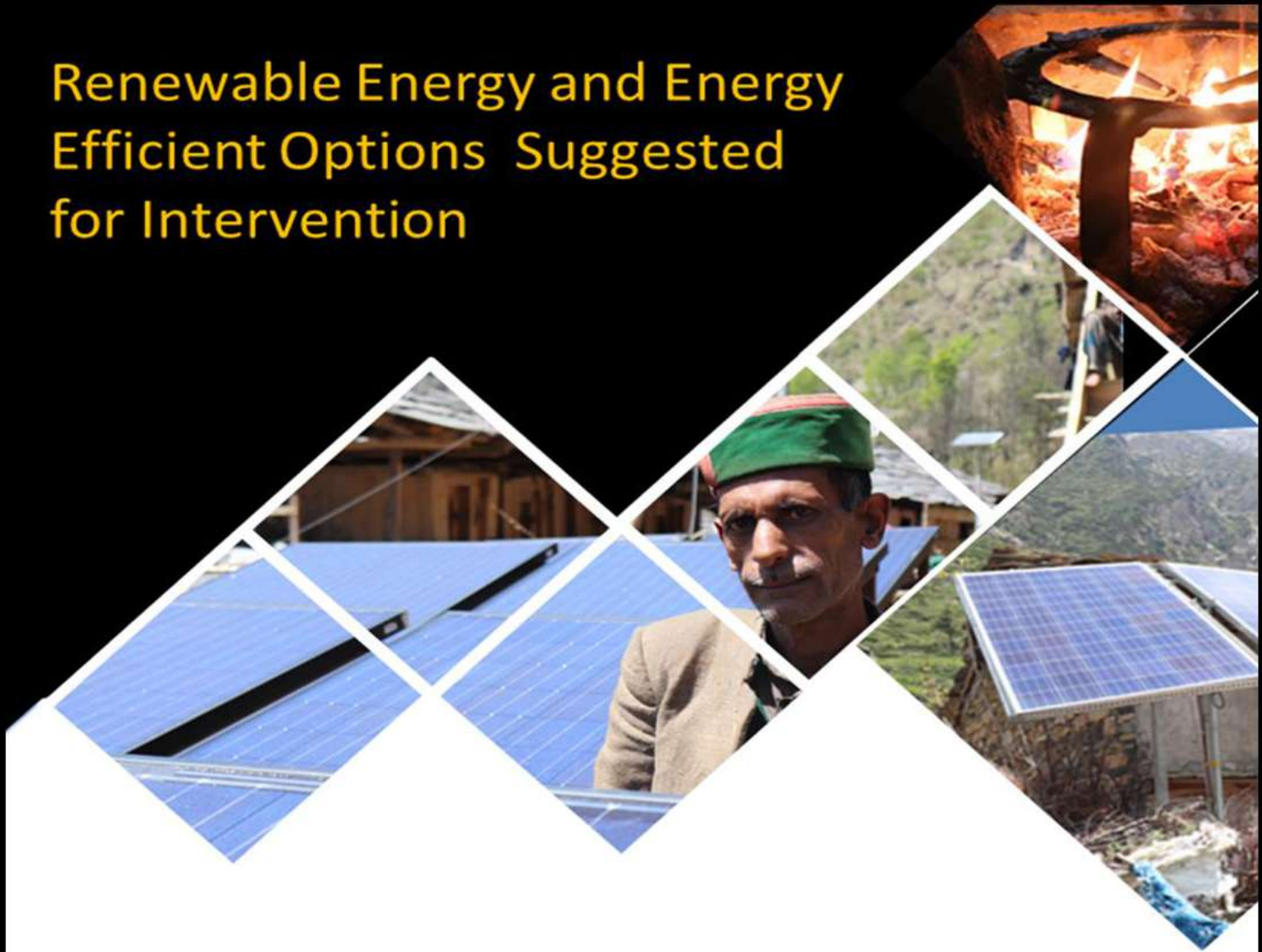


Identification and support the demonstration and implementation of climate smart and energy efficient solutions to reduce stress on natural ecosystems in selected project landscapes of SECURE Himalaya project in Uttarakhand

Renewable Energy and Energy Efficient Options Suggested for Intervention



MARCH 2020

SECURE HIMALAYA- UTTARAKHAND
Report by- Emergent Ventures India Pvt Ltd
(Gurgaon)

MARCH 2020

Identification and support the demonstration and implementation of climate smart and energy efficient solutions to reduce stress on natural ecosystems in selected project landscapes of SECURE Himalaya project in Uttarakhand

MARCH, 2020

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ABBREVIATIONS

EE	Energy efficiency
FGD	Focused group discussions
GCF	Global Environment Facility
km	kilometer
KMVN	Kumaon Mandal Vikas Nigam
kW	Kilo watt
LED	light Emitting Diode
LPG	Liquid Petroleum Gas
m	Meter
MoEFCC	Ministry of Environment, Forest and Climate Change
NH	National Highway
NTPC	National Thermal Power Corporation
pa	per annum
PDS	Public Distribution System
PV	Photo voltaic
RE	renewable energy
SHS	Solar home systems
SSHS	Shared solar home systems
UNDP	United Nations Development Program
UPCL	Uttarakhand Power Corporation Limited
UREDA	Uttarakhand Renewable Energy Development Authority



1. The Study

The Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India along with United Nations Development Program (UNDP) is implementing the project 'SECURE Himalaya¹'- funded by Global Environment Facility (GEF)- in the Himalayan states of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, and Sikkim.

The project is being implemented over six years in the high altitude trans-Himalayan region and aims for:

1. Improved management of high range Himalayan landscapes for the conservation of Snow Leopard and other endangered species and their habitats and sustaining ecosystem services.
2. Improved and diversified livelihood strategies and improved capacities of community and government institutions for sustainable natural resource management and conservation.
3. Enhanced enforcement, monitoring, and cooperation to reduce wildlife crime and related threats.
4. Effective knowledge management and information systems established for the promotion of sustainable management practices in the High Range Himalayan ecosystems.

Objectives

1. Identify, demonstrate and implement climate smart and energy efficient interventions in selected villages of project landscapes.
2. Quantify energy use, green-house gas generation pre and post interventions of alternative options such as clean energy solutions in selected villages.
3. Estimation and quantification of the pressure on natural resources in the pre-project scenario and quantification of the reduced pressure on natural resources in the post-project scenario. Build the

¹ SECURE Himalaya is : Securing livelihoods, conservation, sustainable use and restoration of high range Himalayan ecosystems)"

capacities of a range of stakeholders (local communities, vendors and field staff) for the sustainability of the initiatives.

Approach

Data from 20 villages has been collected through a primary survey exercise and is supplemented, wherever required, with information from secondary sources to develop the energy and emission baseline for the selected villages.

Data was collected through the (i) household surveys, (ii) enterprise surveys, and (iii) Village level focused group discussion (FGDs) in all the three landscapes.

1. Household surveys: 10% of the households have been surveyed, for villages where household number is less than 150. At least 15 households have been selected for the study.
2. The households have been selected by applying the transit approach and depending on the number of families in the village. For villages with hamlets, the spread of households across hamlets has been considered and transit-based (household) selection approach has been applied for each of the hamlets.
3. Enterprises: Enterprises existing in villages were also surveyed. It has been ensured that all types of enterprises get covered in the study.
4. FGDs: At least one focused group discussion (FGD) per village was carried out.

Village selection

The baseline study was carried out in 20 villages (of the 30 project villages) in the Govind, Gangotri and Darma landscapes. The villages were selected based on the following criteria:

1. Very small villages were excluded from the sample.
2. Inputs from the forest department, local UNDP project team were considered, ensuring that the selection represents the natural-economic and cultural diversity of the region.
3. Using spatial tools, villages close to forests were identified and captured in the sample,
4. Wherever possible, the sample was expanded (biased) to capturing renewable energy (RE) interventions in the region, hence villages with active RE projects were included in the sample.

A total of 20 villages from the three landscapes were selected for the study (Table 1).

Village selection: The baseline energy surveys were carried out in 20 villages of the 30 project villages (Table 1).

Table 1: List of project villages of Uttarakhand in three landscapes

SL	Landscape	District	Project villages	Surveyed villages
1.	Govind National Park/Sanctuary	Uttarkashi	Osla, Sor, Pujeli, Dhatmir, Satta, Gangar, Pawani, Khanyiasany, Doni, Lewari	Osla, Sor, Dhatmir, Gangar, Pawani, Khanyaisany, and Lewari
2.	Gangotri landscape	Uttarkashi	Dharali, Harshil, Mukhwa, Sukki, Bhukki, Tihar, Purali, Hurri, Bagori, Jaspur, Bhngeli, Jhala, Salang, Barsu	Dharali, Mukhwa, Sukki, Bhukki, Tihar, Purali, Hurri, Bagori, and Salang
3.	Darma landscape	Pithoragarh	Dugtu, Bon, Seepu, Marcha, Tedang, Dangtu	Dugtu, Bon, Seepu, and Marcha

Data collection process

Structured questionnaires were developed for collecting information on households and enterprises. For focused group discussions (FGDs) a check-list was developed and the village level discussions were carried out to collect information as required to meet the baseline data collection objectives.



2. Geographic scope and landscape brief

The studied landscapes under the "Secure Himalaya Project" of the Government of India and UNDP for "Energy use and Efficiency" are part of the Great Himalayas of Uttarakhand State. In Uttarakhand, the project villages are spread in three landscapes, (i) The Govind National Park/ Wildlife Sanctuary, (ii) Gangotri region (both in Garhwal region), and (iii) Darma landscape in the Pithoragarh district of Kumaun division.

2.1 Govind Landscape (Govind National Park/Sanctuary) - A Brief

Govind National Park and Wildlife Sanctuary was established in 1955 as a wildlife sanctuary in the Uttarkashi district of Garhwal region, subsequently, a section of the Sanctuary was converted into the National Park. The Govind National Park is spread over 472 sq. km with altitude ranging from 1400 m to 6300 m above mean sea level.

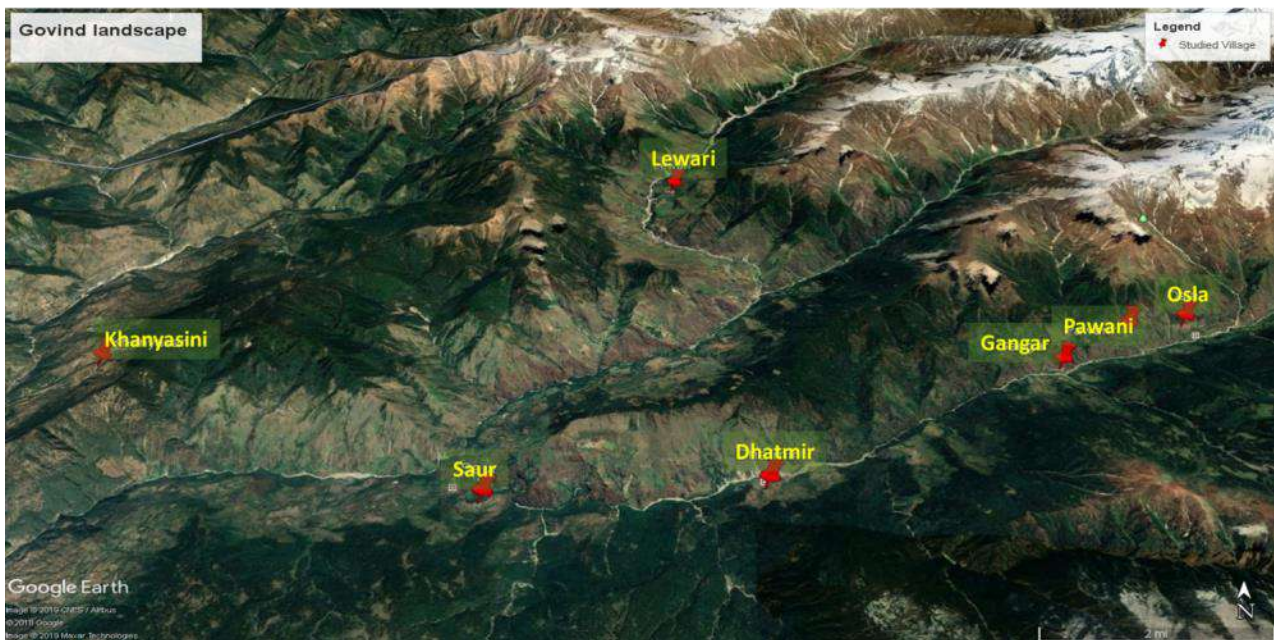
The project covers 10 villages in the landscape, for the sample survey, the consultant identified seven villages in consultation with the Forest Department. Spread in Rupin, Supin and Sankari ranges of the national park, the select villages are a good representation of the human settlements in the landscape. Figure 1 displays the geographic spread of the villages selected for the baseline study.

Farming and animal husbandry are the main occupations of the villagers- cultivating mainly Kidney Bean (Rajma), Amaranthus and potato; however, some families are involved in weaving and wool carding. The majority of the villagers residing in Govind National Park own (apple) orchards in Sankari, some households in Khanyaisani too have apple orchards. Natwari is the nearest main market where they sell their agro produce, particularly, kidney beans and potato to local traders. Apple is largely sold directly to the traders. Tourism is an additional income source for few households in the Govind National Park area. In particular, family youths are involved in the tourism sector- engaged as a guide, porter, etc. There are some homestays in village Sor, Gangar and Osla that are operated by local villagers. Campers often put-up their tents close to these villages.

Villages inside the Govind National Park and Sanctuary lack even basic services like health, transportation, communication, banking, etc. Mules or horses are used extensively to support life in the villages inside the sanctuary. Each village has a primary school, some have post office outlets (the consultant didn't find any functional hospital in the sample villages). Villages have ANM and child welfare personnel. The nearest main market is Natwari which is 35 km from last village Osla.

Figure 1: Spatial distribution of sample villages in the Govind Landscape

Govind landscape



Villages in Sankri range

Villages in the Sankari forest range fall under the Govind National Park and all the studied villages are located on the famous Har-Ki-Dun trekking route. Motorable road is up to village Taluka which is also the nearest market for the villages in the range; the distance from Taluka to the last village of the range (village Osla) is about 15 km.

Sor is the only village in the range that is connected through all-weather road. A road between Sor and Taluka (a distance of 8 km) is under construction and at the time of this study (June 2019) was accessible using all-terrain vehicles. Dhatmir, Pawani and Osla are beyond village Taluka. All the villages are located along the trail (approx. 1-2 km from the trail) that starts from Taluka and leads to Har-ki-dun- the farthest village being 15 km from Taluka.

Villages in Rupen and Supin forest ranges

The villages in the Rupen and Supen ranges are marginally better connected. Village Lewari and Khanyasany are part of Govind Wildlife Sanctuary located in Supin and Rupin forest Range, respectively. Khanyasany is connected with unmetalled road, whereas, to reach village Lewari, Fetaari is the nearest road-head, from where the village is connected through a trail of about 5 km.

2.2 Gangotri Landscape- A brief

Gangotri landscape is in Bhatwari development block of Uttarkashi. The villages of the landscape are located on either side of the river Bhagirathi. The region carries high religious significance for it finds mention in the Hindu mythologies and the famous Gangotri temple and Gomukh (origin of river Bhagirathi) are in this landscape. Figure 2 displays the geographic spread of the villages selected for the baseline study.

The road connectivity in this landscape is better compared to Darma and Govind landscapes and all-weather roads exist till Gangotri. The last village of the landscape- Dharali- is about 70 km from the district headquarter (Uttarkashi).

The road network to the villages is expanding, and most of the villages are 2-10 km from the roadside and in few cases, the approach to the villages is through a treacherous trek.

Figure 2: Spatial distribution of sample villages in the Gangotri Landscape

Gangotri Landscape



The villages in the landscape have different socio-economic characteristics, few factors that define the village include the distance from the road, climatic conditions, etc.

The roadside villages benefit from the tourist movement, also such villages have better access to energy services, which is not the case for far-off villages, Dharali, for this reason, has evolved as the hub of religious and adventure tourism in the landscape for it is the last village en-route to Gangotri (and high latitude passes). The heavy flow of religious tourists in the region has also benefitted other smaller roadside villages (Sukki and Hurri are such examples). Villages that are far from the main road have not directly benefited from the tourism in the region include Purali, Bhukki, Salang, Tihar, etc.

Dharali has numerous hotels, lodges, restaurants, shops, etc. making it centre of economic activities for the nearby villages. Further, the villages closer to the Gangotri enjoy favourable climate for growing apple and other quick-cash fruits (cherries, peach, etc.). Makhwa is only 2 km from Dharali and it is located on the hill opposite of the town across the river Bhagirathi. Village Makhwa has significance for the pilgrims as in this village Goddess Ganga stays during the winter months (November to April), most of the households in the village derive income from religious activities.

Bagori is a unique village in the landscape, it is home to the Bhutiya community. The Bhutiya inhabitants were relocated in the location post 1962 India-China conflict, the villagers don't own much land and are dependent on cattle rearing, weaving and knitting for income generation.

Seasonal migration is common in villages close to Gangotri- villagers of Makhwa, Dharali, and Bagori seasonally migrate to Uttarkashi and Dunda in October and stay there till April.

Agriculture is the main occupation of the villages located in the Gangotri landscape. Potato, kidney beans, Amaranthus and vegetables are the main crops of the region. In Dharali, apple is the main crop and each family owns apple orchards. Villagers of Dharali, Sukki, and Hurri are also involved in tourism activities and some of the villagers run hotels, restaurants, and homestays. Villagers of Makhwa are the priests as well as own shops in Gangotri Shrine. Some of the villagers are also employed in the service sector or work for the government.

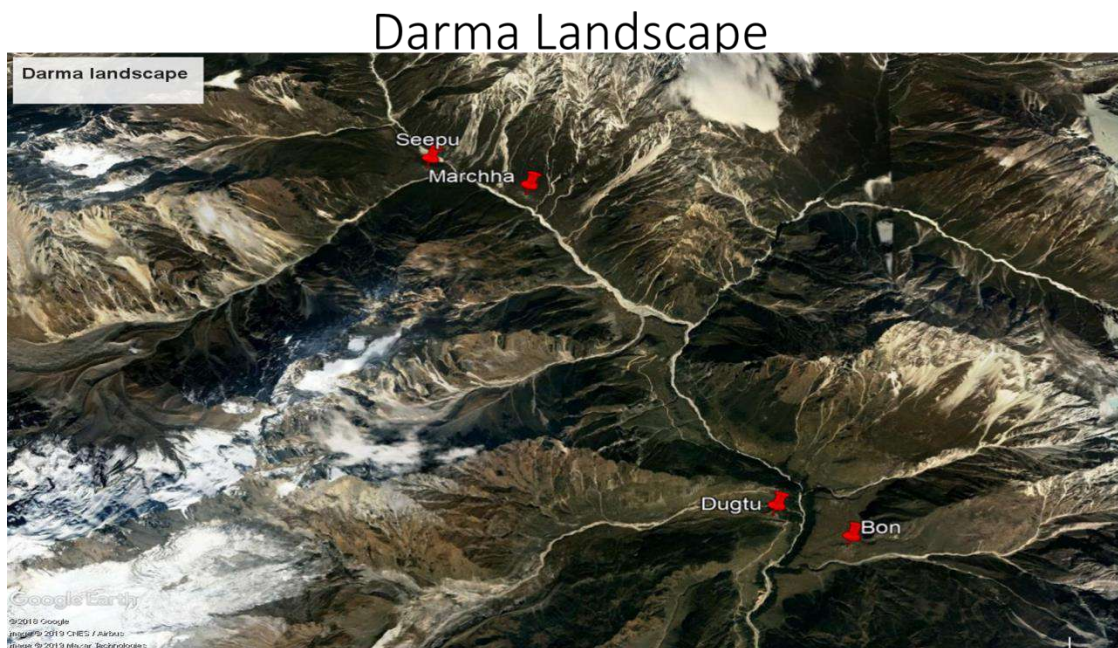
Very few basic amenities exist in the villages (some villages have a primary school, small post office, etc.). The nearest market for the villages in the landscape is Bhatwari, this town is about 35 km from the last village in the landscape, block level offices and health service centres are located in this town. This town is regularly visited by the villages in the landscape to avail banking services, general shopping, and energy services (electricity department office and LPG service provider (viz. Bharat gas) are located in this town).

2.3 Darma Landscape- A brief

Higher Himalayan region of Dharchula has three inhabited valleys (viz. Darma, Vyas, and Chauda), and each valley has 14 villages. As of June 2019, Darma is the most well connected valley among the three and various trekking routes pass through the valley. For the project baseline assessment, four villages in the Darma valley were selected- Bon, Dugtu, Marcha, and Seepu. Figure 3 displays the geographic spread of the villages selected for the baseline study.

The valley has recently been connected to block- headquarter at Dharchula. The newly constructed road (from Dharchula to the valley) is largely unmetalled and under construction as of June 2019. The road passes through Dugtu and Dantu and the last village on the road is Tedang. The other villages in the valley are 3-9 km from the road and can be only reached on-foot through trails (of the samples villages only Dugtu is situated on the roadside, village Bon is 3 km from the road, Marcha and Seepu are 3 km and 6 km from Tedang (the road is only upto Tedang).

Figure 3: Spatial distribution of sample villages in the Darma Landscape



Seasonal migration is common in all the Darma villages. Family elders stay in these villages from late April till early November. Other family members visit here for a short period which is usually for a month for festivities. During winters, villagers migrate to warmer locations (mainly to Dharchula, Nai Basti, etc.).

The valley is dominated by the Bhutiya community. The main occupation of the villagers (during their stay in the valley) is agriculture and the main crops they grow are kidney beans, potato, Amaranthus, etc. Employment with government agencies is the main source of income for the households in the region, and households are also involved in trading of wool and woolen items, medicinal and aromatic plants, etc. Tourism is also one of the income options that exist in the valley- few households in Dangtu, Dugtu, Seepu and Nilang are involved in trekking and tourism related activities.



3. Energy Baseline Findings

3.1 Landscape 1: Govind National Park/Sanctuary - General understanding of the energy baseline of the region

Govind National Park/Sanctuary is located in the Mori development block of the Uttarkashi district. The seven villages that were selected in the landscape for baseline survey are representative of the diverse economic-cultural setting. The villages were selected from the ones (i) inside the Govind National Park, from (ii) villages within the Govind Wildlife Sanctuary, and (iii) outside the park/ Sanctuary area.

Table 2: Villages selected in the Govind landscape for baseline study

Sl.	Village location with respect to National Park/ Sanctuary	Village name
1.	Villages inside the Govind National Park	Osla, Pawani, Gangar and Dhatmir/Taluka
2.	Villages inside the Govind Wildlife Sanctuary	Lewari and Khanyasani
3.	Village is located outside the National Park/ Sanctuary area	Saur

The villages that were studied differ in terms of access to road and provisioning of modern energy services, micro-climatic conditions, economic and livelihood activities, natural resources availability, natural resource dependency, etc.

Villages located inside Govind National Park are not connected by any road. The all-weather road is only upto Saur, beyond it lies Taluka (about 8 km from Saur) and connected through a kutcha road that can only be negotiated using all-terrain vehicle. Osla- the last village is further 14 km from Taluka approachable only through a treacherous mountainous trail. The villages Dhatmir, Pawani and Gangar are on either side of the trail connecting Taluka and Osla. Dhatmir and Taluka are twin-villages with families migrating between the two twice a year.

Similar to the Govind National Park, villages located in the Wildlife Sanctuary area are also remotely located. The villages in the sanctuary area are better connected in compared to the ones in Govind National Park. Village Khanyasani is connected with unmetalled road and local taxis are available for villagers to commute. Liwari is one of the far-flung villages of the Wildlife Sanctuary and located approximately 5 km from the nearest road-head Ferrari.

The following tables depict the survey respondents from each village. In the landscape 108 individual households (randomly selected), 24 enterprises and business were approached with the questionnaires and 7 FGDs was carried out to collect the required data/information for the energy baseline (village wise distribution provided in Table 3).

Table 3: Govind landscape- Survey sample

SL	Village name	Households surveyed	Enterprises covered	Focused group discussions
1.	Osla	15	5	1
2.	Pawani	15	0	1
3.	Gangad	15	10	1
4.	Dhatmir/Taluka	18	4	1
5.	Lewari	15	0	1
6.	Khanyasani	15	3	1
7.	Saur	15	2	1
	TOTAL	108	24	7

The salient features of the survey are summarized in Table 4 and are described in the subsequent report sections.

Table 4: Govind landscape- Snapshot of survey findings

SL	Village name	Sample	Cooking fuel (prevalent option)	Cooking fuel (fall back option)	Electricity options – Grid	Electricity options- off grid	Lighting sources
1.	Osla	15	Fuelwood (100%)	LPG (20%)	0%	93%	
2.	Pawani	15	Fuelwood (100%)	-	0%	100%	100%
3.	Gangad	15	Fuelwood (100%)	-	0%	26%	73%
4.	Dhatmir/Taluka	18	Fuelwood (100%)	LPG (28%)	0%	33% (no supply)	44%
5.	Lewari	15	Fuelwood (100%)	LPG (13%)	100%	-	75%
6.	Khanyasani	15	Fuelwood (100%)	LPG (7%)	100%	-	60%
7.	Saur	15	Fuelwood	LPG (47%)	100%	-	53%

SL	Village name	Sample	Cooking fuel (prevalent option)	Cooking fuel (fall back option)	Electricity options – Grid	Electricity options- off grid	Lighting sources
			(80%), LPG (20%)				

The survey findings are summarized in the following section.

The villagers inside the Govind National Park region are dependent on three major energy sources for cooking and heating.

- Firewood
- Liquefied petroleum gas

Energy for cooking in the landscape:

a. Firewood use in the landscape

Firewood is the most preferred fuel for cooking; it is also used for boiling water and heating in the winter period. Overall high dependency of the households in the Park region exits on firewood for cooking, only few families are dependent on other fuel types, particularly in Saur (where LPG users are high compared to other villages).

Out of the total surveyed households , 100% percentage households prefer firewood over other options. It's only in village Saur that 20% of the surveyed households preferred LPG for cooking. LPG is second preferred option for cooking for 17 % of the households.

For heating purpose firewood is the only reliable options for the residents, 100% of the households rely upon firewood for heating (Use of electricity is another option for keeping housesolds warm, and about 3% of the households use electric heater as secondary option).

b. Sources of firewood

Firewood is the most common option for cooking and heating for the villagers residing in the Govind National Park region. The villagers collect wood from their fields, from Van Panchayats, civil soyam and also from reserve forest area. The wood collection peaks during October to November, as the villagers prepare for the winter season.

c. Cooking/ heating energy transition trends

During last ten years, energy transition has been observed in the landscape. Kerosene stoves were common across landscape, but since kerosene supplies have been discontinued (for non-availability of kerosene in open market or in public distribution shops (PDS)) LPG has emerged as an alternate fuel. The use of LPG has gone up in the region, but dependency of households on LPG is insignificant.

Inside the park, some families have LPG connections but most of them have shifted their stoves to their families outside the landscape and others use it very sparingly.

d. LPG use

20% of the households studied in the landscape use LPG in their households. The dependency on LPG is highest in Village Saur (this village being on road side is an outlier in terms of LPG penetration). Of the total respondents with LPG connection, approximately 50% were from this village. Other villages had LPG connectiones varying between 1-5 and two villages had zero connections. Of all the LPG users, only 3 households were using LPG as primary cooking option.

Sources for lighting (Electricity and other options)

Since the power situation varies in villages inside and outside the park boundary, hence the analysis is carried out separately for both sets of villages.

a. Lighting options for villages inside the Govind National Park

The villagers inside the Govind National Park region are dependent on three major lighting sources:

- Micro-hydro plants (designed to supply power to four villages)
- Solar PV plants (two such plants operate inside the park boundary)
- Solar home systems
- Other (candles, chir sticks, etc.)

The summary of the lighting option is depicted in Table 5 and description provided in section below.

Table 5: Govind landscape- Lighting sources and dependency

SL	Village name	Primary Lighting Option			Secondary Lighting option		
		Grid	Off-grid (hydro)	SHS	Grid	Off-grid (hydro)	SHS
1.	Osla	-	40%	7%	-	53%	53%
2.	Pawani	-	-	-	-	50%	50%
3.	Gangad	-	20%	40%	-	27%	7%
4.	Dhatmir/Taluka	-	-	100%	-	-	-
5.	Lewari	100%	-	-	-	-	60%
6.	Khanyasani	100%	-	-	-	-	33%
7.	Saur	93%	-	7%	-	-	-

The off-grid electricity generation systems support the power supplies in four of the landscape villages. Dhatmir (Taluka) too was serviced through the micro-hydro system but the plant was not functional at the time of baseline survey.

Table 6: Govind landscape- Off-grid lighting sources and dependency (Source: FGD data)

	Off-grid system	Village name			
		Osla	Pawani	Gangar	Lewari
1.	Micro-hydro	80% of the households	36 households	30 households	-
2.	Solar PV system	14 households	-	30 households	42 households

Micro-hydro for electricity: Inside the Govind National Park region, households are connected with off-grid electricity connection, whereas, Saur is electrified by the grid line.

The electricity demand is gradually increasing after the newly built micro-hydro plants in the tributary of river Supin became operational. Established by UREDA the two plants were designed to provide power to four villages inside the Govind National Park. Electrification of the villages started in 2018, and most of the connections were only 2 to 6 months old in when the study was conducted. Meter is installed in all the houses connected with the micro hydroelectricity; however, each household was paying only 100 rupees/month to the watchman cum operator of the micro-hydro system.

At the time of survey (May 2019), a 20 kW run of the stream micro hydro plant in Osla was supplying electricity to three villages- Osla, Pawani and Gangar (power supply hours were between 5 pm to 7 am).

The electricity is used mainly for lighting (other uses include running TVs and phone charging). The other plant (again of 20 kW) built for Dhatmir is not functional, this plant was servicing Taluka and Dhatmir but due to technical snag, is no longer in operation.

Solar PV plant: Osla, Pawani, and Gangar have also solar PV plants that are operated privately and provide electricity for lighting to households. The Osla plant is a 10 kW system that is designed to provide electricity to ~ 15 households (at the time of village survey, the system was not functional). The Pawani plant is source of electricity for 14 households. The plant in Gangad is a 10 kW systems and provides power to 30 households.

Solar Home Systems: Despite all developments, 19% of the sampled households have no proper lighting and use solar lanterns, chir-pine sticks, candles, etc. for lighting their homes. Across the landscape, 15% of the households are dependent on SHS for lighting. Some villages are highly dependent on such system, viz. Liwari, Dhatmir (Taluka) etc. Most of these households exist inside the Govind National Park, also only one non-electrified house is found in Saur. In most of the houses, emergency solar lantern and solar light with one bulb is available.

b. Lighting options for villages inside the Govind National Park

Villages outside the National Park boundary, Saur, Lewari and Khanyasani are connected with the electricity grid and the majority of households have electricity connection. The electricity demand is limited to lighting (other appliances not common) as households are wary of electricity charges.

In Lewari some of the families share the electricity connection with neighbours those are generally their siblings, children or parents (in actual earlier they are part of the joint family and has been separated and living in the same campus or building).

Solar PV plant: Village Lewari has a 17.5 kW solar PV plant that is operated privately and provide electricity for lighting to households. The plant is designed to provide electricity to 42 households. Operated privately, the plant is managed by a villager who operates and maintains the system. In addition, he is also responsible for collecting the monthly fee from the users (he doesn't get any salary from the plant owner but gets power for free for his household consumption).

Solar home systems (SHS):

Lewari and Khanyasani both have the solar home system installed in the majority of houses provided by Gram Sabha through UREDA. However, most of these solar systems are defunct and not in use.

Enterprise-level energy use and concerns:

Enterprises in seven villages were surveyed in the Govind National Park and Sanctuary area.

Mostly cottage enterprises exist in the landscape, amongst these wool craft is the most common activity, the majority of the households are involved in different components of this activity, e.g. sheep rearing, carding, spinning, etc. Most of the households also also into weaving (have hand operated small loom installed in their residences).

The use of timber in house construction is common in the landscape, hence every village has atleast one resident carpenter, village Ganga has the highest concentration of carpenters in the region. These carpenters don't use machines and are 100% dependent on hand operated tools.

The landscape is famous for trekking routes and scenec beauty. Tourists/campers visit the Har-Ki-Dun which is located within the National Park area. Villagers operate homestays, work as porters, guides, etc. Also multiple home-stays, and tourism-related activities floursish in Osla, Gangar, Dhatmir, and Saur. Since, energy options are limited, hence enterprises too are dependent on traditional solutions for heating/cooking. Firewood is the main fuel used for cooking in the homestays located inside the Park, however, camping sites use commercial LPG cylinders for cooking (camp operators carry LPG cylinders and use it to serve their guest). But in Saur, LPG is used commonly in homestays.

Saur again is an exception, being well connected has access to electricity and LPG. Some carpenters in Saur use electric tools but their demand for electricity is very low. Further, homestays in Saur too use LPG and electricity for services to their guests.

Majority of enterprises- wool craft and bamboo handicraft- in the landscape don't use any electricity/ diesel operated machine.

3.2 Landscape 2: Gangotri landscape - General understanding of the energy baseline of the region

For the baseline study, nine of the 14 villages were visited and studied. The villages in the Gangotri landscape are located close to the National Highway (NH34). Two types of villages exist in the landscape,

1. Villages located on higher altitude and are closer to the Gangotri Dham, i.e. Dharali, Makhwa and Bagori. The population in these villages is migratory in nature (seasonal migration to warmer places during winter). Villagers from these villages migrate to Uttarkashi or Dunda during the winter season.
2. Villages further away from the the Gangotri Dham with population that is non-migratory. These villages are Puarli, Sukki, Hurri, Bhukki, Salang and Tihar are non-migratory for they are located in relatively warmer locations.

Further, the villages in the landscape can also be classified based on the road connectivity.

Table 7: Villages selected in the Gangotri landscape for baseline study

SL	Road connectivity particulars	Village name
1.	Situated on NH34	Dharali and Sukki
2.	Within 2-3 km from the road	Bhukki, Hurri, Salang, Bagori, Makhwa and Purali
3.	Not connected	Tihar (about 10 km from NH 34)

The following tables depict the survey respondents from each village. In the landscape 130 individual households (randomly selected), 13 enterprises and business were approached with the questionnaires and 8 FGDs was carried out to collect the required data/information for the energy baseline (village wise distribution provided in Table 8).

Table 8: Gangotri landscape- Survey sample

SL	Village name	Households surveyed	Enterprises covered	Focused group discussions
1.	Bagori	15	1	1
2.	Makhwa	15	-	1
3.	Purali	13	-	1
4.	Salang	15	1	1
5.	Hurri	15	2	1
6.	Sukki	15	3	1
7.	Tihar	15	1	1
8.	Dharali	14	4	-
9.	Bhukki	13	1	1
	TOTAL	130	13	8

The altitude, migratory nature of population, proximity to the roads are the factors that influence the energy behaviour of the community in the landscape. These aspects will be analysed in great detail in this report.

The salient features of the survey are summarized in Table 9 and are described in the subsequent report sections.

Table 9: Gangotri landscape- Survey findings snapshot

SL	Village name	Sample	Cooking fuel (prevalent option)	Cooking fuel (fall back option)	Electricity options – Grid	Solar Home systems	Micro solar lamps
1.	Bagori	15	Fuelwood (100%)	LPG (73%)	100%	0%	100%
2.	Makhwa	15	Fuelwood (87%), LPG (13%)	LPG (80%), Fuelwood (7%)	100%	0%	100%
3.	Purali	13	Fuelwood (92%), LPG (8%)	LPG (92%)	92%	0%	100%
4.	Salang	15	Fuelwood (100%)	LPG (100%)	100%	0%	100%
5.	Hurri	15	Fuelwood (100%)	LPG (73%)	87%	0%	62%
6.	Sukki	15	Fuelwood (100%)	LPG (100%)	93%	7%	29%
7.	Tihar	15	Fuelwood (100%)	Fuelwood (74%)	87%	15%	62%
8.	Dharali	14	Fuelwood (93%), LPG (7%)	LPG (7%)	100%	7%	43%
9.	Bhukki	13	Fuelwood (100%)	LPG (100%)	85%	91%	27%

The survey findings are summarized in the following section.

The villagers inside the Gangotri National Park region are dependent on three major energy sources for cooking and heating

- Firewood
- Liquefied petroleum gas

General comment on the energy behaviour of the community:

Firewood is the most preferred cooking fuel option for the community residing in the landscape because of the availability and reliability of the option. LPG use is common among most of the households in the landscape, however, households usually prefer firewood over LPG cylinder for cooking. LPG use is very occasional.

Refilling LPG is the tedious task for the villagers residing in these villages due to the inaccessibility and irregular LPG refilling services. In summer and monsoon season when Yatra season is on, LPG supply is regular and villagers get the refilled LPG in their nearest market. The cost of refilling of the LPG cylinder, hardship, and non-reliability discourage villagers to use LPG stove regularly. Even villages located on the roadside are not 100% dependent on the LPG and rely on firewood. This is due to zero cost and easy availability of firewood.

Although 98% of households predominantly use firewood stove for cooking their meals however the use of LPG has also increased gradually.

Electricity penetration and demand is also high in the landscape. Most of the hotels have electric appliances such as geyser, grinder, and mixture etc., installed in their enterprise. Similar to Dharali, Sukkhi and Hurri (Garam Kund) have also commercial setups such as hotels and restaurants. The demand for energy in these villages is also higher in comparison to other villages of the landscape. The main driver of the energy of commercial enterprises is influenced by the ease of using, regular and reliable supply and availability, however, for the household energy demand.

Cooking fuel

a. Cooking fuel trend

Firewood is the most preferred fuel for cooking, it is also used for boiling water and heating in the winter period. Out of the total surveyed households in the landscape, 95 % of households prefer firewood over other options. Only 2% ranked LPG as the first preference of choice as cooking fuel. However, 86 % preferred LPG as the second option for cooking fuel.

Also, as per the survey findings, a sharp shift towards LPG use is evident (partial use). Till about 10 years back only 25% of families were using LPG stoves in their kitchen, this has now increased to 97% out of which 3% of households are having LPG stove as the sole cooking option.

b. Kitchen type and firewood cookstove design:

Firewood is the main fuel for cooking, and other energy services. Of the surveyed households, 84% have a separate cooking room in their houses. In the villages of Makhwa, Tihar, and Bhukki almost 100% surveyed households had a dedicated kitchen room. In Sukki, households with separate kitchen are the lowest- 40% of households only have a separate kitchen room. Further, in Makhwa and Parali, all the kitchens are inside the house, whereas, in Bagori 73% of households have a kitchen room that is outside the main building.

Fuel consumption across villages varies a lot. Firewood is easily available from the nearby forest and agricultural land. The consumption pattern of firewood in this landscape varies among different villages depending on their duration of stay in the landscape. Villages occupied with the people throughout the year consume more firewood compared to migratory villages as their use of firewood rises during the winter season. Makhwa is an exception as this village is only inhabited during the months of May and June, thus the fuel is required only for a few months. In these migratory villages residents also use LPG stoves.

c. LPG Use:

LPG is the second option for preparing meals however its use is very limited. LPG stoves are available with majority of the families. In Bagori, Hurri, and Bhukki 73% of households have LPG stoves in their kitchen and in the remaining six villages 100% of households have LPG connections. Most of the LPG connections are more than 10 years old, however few new connections under Ujjwala scheme were also recorded.

Despite high LPG penetration, the LPG use is low in the landscape. On average one cylinder lasts about 4 months (116 days). Compared to other villages in the landscape, in Bagori LPG consumption was the highest, i.e. ~60 days, this was followed by Dharali where on an average LPG cylinder lasted for an average of 75 days. In Hurri LPG consumption was the least (average one cylinder lasted 168 days). There were outliers- in Tihar and Makhwa there were few households who were refilling their cylinders once in 12-15 months.

Lighting options for villages inside the Gangotri landscape

The villagers inside the Goangotri landscape are dependent on three major lighting sources:

- Grid electricity
- Solar home systems
- Solar micro lamps and candles etc. (largely back up arrangement)

The summary of the lighting option is depicted in Table 10 and description provided in section below.

Table 10: Govind landscape- Lighting sources and dependency

SL	Village name	Primary Lighting Option			Secondary Lighting option	
		Grid	SHS	Solar lamps	SHS	Solar lamps
1.	Bagori	100%	0%	-	-	100%
2.	Makhwa	100%	0%	-	-	100%
3.	Purali	92%	0%	8%	-	92%
4.	Salang	100%	0%	-	-	100%
5.	Hurri	87%	0%	13%	-	83%
6.	Sukki	93%	7%	-	-	29%
7.	Tihar	87%	-	-	15%	62%
8.	Dharali	100%	-	-	7%	43%
9.	Bhukki	85%	-	-	91%	27%

Grid connectivity is 100% in the landscape, but not all households have access to grid electricity. Based on the survey it's estimated that 94% of families are connected to the gridline and are fully dependent on it. In addition, villagers also use other option for lighting, such as solar lamp, candles, etc.

Of the houses are connected to the grid 7% households share their meter with the siblings living in the same premises. Of all the villages, the least numbers of the houses connected to the electricity grid are in Bhukki (85%) followed by Tihar and Hurri (87%), Parali (93%) and Sukkhi (93%). In the remaining four villages, 100% households are connected to the grid.

Village Tihar faces a peculiar problem, Bighar, a hamlet of Tihar was acquired by NTPC for a hydro-power project, few households migrate to this hamlet for seasonal activities. To solve the lighting issue in this hamlet UPCL has provided solar home systems to the villagers for installation in Bighar. Total 16 such solar PV units are sanctioned for the villagers and presently four such plants has been provided to the families.

Apart from the grid line, villagers also have solar home systems. For emergency situations, villagers also have solar lanterns or micro solar systems. These solar lanterns and solar home systems were distributed by the government and other non-profit agencies during 2013 disaster rehabilitation scheme. The use of SHS is prevalent in the village Bhukki where 77% houses have such systems in their homes. Other than Bhukki, solar home systems are also used in Tihar, Dharali and Sukkhi.

In addition, there are two solar plants (one each in Dharali and Salang), installed under the net-metring scheme, these 20 kW plants are connected to the grid.

Use of LED bulbs is common, of the 121 households, only 38 families had incandescent bulbs installed in their homes.

Summary of enterprise-level energy use

The Gangotri region is an important spiritual and ecological landscape of India. Spiritual tourism is the main source of income in the Gangotri valley. Numerous hotels and restaurants, lodges, homestays are situated en-route to the Gangotri shrine. Out of the surveyed villages, Hurri, Dharali and Sukkhi have the maximum numbers of hotels and restaurants. In addition there are few homestays too that operate in the region.

Flour mills are common across the region (e.g. Village Hurri has three water-operated flour mills and Tihar has two flour mills that run on electricity).

Dharali, Sukkhi, Satta and other villages located on the road-head offer lodging facilities in their respective villages. These villages are home to large numbers of hotels, home stays, restaurants and restaurants, which are generally fully occupied during the Yatra season. For these villages supply of regular and reliable electricity is essential to cater services to their customers. The majority of hotels, restaurants and home-stay have diverse electric appliances such as geyser, TV, etc. and kitchen utilities such as grinder, mixture, juicer, etc. Hence demand for electricity in these villages is much higher in comparison to all the other villages studied in all three landscapes.

For cooking, the commercial setups usually use LPG stoves, few of them also use diesel stoves. The supply of LPG cylinder is regular and timely during the *yatra* season.

Issues faced by enterprises:

The electricity from the grid is mostly regular except during rains and winter. Also, voltage fluctuation is a major problem faced by the enterprises. Many hotels/homestays thus rely upon diesel generators to improve power quality.

3.3 Landscape 3: Darma Landscape- General understanding of the energy baseline of the region

In Darma valley only four villages were surveyed, all the surveyed villages are inhabited for six months only. The residents of Darma valley are migratory, they reside in the valley for about six months starting from April-May and move to warmer places post-Diwali (around October- November). Permanent migration in the valley is very high, thus the energy requirement is much lower than the comparison of other landscapes.

Road accessibility and remoteness

The road to the valley goes up to Tedang village (the last village in the valley, i.e. Seepu, is about 9 km from the road head in Tedang) was only built two years back (in 2017) and is not fully operational. Of all the project villages in the landscape, only Dugtu and Dantu are situated on the roadside, the remaining villages are 3 to 10 km from the nearest road. This road is seasonally functional and only remains open from May to October and is closed during winter due to heavy snowfall. The glacial streams originating from the snow-laden peaks make commuting to the landscape difficult.

Energy baseline survey and findings

The following tables depict the survey respondents from each village. In the landscape 53 individual households (randomly selected), 2 enterprises was approached with the questionnaires and 4 FGDs was carried out to collect the required data/information for the energy baseline (village wise distribution provided in Table 11).

Table 11: Darma landscape- Survey sample

SL	Village name	Households surveyed	Enterprises covered	Focused group discussions
1.	Bon	15	1	1
2.	Dugtu	14		1
3.	Seepu	9		1
4.	Marcha	15		1
	TOTAL	53	1	4

The salient features of the survey are summarized in Table 12 and are described in the subsequent report sections.

Table 12: Darma landscape- Snapshot of survey findings

SL	Village name	Sample	Cooking fuel (prevalent option)	Cooking fuel (fall back option)	Electricity options – Grid	Lighting- Shared SHS
1.	Bon	15	Fuelwood		0%	100%

SL	Village name	Sample	Cooking fuel (prevalent option)	Cooking fuel (fall back option)	Electricity options – Grid	Lighting- Shared SHS
			(100%)			
2.	Dugtu	14	Fuelwood (100%)	LPG (7%)	0%	100%
3.	Seepu	9	Fuelwood (100%)	-	0%	100%
4.	Marcha	15	Fuelwood (100%)		0%	100%

The survey findings are summarized in the following section.

Energy options for cooking in the region

Due to the remoteness, the penetration of modern energy options is limited. Dependency on firewood is high, the villagers collect firewood from adjacent forests to fulfill energy needs for cooking, heating, etc. In particular, Van Panchayats are the main source of the firewood but the majority of the households also source wood from their respective fields. Interestingly, in village Dugtu, households also buy trees from the village forest (trees are auctioned to meet the demand of the households).

Fuel mix for cooking and heating in the region

Firewood is the preferred fuel for cooking and indoor heating, only 2% of the respondents reported LPG as the second choice for cooking fuel (use restricted to the preparation of tea, heating milk, etc.), another 2 % of the respondents reported dung cake as the fall-back cooking fuel.

The cookstoves in Darma landscape are the rudimentary three stone stoves (see picture), but very few households in Seepu and Marcha also use smokeless stove, termed ‘ Bukhari’. These stoves were provided to the villages by the Forest Department. In total about 6 such stoves were operational in the two villages.

The Bukhari users reported a significant drop in the indoor air pollution compared to the traditional three stone stoves. Also it was considered to be safer compared to the old stoves. But no change in the wood demand was observed by the households, in fact the Bukhari users reported higher wood consumption compared to the traditional three-stone stoves.

Features of cooking and heating in the region:

Kitchen and stove features: The kitchen in the household also seconds as the dining and living room. In few a villages, households also have a secondary kitchen outside of the home (in Marcha 33% of the respondents reported a secondary kitchen outside the house).

The cookstoves in Darma landscape are the rudimentary three-stone stoves (see picture), but very few households in Seepu and Marcha also use engineered smokeless stove, termed ‘ Bukhari’. These stoves were provided to the villages by the Forest Department. In total, about 6 such stoves were operational in the two villages.

Cooking fuel: Firewood is the main fuel for cooking, heating and boiling water. Villagers collect firewood from nearby forests or branches of shrubs from their agriculture field to fulfill the requirement. Villagers collect firewood in September and October for the summer months.

Firewood is the preferred fuel for cooking and indoor heating, only

LPG use and penetration: A very few households in the whole landscape have LPG stoves. In the whole valley, only in village Dugtu and Dantu (Dantu not surveyed) LPG stoves were reported (7% of the respondents had LPG stoves). The LPG stove use is restricted to the preparation of tea, heating milk, etc.

LPG penetration is low, the households bring along with them their LPG stoves and cylinders when they move to the valley, carrying only one cylinder, which practically lasts for about 6 months (refilling is not possible).

Lighting options for villages inside the Darma valley

The villagers inside the valley are dependent on three major lighting sources:

- Shared solar home systems
- Micro-solar devices (lamps, torches)
- Candles

The summary of the lighting option is depicted in Table 13 and description provided in section below.

Table 13: Darma landscape- Lighting sources and dependency

SL	Village name	Primary Lighting Option		Secondary Lighting option	
		Grid electricity	Shared solar home systems	Micro-solar devices	Candles
1.	Bon	0%	100%	100%	100%
2.	Dugtu	0%	100%	100%	100%
3.	Seepu	0%	100%	100%	100%
4.	Marcha	0%	100%	100%	100%

Lighting status and options

The landscape has no grid connectivity (in village Dugtu, the electric supply lines have been erected for grid supply (the villagers had no information on when power will come to the village)). Households rely on SHS and other solar-based micro lighting devices.

Lighting options: Shared solar home systems (SSHS) have been installed by the UPCL in the villages (about two years back). Each such installed unit has two solar panels (~ 4 kW system) supplying electricity to four to eight families. Every two-story home has been provided with setup supporting three LED bulbs (of seven watts each), few households have also been provided with charging points (can be used to charge phone batteries). No other electrical appliances were reported by the households in the villages.

For lighting, 100% of households use LED bulbs provided by the implementing agency, each household has an average of 3 LED bulbs in their house. The LED bulbs are specially designed bulbs that are not available in the open market. For the emergency purpose, the villagers also use other options such as kerosene lamp, candles and small solar lighting devices popularly known among them as 'Makari'.

Issues with lighting options:

- Many of these solar systems are partially/ fully damaged for the frame supporting the system collapsed during winter (due to the weight of the accumulated snow). However, most of the inhabited homes have access to lighting from the operational SHS.
- The LED bulbs are specially designed bulbs that are not available in the open market.
- For the emergency purpose, the villagers also use other options such as kerosene lamp, candles and very small solar lamps locally known as 'Makari'.
- All the villagers in the surveyed villages also use candles and other devices such as small solar devices and battery-powered lighting solutions.

Enterprise-level energy use

The Darma valley is inhabited by the Bhotiya community, who are locally known as Darmya or Darmani. Traditionally, the main occupation of the villagers in the region had been trading (bartering of goods), sheep

rearing. Locals now began to give up the traditional way of living and presently the primary occupations of people are government jobs, livestock rearing, trading, and farming.

In the Darma valley, most of the villagers have salaried jobs and private jobs and some of them are in the tourism industry and working as a homestay operator, guide and porter. The famous tourist destinations the Panchachuli base camp is only 2.5 km far from the Dugtu village. 16 households in Dugtu are registered under the homestay schemes, which are still in the development process. The Kumaon Mandal Vikas Nigam (KMVN) has brought several villages of Darma valley under this scheme. The people of the village showed a keen interest in the homestay scheme during the survey. Various kinds of training have been provided in the villages by the tourism department to encourage the local community.



4. Analysis of factors affecting energy choices and fuel transitions

In this section, the energy related data across the landscapes is statistically analysed to test hypotheses to establish cause-effect relationships and check the assumptions linked to the adoption/rejection of energy related interventions.

The different relationships that were tested include:

Table 14: Energy behaviour- cause and effects considered for evaluation

Sl	Cause	Impacts
1.	Household income levels	Across Landscapes, i. Households with higher income and education level should have a higher tendency to switch to a cleaner fuel (LPG use and penetration taken as proxy) ii. Households with higher/ better income will display higher willingness for switching towards cleaner fuels(firewood use taken as proxy)
2.	Proximity to LPG refilling centres	LPG use across Landscapes, iii. Households relatively closer to LPG refilling centers should have a higher tendency to switch towards LPG iv. Households relatively closer to LPG refilling centers should have a higher tendency to consume more LPG
3.	Road proximity	Villagers close to roads should display higher degree of awareness (information on energy efficiency solutions was taken a proxy to measure the degree of awareness levels)

Income group and energy use

During the survey, the consultant tried to ascertain the household ranking through interviews and village level FGDs and such information was compared with the energy use and preferences of the households.

Based on the FGD input and the analysis of survey findings it was concluded that almost 60% of the households in the three landscapes can be categorized as low-income households, wherein another 32% are very low-income households and only 8% of the surveyed households qualify to be middle-income and high-income households. It should be noted that this analysis is purely qualitative (including household aspects like number of rooms in the house, income sources, number of earning members, education, landholding, appliances in the household, etc.).

Despite income differences, the preferred cooking fuel for households across landscapes is firewood. In Govind and Gangotri the average firewood use of the household was approximately 7 to 8 tonne p.a., but in Darma, where villagers live only for 6 months from April to October the firewood consumption was on an average 2 to 3 tonne p.a. It was observed that the correlation between the income of the family and average firewood use was weaker as the firewood is available for free to all (from the nearby forest).

The use of the cooking option other than firewood depends on many factors such as household income, awareness, access to such energy options, etc. Of all the households surveyed in the 20 villages in the three landscapes, ~48% of households have LPG connection. It is a primary cooking option for only 2.4 percent of such households.

It has been observed that in the villages there is a positive correlation between the low-income group and LPG stoves in their kitchen, however, it is a moderate positive correlation, which means that if low-income group more on comparison of very low/poor income group, the numbers of LPG stoves will also more and vice-versa.

In contrast, very low/poor income group and the availability of LPG is negatively correlated, the relation established is a moderate negative correlation, which means there is a tendency for LPG stoves numbers in the villages decrease with the increase of very low or poor income group (and vice versa). It shows the most of the families having very low or poor income ranking are only dependent on firewood they have no other option for cooking, however, now some of them have LPG stoves under Ujjwala scheme, and it is gradually increasing.

But it may not be the only factor that determines the above comparison; other factors can also impact the LPG availability of LPG in the kitchens of these studied villages such as distance, distance from refilling center, etc.

Accessibility and use of LPG stoves

The surveyed villages are in the remotest part of the Uttarkashi and Pithoragarh district in Uttarakhand. The accessibility is not easy to these landscapes; however, relative accessibility to Gangotri is better in comparison of the other two landscapes i.e., Govind and Darma.

In Govind landscape-

- (i) Villages inside the national park can be approached only through trails,
- (ii) Dhatmir and Saur are located on the roadside,
- (iii) Connectivity of the villages in the Govind Wildlife Sanctuary villages is also not good- Khanyasani is on the road head and Lewari is about 5 km from the nearest road.

Villages inside the Govind National Park are on an average 13 km from the nearest road head and about 17.7 km from the nearest LPG refilling point/station. Village Saur is an exception for it is located on the roadside (at the gate of Govind National Park) and shares its boundary with Sankari (nearest market place for the area).

Road accessibility has a very high bearing on the LPG penetration in the village. As the distance from the refilling station increases the numbers of LPG connections in the respective village decrease. Thus households in Saur have maximum LPG penetration followed by Dhatmir. For villages of Govind Wildlife Sanctuary (Khanyasani and Lewari) the average distance from the village to refilling station is ~22 km and the consequence is that the LPG penetration in these villages is poor.

Like Govind Landscape village in Darma landscape are situated in far-flung locations, nearest town Dharchula is about 66 km from nearest surveyed villages Dugtu. The villagers inhabit only in summer and monsoon period for six months, and for the rest of the months, villagers migrate to their winter settlements (in Dharchula and nearby places). During their summer migration, some villagers bring LPG stoves along with them. Since the average distance of the villages from the LPG refilling station is about 76 km hence the use of LPG is also almost negligible in the surveyed villages.

Unlike Govind and Darma landscape, villages of the Gangotri landscape is nearer to the road head and the National Highway (NH34) passes through the valley. The average distance of the villages from the nearest road head is 2 km where the main road passes through the Dharali, Sukkhi. Tihar (connecting road work is under progress) is about 5 km from the main road. The average distance from the LPG refilling station or distribution point is 4 km. The accessibility to the LPG cylinder is easier in comparison to other landscapes, during the Yatra season the supply of filled LPG cylinders is regular.

LPG accessibility and village penetration of LPG stoves

The distance from the road to the villages and the numbers households with LPG stoves in the village is correlated to each other, as the distance increase, the numbers of LPG in the villages go down. The distance from the refilling station and LPG stove has a moderate yet significant negative correlation to each other.

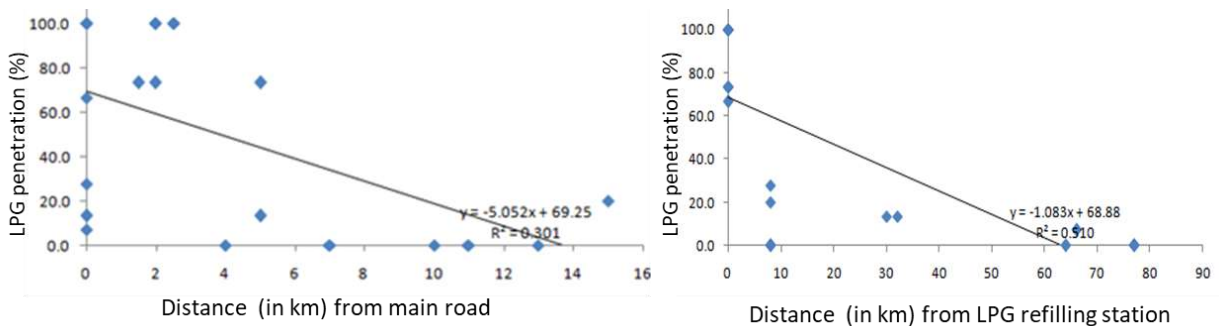


Figure 4: Graphical representation- factors influencing LPG adoption

Also, as the distance of the LPG distribution/ refilling station decreases the LPG penetration (i.e. households level shift towards LPG based cooking) goes up. In Gangotri landscape, the average distance of the refilling station from the villages is just 2 km and the 98% out of total households have LPG stoves, whereas, in Govind landscape the average distance is about 20 km and the LPG stoves penetration is 39.62%, and in Darma valley which is about 76 km from the nearest LPG refilling center only 0.34% households are using LPG.

Table 15: Accessibility of LPG refilling stations

Landscape name	The average distance from LPG distribution centre (permanent as well as roadside distribution point)	LPG penetration
Govind landscape	20 km	39.6%
Gangotri landscape	2 km	98%
Darma landscape	76 km	0.34%

The LPG accessibility is also closely linked to the LPG use in the village. The LPG consumption across landscapes was measured, the villages further from LPG refilling stations were consuming a lesser amount of LPG compared to well-connected villages.

Table 16: LPG consumption pattern

Landscape/ village name	The average distance from LPG distribution centre (permanent as well as roadside distribution point)	The average time when an LPG cylinder is consumed
Village Saur (Govind landscape)	0 km	75 days
Bagori (Gangotri landscape)	0 km	60 days
Darma landscape	76 km	5-6 months

Awareness level in the context of clean energy

Communities living in all three landscapes have low awareness of the energy programs by the government. Factors such as remoteness, low education level and accessibility to communication/ information medium are the reason behind the lower awareness levels. In the landscapes, although 82% of households have LED bulbs but only 33% are aware of the subsidies available on such bulbs.

Further, of the 33% households who are aware of the LED subsidy program, only 11% have availed the benefit under the program and only 7% think that subsidy LED bulbs are easily available. In the Gangotri landscape, maximum households have availed the benefit under the LED scheme (24% households have benefitted).

In the Govind landscape villages are well connected to the road and have access to multiple information mediums (TV, mobile phone, etc.). Wherein, villages in the Govind landscape are the remotest, hence the accessibility of villagers to the outer world is not easy also no communication medium works in the region. Darma valley is in the far-flung region of Pithoragarh district, and access to information is an issue in this region also.

Accessibility to the landscape is one of the main factors that determine the awareness level which is also correlated with accessibility to the information. This could be the reason why awareness level about the subsidized LED bulb in the Gangotri landscape is better compared to the other two landscapes.

Willingness to change cooking fuel and the income/education status

Most of the surveyed households displayed the willingness to change the fuel type and switch to cleaner fuel options. Yet, there is no significant correlation that could be established between the household income/education and willingness to shift towards cleaner fuel choices. Households across all income class and education levels displayed a similar tendency towards changing the cooking practice. Similar to the fuel switch, the households inclination to pay for improved energy options too is equally distributed across economic class and education levels. Thus no quantitative assessment could be made

The main reasons that motivate the households to switch from wood stoves towards cleaner choices were:

- i. Firewood collection is time-consuming- thus the process of wood collection is an opportunity loss. During the survey, anecdotal pieces of evidence were found where households complained of loss of income due to effort that goes into wood collection. Though the quantification of loss could not be ascertained.
- ii. The firwood supply is dwindling (villagers have to travel long distances, on an average 2 to 5 km to collect the firewood). Getting firewood to fulfil the household energy demand is a difficult task that has to be repeated across seasons and the wood stock has to be replenished to ensure energy security. Women cover long distances- in tough terrain- and with each passing year, the wood availability worsens.

Access to firewood: In the Gangotri landscape firewood accessibility is still the same as it was in 2009, but according to 16% of households, in 2009 accessibility to firewood was very good, now only 3% of the household think that the accessibility is still very good. In the Darma valley, no change in the accessibility to

firewood in, 100% surveyed families were of the view that firewood was easily accessible. In the Govind National Park region 97% household still feels that the accessibility to firewood is good

Access to the LPG: During ten years the accessibility to LPG cylinder has improved substantially. In 2009 only 9% of households were satisfied with the accessibility of LPG, but in 2019, the satisfactory level has increased to 44% of households.

iii. Indoor air pollution (as this affects their health).

iv. Fire hazard (there have been cases of households engulfed by fire and minor accidents where the children suffered burn injuries).



5. Select Cases: Energy efficient and renewable energy interventions in the Govind-Gangotri-Darma landscapes

5.1 Woodstove use, types and transition

Firewood is the main source of energy for heating (cooking, indoor heating) for the community in all the three landscapes. There is limited penetration of and access to alternate fuels in the region (see the section under LPG, electricity, etc.) making firewood the default option for cooking and heating. All the surveyed villages (and the project villages) have access to firewood, though the access and availability is lowest when snowy conditions.

Woodstove types across landscapes

Traditional non-engineered wood-stoves are predominantly used across the landscapes and this stove also seconds as an indoor heating device (during winter season). But the stove models vary across landscapes.

The landscape of Uttarkashi district is different from the Darma Valley both socially and culturally. The difference also is reflected in cooking practices and woodstove types commonly used in the kitchens. The cookstoves in Govind-Gangotri landscapes are fixed two pot stoves, wherein the one in the Darma landscape are typical three-stone stoves. The two-pot stoves are technologically advanced compared to the three-stone stoves.

The kitchen room in Darma valley is the biggest and most important room in the house for this is the room where the family spends most of the time (it also seconds as dining and bedroom for it being the only room with heating facility). Such stoves are mostly located in the centre of the kitchen room.

In the Govind landscape most of the villagers have two kitchens, and the households switch between kitchens depending on the weather. During winters when the region receives heavy snowfall, villagers use the kitchen which is generally located in the loft of the house. The alternate kitchen usually is a room located outside the house.

Engineered stove penetration in the project villages

There are very few cases in the select landscapes where the transition from traditional cookstove to other stoves was observed. In Darma valley, seven (7) households in Marcha and Seepu villages have switched to bukhari for cooking/ heating. Also, in village Hurry in Gangotri landscape, one household shifted from traditional stove to bukhari.

In Darma valley, bukharis were distributed by a government department to the villagers from Marcha and Seepu villages. Here it should be noted that the villagers received these stoves for use at the winter residencies and when moving to the valley during the summer season they carried their bukharis along. Whereas for the Bukhari user in village Hurry (Gangotri), the improved stove was a gift to the household.

According to the beneficiaries of Bukhari, the new stove is considered to be safer and cleaner than the open traditional stove, however, amount of firewood consumed is same as in traditional stove (according to some users of Bukhari, the new stove requires a high amount of firewood compared to the traditional open stove). Bukhari is smokeless (has chimney attached to it, thus it reduces the indoor pollution levels).

LPG use

The LPG awareness is similar across the landscapes, but the use of such stoves varies significantly across villages.

In Gangotri landscape, the LPG penetration is high compared to other landscapes, the road infrastructure and a mature LPG distribution network support the LPG transition. The remotest village in the landscape- Village Tihar- has the least LPG dependency and the LPG stove use is limited and restricted to urgent-quick heating. The average number of cylinders used by the select beneficiaries were less than two, also there was a case in the village where a single cylinder of the household has lasted for more than two years.

In Govind landscapes, inside the national park or in sanctuary area proxy users of LPG stoves are very high compared to actual users. Most of these stoves are though owned by the villagers but are used by the family members who reside outside the village (in the nearby town or cities). The active users too don't display high dependency on LPG. One LPG cylinder lasts between six to eight months in the village inside the national park. For villages that are close to the motorable road, the LPG penetration and use is high. The LPG consumption can range between 2-3 cylinders per annum in most of these villages.

In the Darma landscape, there are no LPG refilling stations. During the annual migration process, along with other household items, the families also carry their LPG stoves and cylinder. The LPG stove is sparingly used to ensure that it lasts during their entire summer stay in the village.

Firewood management practices in the landscape

For firewood, villages are completely dependent on the natural resources available nearby. Few villages have adopted practices to ensure the health of the wood stock available to the villagers. Few anecdotes were identified and are described in the following section.

In Sukkhi and Parali in the Gangotri landscape, the village/ panchayat forest management is the responsibility of village women groups (Mahila Mangal Dal). Standard wood extraction protocols are designed and strictly followed. In Parali forest is open only for 4 to 5 days in summer and again only for 8 to 10 days during autumn for wood collection. Whereas in Sukkhi, the forest is open every year for 7 to 8 days in June and again in November for collection of firewood. To control wood extraction, only one member from each family is allowed to go to the forest for firewood (there is no financial transaction involved- the firewood is available for free). Villagers also collect other resources from the forests, including fodder for large herds of sheep/goat. In villages Lewari and Khanyasani, villagers have planted fodder tree species in the bunds of their agriculture land.

In the Darma landscape, villagers inhabit only for six months and during their stay they use firewood and branches of shrubs collected from nearby forest and villages land. Villagers also store wood for subsequent years during their stay. Interesting practice of firewood auction was observed in village Dugtu, here

households participate in an auction to bid for the birch trees from the village forest. Similar practice was not observed in other villages in the landscape.

5.2 Solar PV for a hamlet in Tihar village

(case of beneficiaries installing the solar PV system without any technical support)

Tihar village in the Gangotri landscape is unique in a manner that the main village (Tihar) is connected to the grid but its hamlet (in Helgu) has no access to electricity (as on June 2019). The private land in Helgu was sold to National Thermal Power Corporation (NTPC) for hydro-electric project (Loharinag Pala Hydropower Project). Since the project was shelved in 2009, hence NTPC ceased using the land. The agriculture land vacated by the NTPC is now cultivation by the Tihar farmers (though they don't own it).

About 12-15 families migrate seasonally to Helgu along with their cattle. In absence of ownership rights, such families cannot get grid electricity to their houses in this hamlet. Hence Uttarakhand Power Corporation Limited (UPCL) in 2018 offered off-grid Solar PV system to four such families (though about 15 odd households had submitted application for such system).

The solar PV systems thus provided to these four families were not delivered to the beneficiary doorstep, rather dropped in Bukki market. The beneficiaries themselves got the systems transported to the villages and got it installed on their own. At the time of the survey for this baseline study, three of the households had installed the system at their homes in Tihar (not in Helgu- the intended location for installing the system) and had the intention of taking it along to Helgu (when they migrate during winter).

Figure 5: UPCL provided and self-installed solar PV home system in Tihar village



5.3 Solar Street lighting- survey findings for all villages

Villages in all the three landscapes have community solar street lamps. Among three landscapes, the relative number of such lamps is highest in the villages of the Gangotri landscape. These lamps have been installed under different programs and projects of the government and private institutions.

The summary of street lights installed and its status is provided in Table 17.

Table 17: Status of solar street lights across three landscapes

Landscape	Village	Functional solar street lights	Non-Functional solar street lights
Govind	Pawani	1	5

Landscape	Village	Functional solar street lights	Non-Functional solar street lights
	Lewari	1	15
	Khanyasani	3	3
Gangotri	Makhwa	50% of 100-150 lights	50% of 100-150 lights
	Purali	13-15	05-Jun
	Sukki	10	15
	Hurri	20	0
	Tihar	23	10
	Bagori	10	20-30
	Salang	15	8
Darma	Dugtu	10-12	4-6
	Marchha	3	2
	Seepu	0	5

In the Gangotri landscape, Village Mukhwa has the highest number of such street lights (125). In Tihar and Salang most such lamps are relatively new installations and are provided by the Gram Sabha and the Zila Panchayat during the last one year (2018-2019).

It should be noted that the majority of these street lights are not functional.

Figure 6: Solar street lights in Gangotri landscape (a defunct and a functional unit)



Inside the Govind National Park -landscape villages all the villages have solar street lamps but only village Pawani had the sole functional lamp. In the Govind landscape, outside the national park boundary, the villages Sor, Lewari and Khanyasani though are connected to the grid but like other villages in the region, the street

lights are powered by solar. Lewari has 16 street lights but only one is functional, in Khanyasani there were 6 solar street lights but only three were found to be in working condition.

In Darma landscape, UPCL has installed solar street lamps. Maximum such lamps are in village Dugtu and during the time of the visit to the village most such lamps were functional. In village Marchha only two of the five such lamps were functional and in Seepu and Bon, none of the solar street lamps were working.

5.4 Case of re-electrification of village Bagori in Gangotri landscape

The villagers of Bagori in the Gangotri landscape migrate to their winter settlement for six months and come back to the native village after April. The village was electrified in 1990-91, but the power supply to the village was discontinued by UPCL because of non-payment of electricity charges. The villagers complained against the electricity charges for they believed that the electricity meter readings mentioned in the bills raised by the UPCL were way high compared to the actual usage. Thus the villagers collectively refused payment of bills to the power corporation.

In 2019, the village was again connected to the grid under Saubhagya Yojana by UPCL. At the time of the village survey (June 2019), most of the village households were awaiting their turn for grid-electricity connection. Thus among all the villages in the Gangotri landscape, the households connected to the grid are lowest in village Bagori.

5.5 Shared Solar PV systems in Darma valley

In the Darma valley, there is no grid power. All the villages have been provided with shared solar PV systems by UPCL. In the studied villages of the Darma valley, solar units installed in the villages have two solar panels and two batteries. Each such unit can provide electricity in 8 to 10 nearby houses. Each house has also been provided with electric fitting to support 3-4 LED bulbs (and a charging point).

At the time of baseline survey (June 2019), in Dugtu and Bon most of these solar units are functional, but in Seepu and Marchha some of these solar units were damaged as the supporting frame of such system is weak and poorly installed. Unable to bear the weight of the snow, the frame collapsed in most of the cases and also resulted in damages to the modules.

Figure 7: Shared solar home system in Darma Valley (Damaged system)



In Dugtu village it was observed that one solar unit was broken, wherein in Bonn, Marcha and Seepu, three-four such units were damaged. Since most of the households have migrated from the region hence the villagers repair such systems by cannibalizing the non-functional units.

Appendix

Appendix 1: Season wise Firewood consumption in ton

Village	Winter	Summer	Monsoon	Annual
Govind landscape				
Osla	5.02	1.51	1.51	8.04
Pawani	5.08	1.52	1.52	8.12
Saur	4.86	1.46	1.46	7.78
Gangar	5.02	1.51	1.51	8.04
Dhatmir	5.00	1.50	1.50	7.99
Khanyasani	5.02	1.51	1.51	8.04
Lewari	4.86	1.46	1.46	7.78
Gangotri landscape				
Bagori	0.00	1.49	1.49	2.98
Makhwa	0.00	1.57	1.73	3.29
Parali	5.09	1.53	1.53	8.14
Salang	5.08	1.52	1.52	8.12
Hurri	5.02	1.51	1.51	8.04
Sukkhi	5.13	1.54	1.54	8.21
Tihar	5.02	1.51	1.51	8.04
Dharali	0.00	1.57	1.57	3.14
Bhukki	5.03	1.51	1.51	8.04
Darma landscape				
Bon	0.00	1.46	1.46	2.92
Dugtu	0.00	1.53	1.53	3.07
Seepu	0.00	1.57	1.57	3.13
Marchha	0.00	1.54	1.54	3.08

