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Uttarakhand: Decentralized Renewable Energy Plan 2018-2025

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Contributors:

S.N. SRINIVAS
KRITHIKA P. R.
PRERNA SHARMA

PARIMAL M. SADAPHAL
TAPAN KAPOOR
SATEESH KULKARNI

Disclaimer

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Foreword

Energy is a key component in the development framework of any nation. It is an important stimulant that triggers, fosters and sustains socio-economic growth. Recognizing this, the Government of India is emphasizing upon achieving self-sufficiency and universal access to energy for all in the country. It has set very aggressive time-bound targets aimed at achieving the above goals. As of now, implementation efforts are underway on full steam and the goals are very close to realization. Nonetheless, the scope and importance of Decentralized Renewable Energy (DRE) remains relevant despite extension of grid coverage to all areas of the country, albeit in a slightly different avatar, as its immense potential can be gainfully leveraged to boost contribution of renewable energy to the overall energy mix thereby enabling closure of the energy gap in a sustainable and less polluting manner.

Importance of DRE becomes more significant in case of a state like Uttarakhand in India where there the terrain, weather/climate and inadequate socio-economic growth tend to impede extension of energy supply services to the local population. However, the fundamental concepts and assumptions behind DRE planning will now be much different than earlier, in view of the transformed circumstances. It would be interesting and useful to see how a DRE Plan for a state like Uttarakhand would emerge in the current scenario and the manner in which it could contribute to strengthening the overall energy sufficiency and security in the state.

We are happy to see that the Uttarakhand Renewable Energy Development Agency and CLEAN are taking the initiative to embark upon preparation of a DRE Plan for the hill state of Uttarakhand, which not only is lagging behind in development but also prone to natural disasters and fraught with migratory trends in its population. We sincerely hope that this DRE Plan document will be useful to the state government, policy makers, planners, researchers and Community Based Organizations in their efforts towards fostering sustainable development in Uttarakhand.

August, 2018
New Delhi

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GLOSSARY

AWC	Anganwadi Centre
BPL	Below Poverty Line
BU	Billion Units
CAGR	Compound Annual Growth Rate
CBO	Community Based Organization
CEA	Central Electricity Authority
CEEW	Council on Energy Environment and Water
CHC	Community Health Centre
CII	Confederation of Indian Industries
CSC	Common Services Centre
DASI	DRE based Agriculture Sector Improvement
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DPR	Detailed Project Report
DRE	Decentralized Renewable Energy
EA	Energy Assessment
EANDS-DACNET	Economics and Statistics, Department of Agriculture Cooperation
EIDP	Energy Infrastructure Development Program
EIP	Energy Infrastructure Plan
FRBM Act	Fiscal Responsibility and Budget Management Act
FSI	Forest Survey of India
FY	Financial Year
GEA	Generic Energy Assessments
GoI	Government of India
GoU	Government of Uttarakhand
GP	Gram Panchayat
GSDP	Gross State Domestic Product
GW	Giga Watts
Ha	Hectare
HMIS	Health Management Information System
ICAR-DMR	Indian Council of Agricultural Research - Directorate of Mushroom Research
kWp	Kilo Watt peak
LED	Light Emitting Diode
LFPR	Labour force participation rate
LPD	Litres Per Day
LPG	Liquefied Petroleum Gas
MDM	Mid-day Meals
MMHP	Mini and micro hydropower project
MNRE	Ministry of New and Renewable Energy
MSME	Micro, Small and Medium Enterprises
MT	Metric Tonne
MU	Million Units
MW	Mega-watt
NGO	Non-Governmental Organisation
NHP	National Health Policy
NRLM	National Rural Livelihoods Mission
PHC	Primary Health Centre
PHDCCI	PHD Chamber of Commerce and Industry
PIB	Press Information Bureau
PPAC	Petroleum Planning and Analysis Cell
REEEP	Renewable Energy & Energy Efficiency Partnership

RES	Renewable Energy Sources
SAUBHAGYA	Pradhan Mantri Sahaj Bijli Har Ghar Yojana
SHG	Self Help Group
SHP	Small Hydro Project
SPV	Solar Photo Voltaic
SRLM	State Rural Livelihoods Mission
U-DISE	Unified District Information System for Education
UKSRLM	Uttarakhand State Rural Livelihood Mission
ULV	Ultra-Low Volume
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UPCL	Uttarakhand Power Corporation Limited
UREDA	Uttarakhand Renewable Energy Development Agency

EXECUTIVE SUMMARY

The Decentralized Renewable Energy (DRE) Plan for the hilly state of Uttarakhand in India was prepared in partnership with the Uttarakhand Renewable Energy Development Agency (UREDA). The preparation of this plan was necessitated because of the changed energy policy scenario in India wherein the Government is aggressively pushing for extending grid coverage over the entire country and is also promoting clean fuels like LPG for cooking. On account of this changed policy environment, it was important to re-orient the context in which to view DRE and examine the fresh perspectives of fitting in DRE interventions in the new circumstances. Accordingly, it was agreed to prepare this DRE plan, with specific reference to the following energy use sectors:

1. **Domestic**: This includes all household and community energy requirements such as lighting, household electrical appliances, cooking, water heating, space heating, etc.
2. **Agriculture**: This covers energy requirements in agriculture, horticulture and livestock which are predominantly irrigation and post-harvest applications such as food processing, cold chains, etc.
3. **Micro, Small and Medium Enterprises (MSMEs)**: This category encompasses energy requirements of MSMEs including lighting, office equipment, manufacturing equipment, process heat requirements, etc.
4. **Institutional Buildings**: This includes the Government's public welfare infrastructural facilities such as Health Centers, Educational Institutions, Panchayat Buildings, Anganwadi Centres etc.
5. **Rural Livelihoods**: This covers all cottage rural enterprises and other typical livelihood activities undertaken by individuals or groups in villages for their subsistence

While details of this plan are available in the main document, a summarized and self-explanatory extract of the main recommendations and estimated associated costs that emerged with the development of this plan are given on the next page.

It is hoped that this plan will not only provide useful guidance in improving the energy availability situation while taking substantial pressure off the grid but also foster energy reliability and sustainability in the state.

DRE Plan for Uttarakhand – Summary

Sectors	Proposed Interventions to be completed by 2025	Cost (Rs. in Crore)	Sector Total (Rs. in Crores)
Institutions	Solar power plant in 6510 govt. Off-grid schools	143.22	
	Solar power plant in 11448 on-grid schools	251.86	
	Improved cook-stoves in 17664 schools providing MDM	125.13	
	Solar power plant, solar water-heater and improved cook-stoves in 60 CHCs	1.45	
	Solar power plant, solar water-heater and improved cook-stoves in 257 PHCs	1.40	616.96
	Solar power plant and LPG cook-stove in off-grid 616 sub-centres	7.76	
	Solar power plant and LPG cook-stove in on-grid 1231 sub-centres	3.30	
	Solar power plant in 2278 AWCs (constructed buildings)	2.28	
	Solar power plant in 8056 GPs	80.56	
Agriculture	Solar pumps (500)	6.00	
	Solar pumps in drip irrigation (200 ha)	12.50	
	Small (5MT) solar based cold storages (100)	8.00	166.5
	Canal top solar (6MW)	120.00	
	Solar power plants on barren and un-culturable land (1 ha)	20.00	
Livelihoods	650 pilots on DRE integration with livelihoods	32.50	
	Business enrichment studies	2.00	
	Research studies on watermills (1) Livelihood Generation potential (2) Potential for grid feeding with two piots	3.50	41.05
	Capacity building to train the stakeholders engaged in implementing pilots	2.00	
	Monitoring of 650 pilots	1.05	
MSMEs	DRE integration in selected 8 categories of MSMEs (grinding services, eateries, local services, hotels, textiles, handicraft, tailoring and food processing)	40.21	46.71
	Energy assessment of 200 MSMEs selected for DRE intervention and their monitoring	6.50	
Domestic	Stock of 10 solar lanterns per GP for disaster preparedness	12.08	
	Creation of revolving fund for facilitating adoption of biomass cookstoves through carbon credit mechanisms	21.00	
	Pilot study of solar PV based induction cookers in 10 HHs	6.00	73.78
	Research for biomass based (including pine needles) improved space heating technology with one pilot	20.00	
	Research Study on power generation from pine needles with one pilot	14.70	
	Total Budget Required		**945.00**

Definitions

Village Electrification	A village would be declared as electrified, if (a) Basic infrastructure such as Distribution Transformer and Distribution lines are available in the inhabited locality as well as the Dalit Basti hamlet wherever it may exist; (b) Electricity services are accessible in all public places like Schools, Panchayat Office, Health Centers, Dispensaries, Community centers etc; (c) The number of households electrified in the village should be at least 10% of the total number of households in the village.
Decentralized Renewable Energy	Refer *section-1.3*
Labour force participation rate	Section of working population in the age group of 16-64 in the economy currently employed or seeking employment
Marginal Farmer	A farmer with landholding less than 1 hectare
Small Farmer	A farmer with landholding between 1-2 hectares
Semi-Medium Farmer	A farmer with landholding between 2-4 hectares
Medium Farmer	A farmer with landholding between 4-10 hectares
Large Farmer	A farmer with landholding greater than 10 hectares
Gross Irrigated Area	This represents the total area sown once or more than once in a particular year, i.e. the area is counted as many times as there are sowings in a year. This total area is also known as total cropped area or total area sown
Minor Irrigation	Ground water or surface water based schemes (both flow and lift) having culturable command area up-to 2000 hectares individually
Common Service Centres	Physical facilities for delivering Government of India e-Services to rural and remote locations. These services include web-enabled e-governance services such as application forms, certificates, and utility payments such as electricity, telephone and water bills

1. Introduction

The Clean Energy Access Network (CLEAN) is an all India representative organization launched in 2014 with a mandate to support, unify and grow the decentralized clean energy sector in India. Member organizations of CLEAN are industries and international think tanks / non-profits who share a common vision of promoting clean and renewable energy. It particularly aims to bring together diverse stakeholders across India working to improve energy access for the rural and urban poor and create an inspiring model for countries around the world to follow.

Currently in India, the energy sector is witnessing an aggressive Government effort on grid extension that strives to electrify all villages in the country by 2019. Although this massive program is almost on the verge of completion and its targets are most likely to be achieved, aspects such as full household coverage and optimal service delivery quality still remain relevant. These challenges are particularly conspicuous in case of states that are lagging in development and/or have difficult terrain or topography. Uttarakhand which is one of the newest states in India carved out of the erstwhile Uttar Pradesh, is one such example where its relative backwardness in terms of development indicators coupled with some of the most inhospitable terrain in the world pose significant challenges to the Government's efforts on extending energy services to all its villages and habitations. These challenges are posed not only to grid extension efforts but also to fuel supply, be it petroleum products, coal, Liquified Petroleum Gas (LPG) or natural gas. In fact, inadequate energy access could also be one of the triggers of the long-standing problem of out migration of people from the state.

Given the above situation, the Government of Uttarakhand (GoU), through its State Designated Agency established in 2008, the Uttarakhand Renewable Energy Development Agency (UREDA) was exploring possibilities to address the challenges it faced in providing reliable energy services to its people. Over a series of dialogues with CLEAN, the option of leveraging Decentralized Renewable Energy (DRE) options emerged as one possibility. Consequently, it was resolved to commission CLEAN for developing a Decentralized Renewable Energy (DRE) Action Plan for the state. One of CLEAN's prominent donors, USAID agreed to provide the requisite financial support for preparing this action plan with cooperation from UREDA, who would provide data, information and local facilitation to CLEAN's project team. The plan is expected to help UREDA in charting its way forward in the coming years.

For purposes of this plan, UREDA suggested looking at the following sectors for possibilities of DRE applications (electrical as well as thermal):

1. **Domestic**: This includes all household and community energy requirements such as lighting, household electrical appliances, cooking, water heating, space heating, etc.
2. **Agriculture**: This covers energy requirements in agriculture, horticulture and livestock which are predominantly irrigation and post-harvest applications such as food processing, cold chains, etc.
3. **Micro, Small and Medium Enterprises (MSMEs)**: This category encompasses energy requirements of MSMEs including lighting, office equipment, manufacturing equipment, process heat requirements, etc.
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It is hoped that when implemented, this plan will not only provide useful guidance in improving the energy availability situation while taking substantial pressure off the grid but also foster energy reliability and sustainability in the state.

Brief State Profile	As per Census of India, 2011
Population	10116152
• Rural	• 70,25,583
• Urban	• 30,91,169
Geographical Coverage	53,483 Sq. Km
• Hilly Terrain	• 46,035 Sq. Km (86%)
• Plain	• 7,448 Sq. Km (14%)
• Forest cover	• 34,651 Sq. Km (65%)
• Rural Areas	• 52,581 Sq. Km (98.31%)
• Urban Areas	• 902 Sq. Km (1.69%)
Administrative Units	
• Districts	• 13
• Blocks	• 95
• Gram Panchayats	• 7,555
Number of villages	16,793
• Inhabited	• 15,745
• Uninhabited	• 1,048
Literacy Rate	79.63%
Sex Ratio (females per 1,000 males)	963

Figure 1.1 - Uttarakhand Map and State Profile

1.1 State Profile

1.1.1 Geographical Overview

Uttarakhand, formerly Uttaranchal, is a state in the Central Himalayan Region of India. It was formed on November 9, 2000 to become the 27th state of India., With a geographical spread of 53,484 sq. km (1.63% of India), Uttarakhand is situated in the northern part of India extending between 28°43' N to 31°27' N latitude and 77°34' E to 81°02' E longitude. It is predominantly a hilly state, having international boundaries with the People's Republic of China in the north and Nepal in the east. On its north-west lies the State of Himachal Pradesh, while on the south it is bounded by the State of Uttar Pradesh. The interim capital of Uttarakhand is Dehradun which is its largest city and the state high court is located at Nainital. The State is home to some of the most important pilgrimage centres known as the "Char-Dham", i.e. the Gangotri, Yamunotri, Kedarnath and Badrinath. An overall snapshot of the state and its demography is given in ***Figure 1.1***.

Hindi is the most widely spoken language in the state while Garhwali and Kumaoni are the main regional languages. The state also houses several communities speaking a host of other hill dialects and sub-dialects. The state is quite rich in natural resources especially water and forests with many glaciers, rivers, dense forests and snow-clad mountain peaks. Being mountainous, the state host considerable bio-diversity: about 175 rare species of aromatic & medicinal plants are found in the State[1]. It also has a wide range of climatic zones that opens up avenues for exploiting a variety of commercial opportunities in horticulture, floriculture and agriculture. It has a vast tourism potential in adventure, leisure, and eco-tourism.

1.1.2 Topography and Climate

The topography of Uttarakhand is characterized predominantly by hilly terrain, deep valleys, high peaks, swift streams and rivulets. Certain areas of the states lie in the foothills and plains as well. Consequently there is extensive soil erosion resulting in frequent landslides. Human habitations in the state tend to be small and widely scattered. The northern region of the state is situated in the Himalayan ranges and glaciers, whereas the lower parts of the state are mainly

[1] Directorate of Economics and Statistics (2014), Government of Uttarakhand

covered with dense forests. Out of the total geographical area of 53,483 sq. km, about 85% area (i.e., 46,035 sq. km) consists of hilly terrain, which is characterized by loose soil and steep slopes (slope angles of more than 20 degrees). This makes the terrain highly susceptible to soil erosion during rains. There are 13 districts in the state, of which 10 lie in the Northern region with hilly and difficult terrain while the remaining 3 districts lie in the plain region located in the southern part of the state (***see Figure 1.2***). At 7,817 m above sea level, the Nanda Devi peak located in district of Chamoli is the highest point in the state. 65% (34,651 sq. km) of the state's area is under forest cover consisting of rainforests and alpine forests which house a considerable spectrum of biodiversity including highly endangered wild life species. Merely 12% of the land area of the state is cultivated of which, only about 37% is irrigated[2]. The region receives about 1,631 mm of rain annually[3]. Two of India's major river systems: the Ganga and the Yamuna, originate from Uttarakhand.

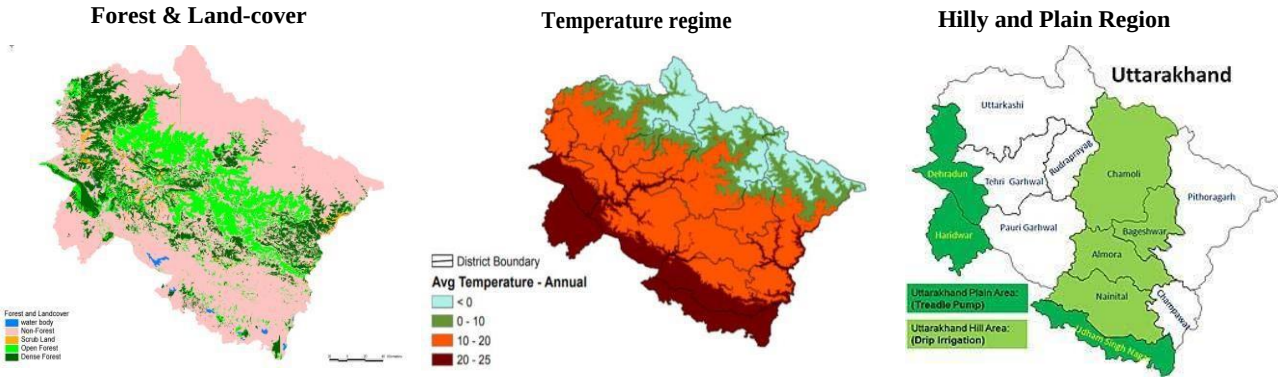


Figure 1.2 - Topographic Maps of Uttarakhand

Climate in Uttarakhand varies widely from location to location depending upon the altitude. In the plains the conditions are primarily tropical-like with relatively hot summers and moderate winters. However, at higher altitudes, summers are pleasant while winters are harsh with temperatures reaching sub-zero levels. The minimum and maximum temperatures recorded are -4.6°C at Mukteshwar and 43°C at Dehradun respectively [4]. Floods and landslides are commonplace, particularly during the rainy season in the lower stretches of the valleys. In the northern parts of the state, 10 to 15 feet (3 to 5 metres) of snowfall is common between December and March. In June 2013 several days of extremely heavy rain on account of a cloudburst caused devastating floods in the region, leading to more than 5000 people reported missing and subsequently presumed dead. The flooding was referred to in the Indian media as a "Himalayan Tsunami".

1.1.3 Administrative Units and Demography

Uttarakhand comprises of 13 districts, 95 blocks, 8,056 GPs and 16,793 villages. Around 94% of the villages are inhabited including forest settlements while remaining 6% are un-inhabited due to out migration of local residents on account of a host of issues such as hilly terrain, adverse climate, lack of livelihood opportunities, lack of basic infrastructural facilities, etc. With a population of 1.01 Crore [5] and almost equal representation of males and females, Uttarakhand is a predominantly rural state with majority (70%) of the total population residing in rural areas (***see Figure 1.3***). 16,826 rural settlements, of which 12,699 or 81% have a population of less than 500. The small size of settlements, their widely dispersed locations and difficult topographical conditions pose a formidable challenge to service delivery in the state. The growth process in Uttarakhand has been notably faster in the 3 districts plain,

[2] Strategy Paper for different agro-climatic zones published by GoI (http://farmech.dac.gov.in/)
[3] Directorate of Economics and Statistics (2014), Government of Uttarakhand
[4] Directorate of Economics and Statistics (2014), Government of Uttarakhand
[5] Census of India, 2011

conspicuously eluding the hilly areas. Most of the manufacturing and industrial units are located in the plain districts.

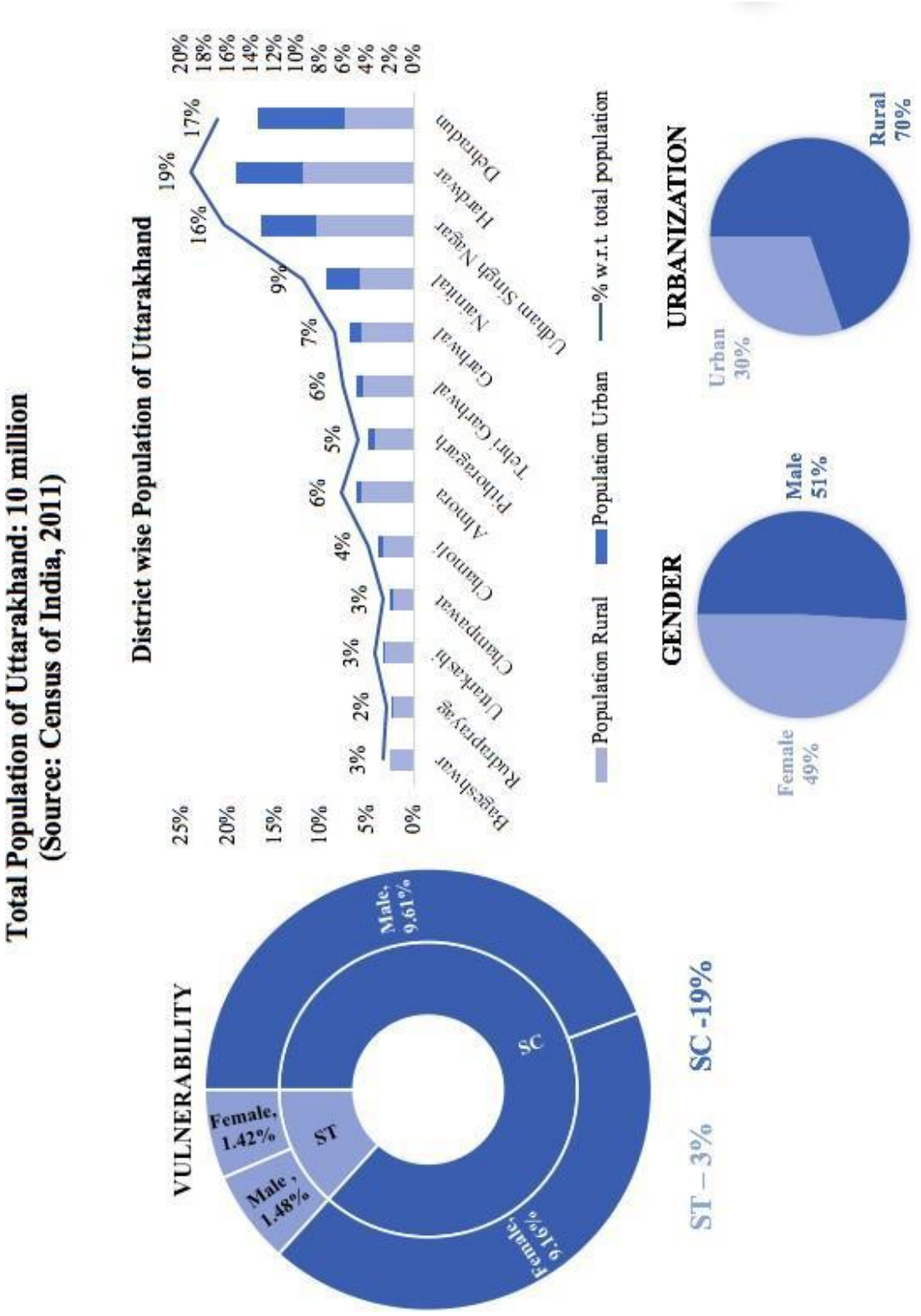


Figure 1.3 - Population and Demographics

The state is divided into two distinct regions based on cultural traditions of the resident population: Kumaon and Garhwal. Four of the 13 districts, namely Dehradun, Haridwar, Udham Singh Nagar and Nainital account for 62 % of the state's total population. On adding Tehri Garhwal, Pauri Garhwal and Almora, this accounts for nearly 81%. This clearly shows that the concentration of population is quite high in the mid and foothills as compared to the remaining six districts of high hills.

1.1.4 Economic development

Since its formation in 2000, the state has witnessed substantial economic growth. Between 2011-12 and 2017-18, Gross State Domestic Product (GSDP) grew at a Compound Annual Growth Rate (CAGR) of 11% to Rs.2,18,000 Crore (US$ 33.76 billion). The state has a robust social and industrial infrastructure, reasonably good (though still not fully adequate) connectivity with over 39,000 km of road network, two operational domestic airports, 345 km of rail routes and an installed power generation capacity of 3,356 MW as of March, 2018.

As per economic survey report of state (2017-18), the state's growth rate was estimated at 6.7% in FY2017-18, down from 7% in 2016-17 and 7.5% in 2015-16. Increase in unemployment and mass migration to metro cities for jobs may be seen as among the major contributors to this reduction. Contrary to this, the per capita income of the state has shown a steady increase from Rs.1 lakh (2011-12) to Rs.1.8 lakh (2017-18) which is more than the national average of Rs.1.1 lakh (2017-18)[6]. Besides, the fiscal deficit of the state for 2017-18 is Rs.5471 Crore which is 2.37% of the GSDP and is well in the limit of 3% prescribed by FRBM Act. (***see Figure 1.4***) Despite relatively encouraging trends in economic indicators as above, more than 6 lakh

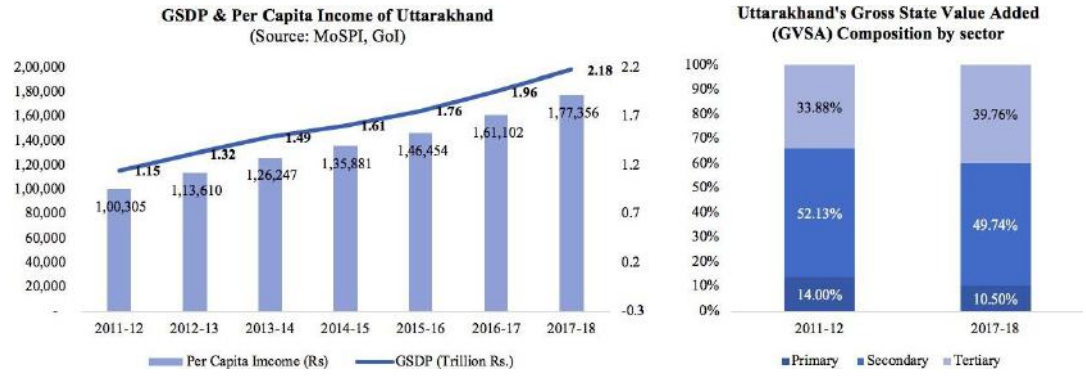


Figure 1.4 - GSDP & PCI of Uttarakhand

families (about 6% of the state's total population) still live below the poverty line, of which almost 50% are located in 4 districts of hilly region namely, Rudraprayag, Tehri, Bageshwar, Almora and Pithoragarh. The BPL figure has actually improved since 2011 when around 11 lakh (11%) of the state's population was living below poverty line[7]. The main reason for concentration of BPL families in the hilly regions of the state is lack of employment opportunities in these regions as most economic opportunities are concentrated in plain areas. Consequently, income inequalities across the hill and plain districts are considerable. The district wise unemployment graph (*refer* ***Section-1.1.5***) clearly indicates continued and persisting trends in the prevalence of economic issues in hilly regions of the state.

The presence of several hill stations, wildlife parks, major pilgrimages and trekking routes make Uttarakhand an attractive tourist destination. Inflow of tourists into the state increased

[6] http://www.esopb.gov.in/Static/PDF/GSDP/Statewise-Data/StateWiseData.pdf
[7] https://www.rbi.org.in/SCRIPTs/PublicationsView.aspx?id=16603

from 3.2 Crore in 2016-17 to 3.5 Crore in 2017-18. Tourism along with allied sectors such as Trade, Hotels and Restaurants contributed 13.57% to the GSDP in 2017-18[8].

Much needed impetus to the state's economic development is being provided by various policies formulated by the state government from time to time, which included MSME Policy 2015, Hill Policy 2008, Central Capital investment Subsidy Scheme, Mega Textile Park Policy, Mega Industrial and investment Policy and Uttarakhand Policy for Skill Development & Entrepreneurship 2018.

1.1.5 Unemployment and Migration

Unemployment

According to the recent statistics[9], unemployment in Uttarakhand has almost doubled to 9.2 lakh in 2017 from 4.9 lakh people in 2008. This pegs unemployment rate at 9% compared to the national average of 5%. ***Figure 1.5*** below clearly confirms that the maximum proportion of unemployed people are indeed located in hilly districts like Pithoragarh, Bageshwar, Uttarkashi, Chamoli and Tehri Garhwal. The reason for this is obviously the higher rates of industrialization and trade in the plains as compared to the hills. One offshoot of this seemingly lopsided pattern of development, is migration.

In 2015-16, the labour force participation rate (LFPR) in the state was 46% against the national average of 50% and workers population ratio is 43% for which the national average is 48%[10]. Thus, there is an emerging need of meeting the employment demands of the rural population in the state to reduce the migration rate as well as increase the per capita income of community located in difficult terrains of the state.

Migration

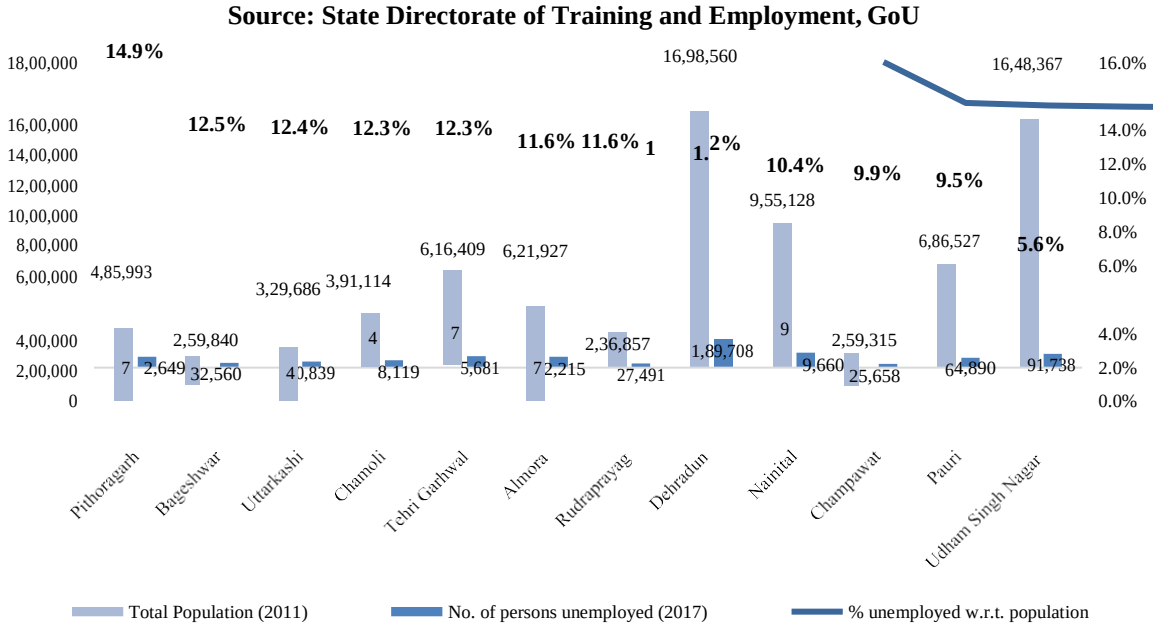


Figure 1.5 – District-wise unemployment in Uttarakhand (Apr, 2017)

As discussed above, migration is a serious issue in Uttarakhand. This can be understood from the fact that the proportion of rural population, which was 75% in 2001 came down to 70% in 2011. While on one hand, the rural population decreased by almost 7%, the urban population increased by as much as 35% during the same period. Out of 13 districts in the state, 4 districts (Dehradun, Udham Singh Nagar, Haridwar and Nainital) are located in the plains while rest of the districts are located in hilly areas. The decadal growth of population between 1981 and 1991

[8] Economic Survey, GoU (2017-18)

[9] Source: Directorate of Training and Employment, GoU (https://timesofindia.indiatimes.com/city/dehradun/number-of-unemployed-people-doubles-in-a-

decade/articleshow/59183444.cms)
[10] Economic Survey, GoU (2017-18)

in the hilly areas was 18% (***see Figure 1.6***), which decreased to 12% between 1991 and 2001. It further reduced to 5% in period between 2001 to 2011. During this decade (2001-2011), Almora and Pauri districts have shown a negative population growth rate of -1.73% (8061 persons out-migrated) and -1.51% (9807 persons out-migrated) respectively. Around 45.4% of villages in Pauri Garhwal have an average size of less than 25 households while the village size in Almora is relatively bigger as per Census, 2011. Presently more than 300 villages are almost uninhabited due to migration in the Pauri district because of lack of jobs in the hilly region[11]. It is important to note that the pace of out-migration continued to increase even after the carving out of Uttarakhand into a separate state[12]. Now, this is not a new phenomenon with regard to people residing in the hills. The pace of migration from some hill districts is so high that many

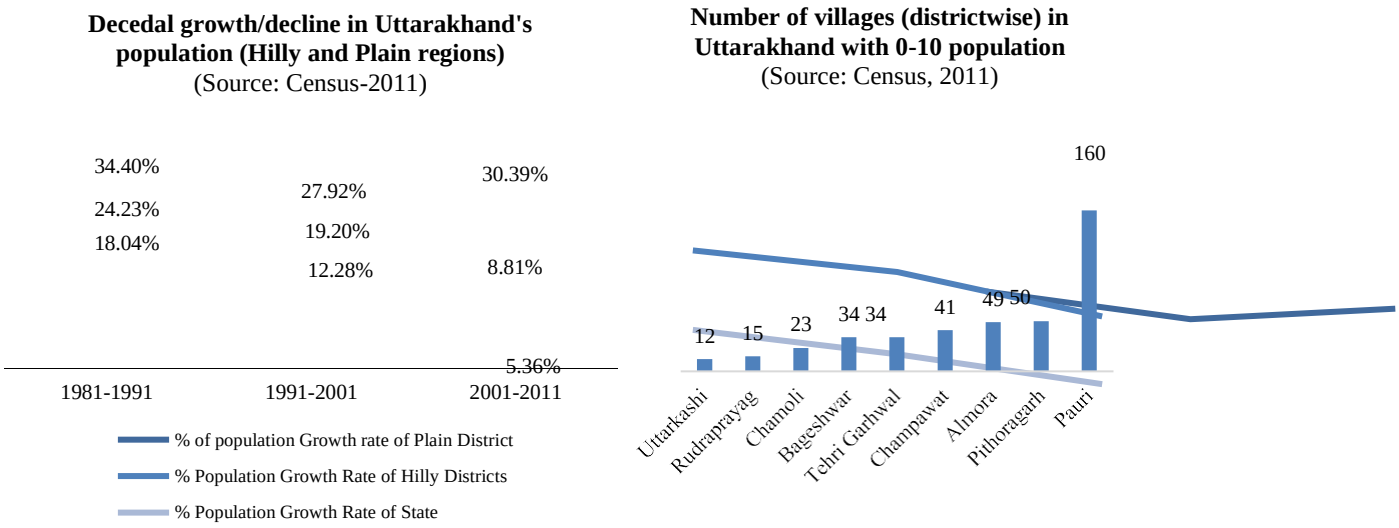


Figure 1.6 - Population change in Uttarakhand due to out-migration

of the villages are left with a population that can virtually be counted on fingers (***see Figure 1.6***). It depicts the hardships of village life in general and women in particular in the Hill Region of Uttarakhand in the wake of increasing out-migration. Overall according to the media reports, 32 lakh people have migrated from the hilly regions since 2000 when the state came into existence[13]. There is a significant increase of around 59% in the number of villages with single digit population from 2011 till 2017. These villages are almost turned into "*ghost villages*". Solely Pauri district has shown an increase from 160 to 341 villages that are having population of less than 10 persons. Presently, (2017) there are around one-fourth (3900) of the total villages in the state having population of less than 50 persons[14].

Reasons for Migration

Marriage and Employment are the two major reasons for long term and/or permanent out-migration from the state in the past (***see Figure 1.7***). According to a recent (2017) survey, the main reasons for migration from the hilly regions of Uttarakhand are low agricultural productivity and educated unemployment[15].

Interactions with officials and local population have revealed that lack of irrigation facilities in the hilly regions is a major factor responsible for the lower productivity of agriculture in

[11] https://timesofindia.indiatimes.com/city/dehradun/in-migration-hit-villages-old-alone-visitors-none/articleshow/62217480.cms
[12] Rajendra, P. Mamgain and D.N. Reddy; Final report: Outmigration From Hill Region Of Uttarakhand: Magnitude, Challenges and Policy Options; www.nird.org.in
[13] Hindustan Newspaper, 26th June , 2017
[14] https://www.hindustantimes.com/india-news/no-village-for-young-men-in-uttarakhand/story-hb7X0LaiyY8X7glSSZ7QXM.html (0-10 population: 418 villages – Census 2011; 664 villages – Media Reports, 2017)
[15] Rural Labour Mobility in Times of Structural Transformation: Rajendra P. Mamgain and D. Narasimha Reddy

Introduction

(2017)

addition to the limited accessibility to health and education. Most of the inter and intra-state migration in the recent years is for getting jobs followed by opportunities for higher studies in other states/ metros.

(Source: Census, 2001 & 2011)

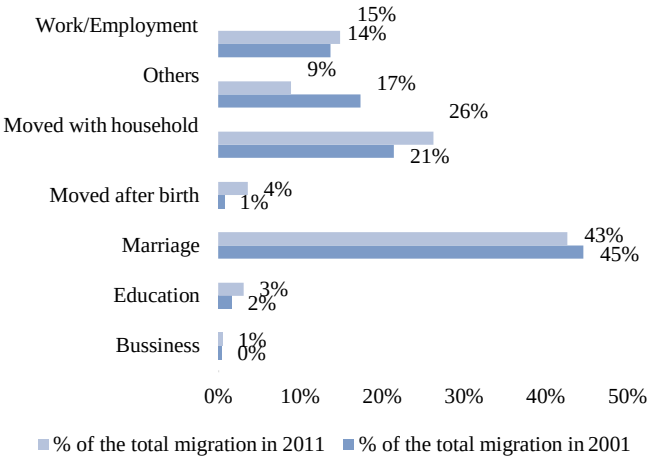


Figure 1.7 - Reasons for Migration in Uttarakhand

Results of field surveys[16] indicate that almost 26% household income of poor families is contributed by remittances by their migrant members. Due to the above, Uttarakhand is often called a "money order economy" as most residents receive remittances from their family members who have migrated outside the state for work. As a consequence of all the above, a decreasing trend in the population in several districts of Uttarakhand is now a reality.

1.2 Energy Scenario: India and Uttarakhand

Significant progress has been achieved by the Indian Power sector in recent years. This became possible because of a slew of supportive actions taken by the Government on multiple fronts such as formulating enabling policies with special emphasis on inclusion, attractive schemes (like *Saubhagya* and *DDUGJY* schemes of GoI) for reaching the hitherto neglected sections of the population, instilling a policy framework to encourage demand side energy efficiency, initiate concrete action on minimizing transmission and distribution losses, significantly expand rural electrification, improve service quality (reduce power cuts, etc.) and significantly add to the country's installed power generation capacity with a clear emphasis on renewable energy.

Village Electrification

With a sharp focus on providing uninterrupted power supply to all, GoI planned to leave no village in the country un-electrified by 2019 and ensure 24×7 supply for every household by 2022 through its "Power for all" program, launched in 2014. The program has been under implementation since then and the Prime Minister of India has announced that as of 28 April 2018, each and every village in the country has been electrified. This is based on the Government's definition of electrification which states that a village can be deemed to have been electrified when the power supply line reaches a transformer in the village and at least 10% of the households in the village as well as public facilities such as schools and health centers are connected to the power supply. Clearly, based on the above, all villages in Uttarakhand can also be deemed to have been electrified.

Household Electrification

In spite of all villages being electrified, not all households comprising these villages are electrified yet. Available data on number of households electrified is given in ***Figure 1.8*** below, from which it can be seen from that at least 11% of the households in the country still remain to be connected to the grid.

[16] Outmigration in Uttarakhand, NIRD Report

In case of Uttarakhand the percentage of off-grid households seems to be considerably higher. It can be seen from ***Figure 1.8*** that as per Saubhagya[17] Portal, 17% households remain un-electrified in the state.

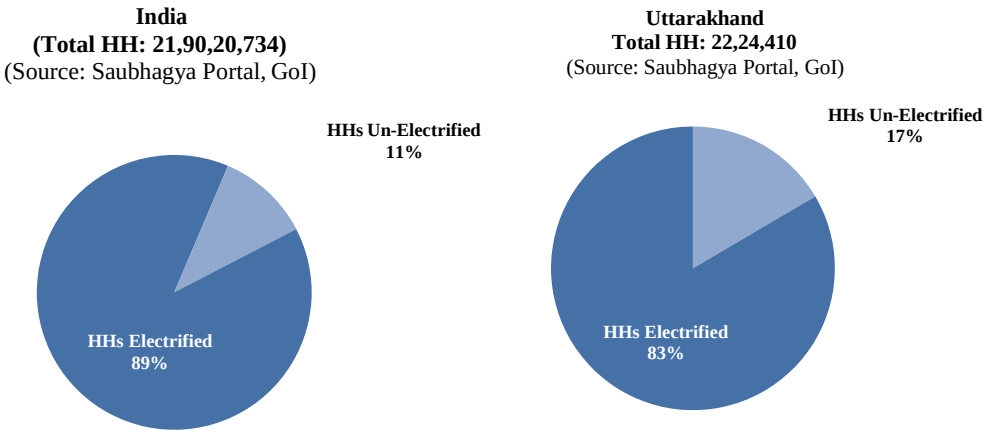


Figure 1.8 - HH Electrification Status of India and Uttarakhand

Looking further at the district wise data on number of un-electrified villages (***see Figure 1.9***) it can be seen that Uttarkashi district has the highest number of un-electrified households at 48%. Several other districts like Champawat, Pithoragarh and Bageshwar also have considerably high percentages of un-electrified households.

(Source: Saubhagya Scheme, GoI)

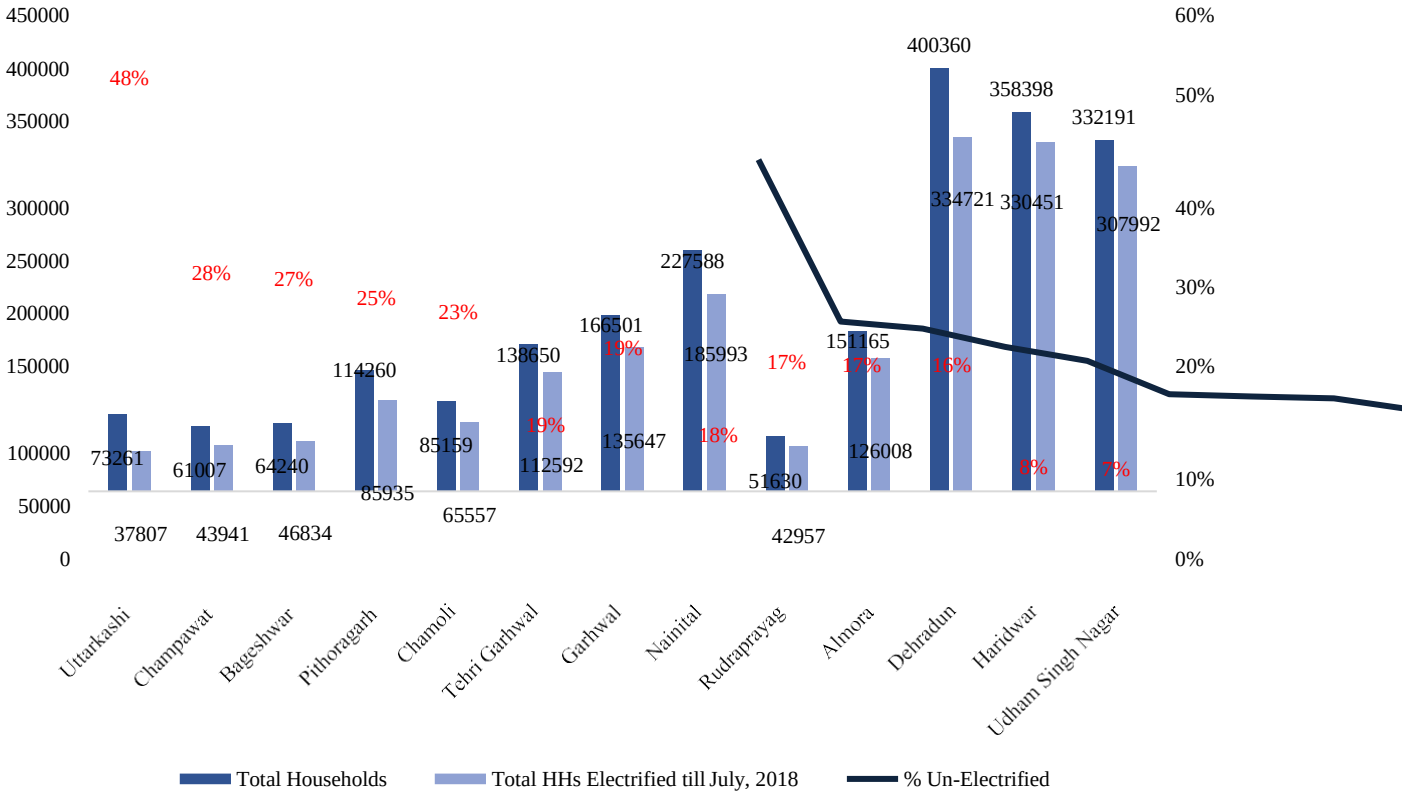


Figure 1.9 - District-wise HH status of electrification in Uttarakhand (2018)

The state has set itself an ambitious target of completing electrification of all households by December, 2018, which is three months before the GoIs target of March 2019. The quality of service has also improved in recent years – the state is already supplying power to the extent of almost 24 hours in urban areas, 22-24 hours in rural areas and 19-22 hours to the industries[18].

[17] http://saubhagya.gov.in/
[18] Power for all report-2017, Joint initiative of GoI and GoU

1.2.1 Installed Capacity

India and Uttarakhand

Presently, the total installed capacity in India is about 344 GW as on March, 2018. The largest share this is of Thermal Power (196 GW: about 57%) followed by Renewables (69 GW: about 20%) and hydro power (45 GW: about 13%). Details are given in ***Figure 1.10*** below. In line with its aim to reduce the dependency on conventional energy sources, GoI has set an ambitious target of achieving as much as 175GW of renewables based installed capacity by 2022. Although this might lead to progressive reduction in the share of coal-based thermal power generation in the country's overall energy mix, this decline cannot be expected to be of any substantial magnitude, at least in the near future. This is because prevailing issues in the Indian Power Sector such demand growth patterns, technical constraints, equipment availability limitations, funds limitations, paying capacity limitations of consumers, etc. are very complex, dynamic and mutually dependent.

It is notable that a total of 99.2 GW capacity (excluding RES) has been added during the 12th plan period till March, 2017 against the target of 88.5 GW. Clearly, the target has been exceeded

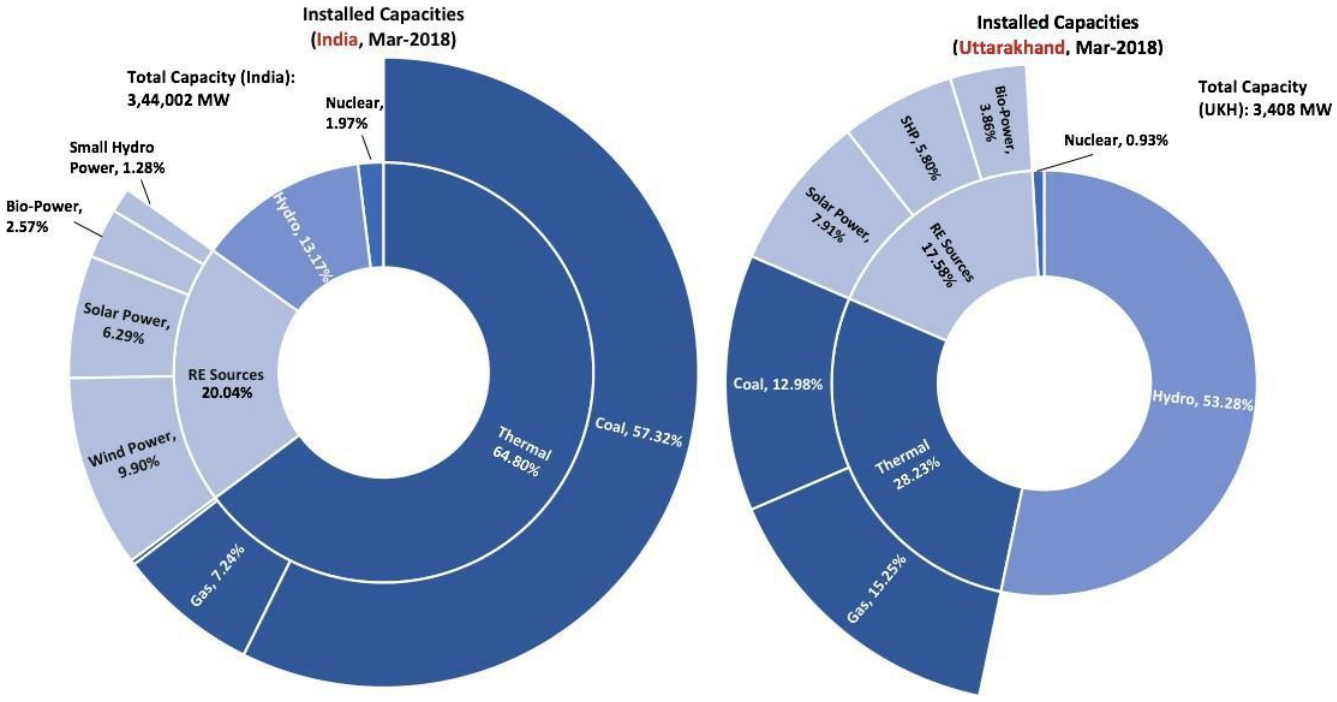


Figure 1.10 - Installed Capacity (India & Uttarakhand)

by as much as 12% which illustrates the aggressive stance of the Government in context of the power sector. Similarly, against an ambitious target of 175 GW of Renewables based installed capacity by 2022, about 62 GW is already installed and an ambitious bidding trajectory for 160 GW (100 GW from solar and 60 GW from wind) has been already laid out. One important outcome of the Government's emphasis on securing the power sector as illustrated above is that India has managed to attain 4th and 6th position in global Wind and Solar Power installed capacity[19] respectively.

Coming to Uttarakhand (see Figure 1.8 above), the total installed capacity of the state (3.4 GW) is just about 1% of that of the whole of India, bulk of which (about 53%) comes from large hydro power plants, followed by thermal (coal and gas: about 28%) and renewables (about 18%). It is prominently noticeable that the values for percentage share of renewables in the

[19] http://pib.nic.in/newsite/PrintRelease.aspx?relid=174832

overall installed capacity of Uttarakhand and whole of India are more or less of the same order i.e. 18% and 20% respectively. Also, what stands out from ***Figure 1.10*** is that within renewables, the percentage sub-shares of solar, mini-micro hydro and bio-power sources are also significant proportions and there is no absolute dominance of any single RE source.

Table 1.1 - Off grid Installed Capacities in Uttarakhand as on 31.03.2018 (MW)

Source	India (Source: MNRE)	Uttarakhand (Source: UREDA)
Small Hydro Power	-	7.73
Waste to Energy	172	0
Biomass Gasifiers	163	59
Wind Power	3	0.024
SPV Systems	671	36
Total	**1010**	**102**

A compilation of available data on off-grid RE installed capacities for India and Uttarakhand is given in ***Table 1.1*** above. The sources of this data are different for India and Uttarakhand. However, what is immediately apparent from this table is that installed off-grid RE capacity in Uttarakhand is almost 10% of that of the whole of India whereas its total installed capacity accounts merely for 1% of the country's total installed capacity. *Interestingly, it can be seen from the compilation that there is an obvious mismatch between the data maintained by MNRE and UREDA. While the MNRE data records no off-grid installed capacity for SHP anywhere in India, the UREDA data mentions a fairly significant figure of 7.73 MW (shown in red color) of off-grid SHP installed capacity currently prevailing in the state*.

1.2.2 Current Energy Availability and Consumption

Power Supply Position

Significant capacity addition over the past years has led to substantial improvement in the country's power supply situation compared to previous years. Latest CEA estimates (see ***Figure 1.11***) indicate that the country will achieve power surplus position in 2018-19. This is going to be a very significant jump in just one year from a deficit of -0.71% in 2017-18 to surplus of 4.61% in 2018-19. The situation with respect to peak demand is expected to improve from a deficit of –2% to a surplus of 2.46% in the same one-year period. The data trends are representative of the fruition of the Government's efforts to achieve energy sufficiency. However, as discussed earlier, issues such as grid extension to remote locations and ensuring uninterrupted supply are still need to be kept sight of.

Talking specifically of Uttarakhand on the other hand (***see Figure 1.11)***, the power supply scenario seems very different from the national picture. The state has an anticipated energy deficit of -5.28% in 2018-19 which is substantially higher than actual deficit of -0.23% registered in 2017-18. However, the state has successfully managed to meet its peak demand for power since 2015-16 as is evident from the equilibrium between the bars representing peak demand and peak met in the ***Figure 1.11***. The same is anticipated during this year as well.

Demand Projections

Table 1.2 below is a compilation of energy demand and peak demand projections for 2021-22 and 2026-27.

Table 1.2 - Energy and Peak Demand Projections

Year	Electrical Energy Requirement (MU)				Peak Demand (MW)			
	India		Uttarakhand		India		Uttarakhand	
	Projected value	Percent increase over 2017-18	Projected value	Percent increase over 2017-18	Projected value	Percent increase over 2017-18	Projected value	Percent increase over 2017-18
2021-22	15,66,023	17%	19,406	33%	2,25,751	25%	3,180	46%

2026-27	20,47,434	53%	26,480	82%	2,98,774	65%	4,538	108%

Source: National Electricity Plan, 2018

It is clear from the above table that the energy demand and peak demand for India are going to jump over and above current levels substantially by 17% and 25% respectively in 2021-22 while the corresponding increase for Uttarakhand is likely to be steeper at 33% and 46% respectively. For 2026-27 the demand projections show a further marked increase. For India, the energy requirement is slated to jump from as much as 53% while the peak demand is likely to shoot up to 65% of current levels. Similar is the scenario for Uttarakhand wherein the energy requirement and peak demand are expected to rise staggeringly to as much as 82% and 108% respectively.

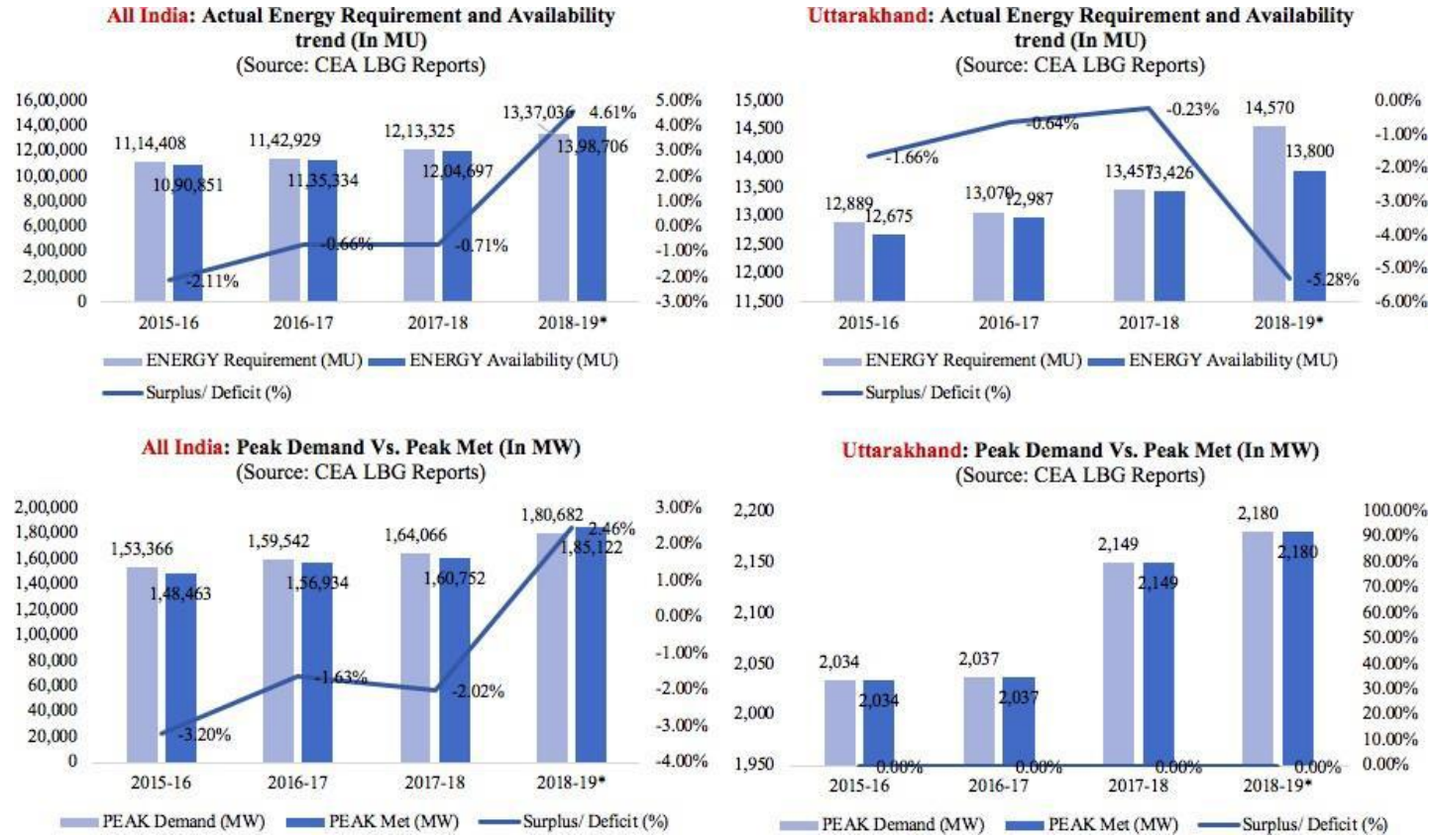


Figure 1.11 - Power Supply position of India & Uttarakhand

1.2.3 Renewable Energy Potential

The total Renewable Energy potential in the country as per the latest estimates (as of March, 2017) is 1,001 GW (see ***Figure 1.12***) in which a majority i.e. 95% is the share of solar and wind energy taken together. The balance 5% is constituted by other renewable sources such as biomass, small hydro, etc.

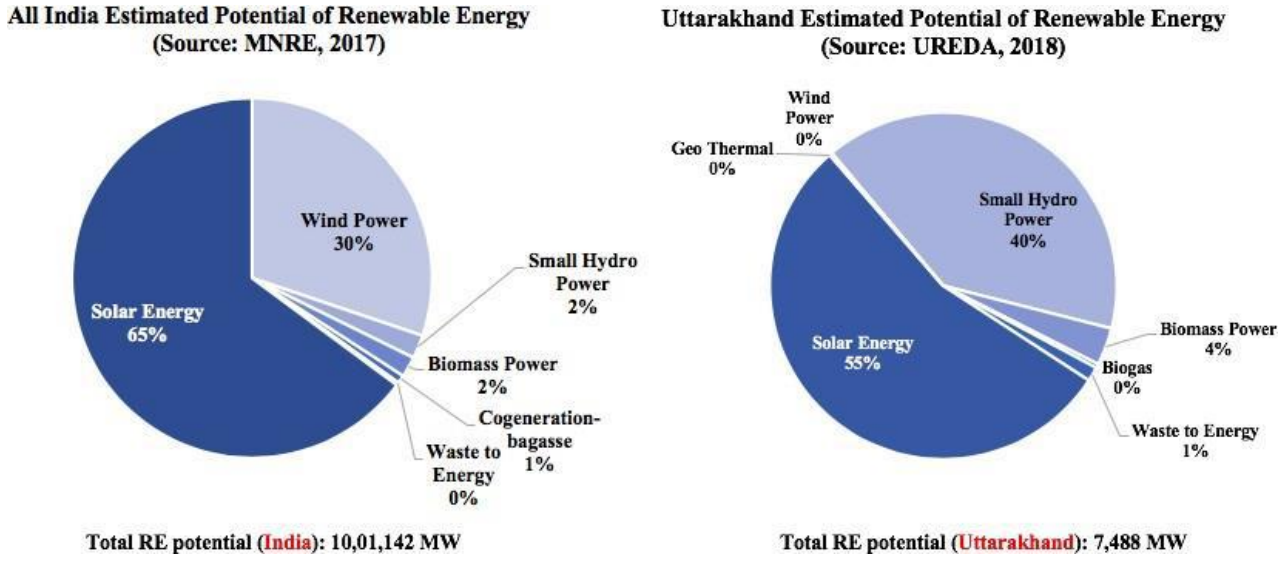


Figure 1.12 - Estimated Energy Potential (India & Uttarakhand)

In case of Uttarakhand, there is considerable difference in the estimated RE potential provided by different information sources. While MNRE estimates peg the total RE potential for Uttarakhand at around 18,000 MW, estimates provided by UREDA say that it is about 7,488 MW as of March, 2018. *For purpose of this DRE Plan document, it has been decided to adopt the UREDA value in order to align this report with their thinking as it is the apex agency responsible for planning and implementation of any renewable energy related programs and activities in the state*.

Therefore, it can be seen that the RE potential for Uttarakhand (as per UREDA's figure of 7,488 MW) is only about 0.75% of India's total RE potential. Interestingly, 95% of the RE potential of both India and Uttarakhand can be seen to originate from just two RE sources. While solar is common to both the national and state scenarios, in Uttarakhand's case, the second source is SHP as against wind in the national scenario. This is because potential for wind power in the state is almost negligible due to low annual average wind speeds (about 4 m/s) in all districts; but at the same time, potential for SHP is considerable on account of predominantly hilly terrain of the state. Consequently, only a meagre 5% energy potential is shared between biomass and other kinds of RE sources.

Uttarakhand has a potential of approximately 390 MW for generation of power through biomass. Only about 72 MW of this has been realized till date. We discuss below the details pertaining to biomass potential in Uttarakhand based upon crop production pattern, forest resources and industrial biomass sources.

Figures on availability of various kinds of crop residue in the state are compiled in ***Table 1.3*** below. The table shows that there is substantial surplus biomass in most districts of Uttarakhand. However, it is the districts located in the plains which have much higher surplus biomass than others.

Table 1.3 - Available Crop Residue in Uttarakhand[20]

District	Area (ha)	Crop Production ('000 TPA)	Biomass Generation ('000 TPA)	Biomass Consumption ('000 TPA)	Biomass Surplus ('000 TPA)
Udham Singh Nagar	260.5	3,171.0	1,317.9	983.8	334.1
Almora	124.9	156.6	494.2	368.9	125.3
Tehri Garhwal	90.1	152.0	447.2	333.9	113.4
Haridwar	168.1	4,323.1	624.2	465.9	158.2
Pithoragarh	79.9	129.7	254.0	189.6	64.4
Chamoli	45.4	73.5	190.2	142.0	48.2
Nainital	81.7	598.5	304.7	227.4	77.2
Uttar Kashi	47.5	79.7	189.2	141.2	48.0
Dehradun	73.7	541.1	279.1	208.4	70.8
Pauri Garhwal	124.7	126.6	232.9	173.9	59.0
Bagheshwar	47.6	55.1	145.9	108.9	37.0
Champawat	39.3	35.5	87.2	65.1	22.1
Rudraprayag	28.0	24.4	55.9	41.7	14.2
Total	**1,212.4**	**9,466.9**	**4,622.6**	**3,450.7**	**1,171.8**

Source Biomass Knowledge Portal 2009

Figure 1.13 below is a compilation of available woody biomass in Uttarakhand. The table is illustrative of the substantial quantities of woody biomass standing at just below 200 thousand cubic meters that could be harvested in the state. In addition, there are also profuse growths of shrubs like lantana which can serve as a very useful fuel, particularly for domestic uses. It is estimated that about 2,00,000 ha of land in Uttarakhand is covered with lantana vegetation. Based on certain calculations by experts, it is estimated that about 16,000 MT of lantana can be collected per year. Going by the above data, calculations (see ***Table 1.4*** below) shows that merely the amount of crop residues generated can support an installed capacity of as much as 143 MW.

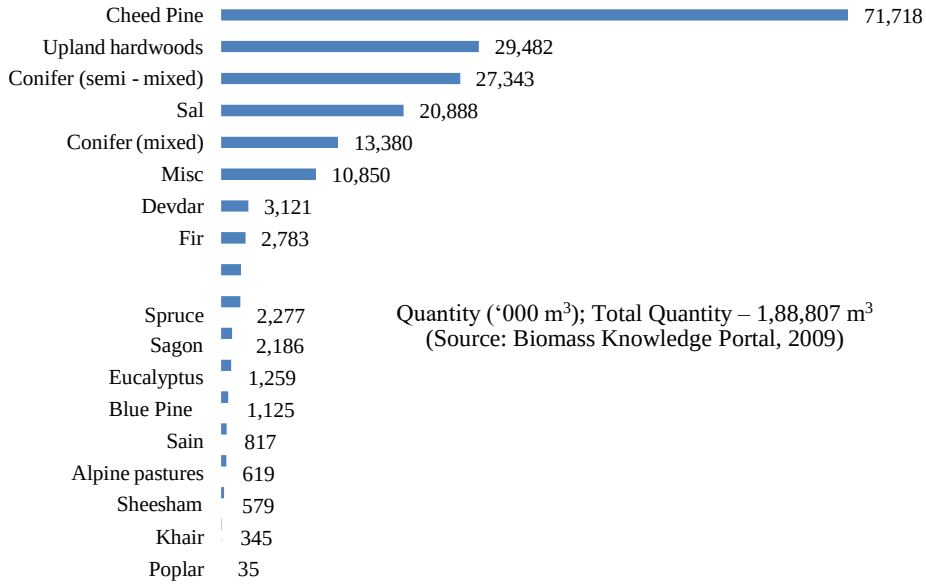


Figure 1.13 - Available woody biomass in Uttarakhand

Table 1.4 - Potential installed capacity in Uttarakhand based on crop residues

[20] https://biomasspower.gov.in/biomass-info-%20resource-%20other%20biomass%20studies-uttrakkhand.php

District	Biomass surplus from crop residues ('000 MT)	Biomass surplus from woods ('000 MT/yr)	Total surplus Biomass from crop residues & woods ('000 MT)	Potential Installed Capacity (MW)
Udham Singh Nagar	334.1	N.A	334.1	34.8
Almora	125.3	21.2	146.5	15.2
Tehri Garhwal	113.4	4.5	117.9	12.3
Haridwar	158.2	N.A	158.2	16.5
Pithorgarh	64.4	22.2	86.6	9.0
Chamoli	48.2	23.6	71.8	7.5
Nainital	77.2	19.8	97	10.1
Uttar Kashi	47.9	46.6	94.5	9.8
Dehradun	70.7	7.1	77.8	8.1
Pauri Garhwal	59.0	21.1	80.1	8.3
Bageshwar	37.0	23.4	60.4	6.3
Champawat	22.1	16.4	38.5	4.0
Rudraprayag	14.1	N.A	14.1	1.5
Total	**1,171.8**	**205.9**	**1,377.5**	**143.4**

Source Biomass Knowledge Portal 2009

Adding potential from other sources such as lantana, rice husk and bagasse, another 119 MW of installed capacity can be added (see ***Table 1.5*** below)

Table 1.5 - Power potential from other biomass sources in Uttarakhand

Type	Surplus biomass ('000 MT)	Power Potential (MW)
Lantana	16,000	1.7
Rice husk	1,42,791	15.7
Bagasse	12,86,058	101.5
Total biomass for power generation		**118.9**

Source Biomass Knowledge Portal 2009

Adding up the totals from the above two tables, it is estimated that the total biomass power potential in Uttarakhand is about 262 MW as given in ***Table 1.6*** below:

Table 1.6 - Total power potential from all sources

Type	Power Potential (MW)
Agro residues and woods	143.4
Rice husk	15.7
Bagasse	101.5
Lantana	1.7
Total	**262.3**

Source Biomass Knowledge Portal 2009

The State Government has recently recognized the potential of using pine needles for energy production, which otherwise are cause of numerous forest fires. The Pine Needles Policy, 2018 has been introduced recently which paves the way using dried pine needles for power generation and fuel. Since this is a relatively new development, the potential for energy production from pine needles has not been incorporated in the potential calculations for biomass power. According to the UREDA, the total area under Pine forests in the state is about 3.4 lakh hectares. These pine forests produce about 21 lakh tonnes of dry biomass every year in the state[21]. It is estimated that 1350 tonnes of pine needles are required per year for a 100KW gasifier running for 24 hours consuming 4.5 tonnes of pine needles per day. As per GoU estimates the potential installed capacity of pine needle-based power plants could be about 60 MW. Collection activity on pine needles is also likely to generate considerable employment.

[21] Pine needles Policy-2018, Government of Uttarakhand

Tapped RE Potential

Information on tapped RE potential was compiled from National level data obtained from MNRE publications and State level data provided by UREDA (*see **Table 1.7** and **Table 1.8***). The data confirms that only about 7% (69,022 MW[22]) of the country's RE potential has been tapped so far[23], of which the maximum tapped potential (48%) is interestingly of Biomass. Percentage of wind potential tapped is about 11% while solar energy is still mostly untapped at 3%. In comparison, almost 8% (600 MW) of the total RE potential Uttarakhand has been tapped (clubbing on-grid and off-grid installed capacities together).

Table 1.7 – Tapped Renewable Energy Potential (India)

Renewable Energy Sources		Approximate Potential (in MW)	Tapped Potential Status (in MW); (as on 31.03.2018)	% of RE potential tapped w.r.t. availability
Small, Mini & Micro hydel segment		21,134	4,418	21%
	Biomass	18,601	8,839	48%
Bio-power	Cogeneration bagasse	7,260	0*	0%
	Waste to Energy	2,554	114	4%
Wind		302,251	340,46	11%
Solar Power		649,342	216,51	3%
Total		**1,001,132**	**690,68**	**7%**

**Disaggregated data not available on tapped potential for off-grid*
Source: Energy Statistics, MNRE, 2018; CEA MPR (Mar, 2018)

Table 1.8 - Tapped Renewable Energy Potential (Uttarakhand)

Renewable Energy Sources		Approximate Potential (MW)	Tapped Potential Status (MW); (as on 31.03.2018)			% of RE potential tapped w.r.t. availability
			On-grid	Off-grid	Total	
Small, Mini & Micro hydel segment		3,000	190	7.73	197.73	6.59%
	Biomass	262	72.6	59	131.6	50.23%
Bio-power	Biogas (cattle dung)	29			0	0.00%
	Waste to Energy	100	-	-	0	0.00%
Wind		Negligible	-	0.024	0.024	-
Solar Power		4,077	233.68	36	269.68	6.61%
Geo Thermal		20	-	-	0	0.00%
Total		**7,488**	**496.28**	**102.75**	**599.03**	**8.00%**

Source: Administrative data sourced from UREDA, GoU

A look at ***Table 1.8,*** which compares the available potential for various RE sources in Uttarakhand with the corresponding figures for current tapped potential reveals that except for biomass for which more than 50% of the potential has already been tapped, the tapped potential for most other energy sources is less than 10% indicating thereby that there is a huge scope for using renewable energy sources for meeting the State's energy demand, It is estimated that the state would require additional 2,845 MW to be able to meet energy demand levels of FY19[24] which are estimated to be about 18,062 MU. What is notable is that the renewable energy potential of the state is adequate to meet present as well as projected levels of energy demand.

1.2.4 Projections/ Targets for Capacity Expansion

India

Available data on capacity expansion plans on pan India basis are summarized in ***Table 1.9*** below (***also see Figure 1.14***). The table shows projections for installed capacity of various

[22] Ministry of Power, Monthly Progress Report of Northern Region Power Committee (Mar-2018)
[23] Calculated from Estimated potential and RE installed capacity in India
[24] Power for all Report

conventional and renewable energy sources in the year 2021-22 and 2026-27[25]. It is apparent from the trends depicted in the table that the share of renewables in the country's overall energy mix will significantly increase from 20% presently to 36% by 2021-22 and further to 44% by 2026-27 which bodes well for the country from the angles of reduced pollution and spending of foreign exchange. Bulk of Renewable Energy capacity addition in 2021-22 is expected to come from solar (20%), followed by wind (12%). Biomass finishes a distant third at 2%. Also very much evident from the same table is the significant corresponding decrease in dependence on coal for thermal power generation.

Table 1.9 - Capacity Expansion Targets (Conventional and Renewable) for India

	S. No.	Energy Source	Current Installed Capacity (2018)	Projected Installed Capacity (India)		% Projected Installed Capacity w.r.t. Grand total		% potential tapped w.r.t. total estimated potential of respective Energy Source	
				2021-22	2026-27	2021-22	2026-27	2021-22	2026-27
Fossil Fuels	1.	Coal	197,172	217,302	238,150	45%	38%		
	2.	Gas	24,897	25,735	25,735	5%	4%		
	3.	Diesel	838	-	-	0%	0%		-
	4.	Nuclear	6,780	10,080	16,880	2%	2%		
	5.	Hydro	45,293	51,301	63,301	10%	10%		
		Sub Total A	**274,980**	**304,419**	**344,066**	**63%**	**55%**	**-**	**-**
Renewables	6.	Solar	21,651	100,000*		20%		15%	
	7.	Small Hydro	4,418	5,000	Bifurcation not Available	1%	Cannot be calculated	24%	Bifurcation not available
	8.	Wind	34,046	60,000		12%		20%	
	9.	Biomass	8,839	10,000		2%		54%	
		Sub Total B	**68,955**	**175,000**	**275,000**	**36%**	**44%**	**18%**	**28%**
		Grand Total	**344,002**	**479,418**	**619,066**	**100%**	**100%**		

Source: CEA MPR (Mar, 2018); National Electricity Plan, GoI (Jan, 2018)
**Break-up of the figure: 20,000MW-Solar power parks; 40,000 MW – Distributed Solar Generation; 40,000 MW – Roof top Solar generation*

Further, on comparing the tapped potential of renewables it found that if the RE targets set are achieved in time, the present tapped potential of RE in India i.e. 7% will shoot up to 18% in 2021-22 which is further expected to be increased to 28% in 2026-27. Biomass and Small Hydro capacities will be added to a great extent during the upcoming 3-4 years as depicted from their projected tapped potential of 54% and 24% respectively by 2021-22. Despite elaborate planning on tapping Solar Energy to the maximum, considering its massive available potential, only about 15% is expected to be tapped by 2021-22. Based on incremental trends, it could be said that almost the entire biomass potential would get tapped by 2026-27. However, the accuracy of these estimates cannot be relied upon fully due to data limitations.

Looking at the projections in ***Figure 1.14*** below, it can be seen that ambitious target of achieving 175 GW of RE installed capacity by 2021-22 would account for a net increase of 154% over and above the present. Looking exclusively at solar energy however, it can be noted that the projected installed capacity could register a marked increase of as much as 362% if the capacity addition targets set for 2021-22 are to be accomplished even though this may still lead to realization of only 15% of the available potential.
A look at data on future projections for likely power generation from renewable sources (*see **Table 1.10**)* in the country shows that the planned cumulative capacity of renewables in 2021-22 and 2026-27 (including added capacity) would be successful in meeting about 21% and 25% of the projected energy demand (1566 BU in 2021-22 and 2047 BU in 2026-27) respectively

[25] Installed capacity projections for individual renewable sources were not available for the year 2026-27; however overall (combined) projections were available.

for the corresponding period. It indicates that dependency on conventional sources of energy for power generation will reduce over time and will be replaced by RE.

Table 1.10 - Projected power generation from RES in India

Year	Estimated Total Energy Demand (BU)	Projected Generation from RES (BU)					%age of total energy demand that can be fulfilled by RES
		Solar	Wind	Biomass	SHP	Total	
2021-22	1,566	162	112	37	15	326	20.8%
2026-27	2,047	243	188	63	24	518	25.3%

Uttarakhand

The picture in respect of capacity addition targets for Uttarakhand is at considerable variance from that of the whole country as discussed above. As per available data, the state is planning major capacity addition in respect of thermal and hydro power plants (some figures had to be back-calculated on basis of available figures of other energy sources and total projected capacity since direct references were not available. These figures are shown in red color in the table). While the capacity addition in terms of renewables is also substantial, it would still stand at only about 23% in the overall share in 2021-22 (***see Table 1.11***). ***Figure 1.15*** below also gives specific targets for Uttarakhand's RE based installed capacity. As can be seen from the Figure, bulk of planned added capacity is in solar (900 MW) and MMHP (700 MW).

(Source: CEA MPR (Mar, 2018); National Electricity Plan, GoI (Jan, 2018))

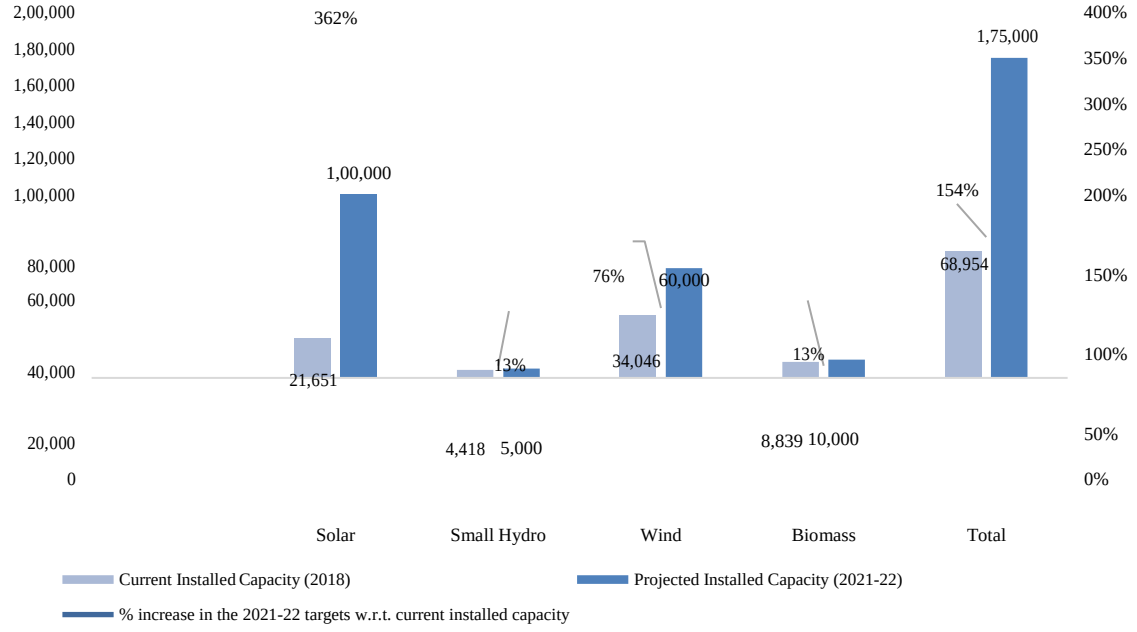


Figure 1.14 - Current Vs. Projected Installed Capacity of RE Source in India by 2021-22

While presently, the installed RE capacity in Uttarakhand constitutes around 17.5% of the total energy mix of the state, the same is expected to increase to 23% by 2021-22 if the RE targets set for state are to be achieved. Solar energy is going to continue to hold the maximum share as its current share of 45% in the RE mix is likely to exceed 50% by 2021-22. The next largest share is likely to be that of Small Hydro power.

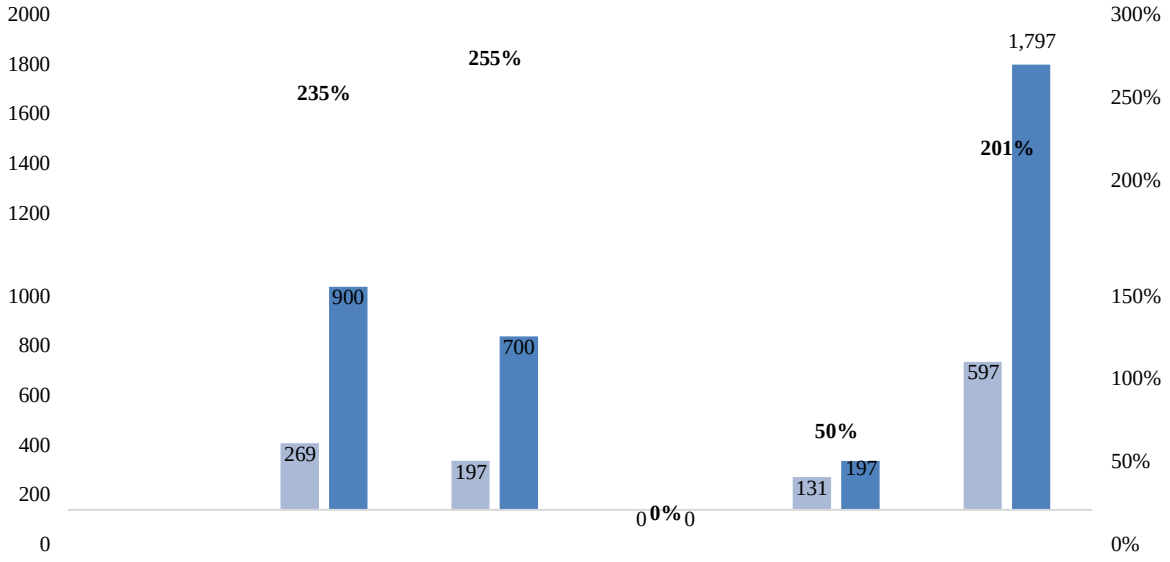
With this, the percentage of tapped RE potential in the state will increase almost three-fold i.e. from 8% to 24% within a span of 3-4 years from now. UREDA will play a key role in executing the GoI and state interventions/ programs so as to achieve the set target in stipulated time frame.

Table 1.11 – Energy Capacity Expansion Targets of Uttarakhand by 2021-22

	S. No.	Energy Source	Current Installed Capacity (2018)	Projected Installed Capacity by 2021-22 (MW)	% Projected Installed Capacity w.r.t. Grand total (MW)	% potential tapped by 2021-22 (w.r.t. total potential)
Fossil Fuels	1.	Coal	442	2844	37%	
	2.	Gas	519	900*	11%	
	3.	Diesel	0	0	0%	-
	4.	Nuclear	31	0	0%	
	5.	Hydro	1815	2230*	29%	
		Sub Total A	**2808**	**5974**	**77%**	
Renewable	6.	Solar	269	900	12%	22%
	7.	Small Hydro	197	700	9%	23%
	8.	Wind	0	0	0%	0%
	9.	Biomass	131	197	2%	75%
		Sub Total B	**599**	**1797@**	**23%**	**24%**
		Grand Total	**3407**	**7771**	**100%**	**100%**

Note: Figures shown in red color have been back calculated from available figures for installed capacities of other energy sources and totals as they were not quoted in any source
** http://www.cea.nic.in/reports/committee/scm/allindia/notices/3rd_briefnote.pdf*
@ https://mnre.gov.in/sites/default/files/uploads/Tentative-State-wise-break-up-of-Renewable-Power-by-2022.pdf

(Source: Compiled from CEA and MNRE Reports, 2018)



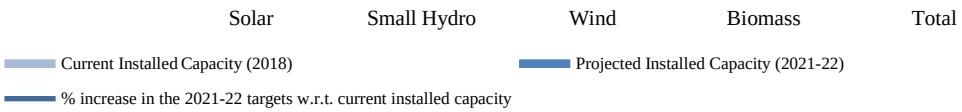


Figure 1.15 - Current Vs. Projected Installed Capacity (2021-22) of RES in Uttarakhand

When the targeted installed RE capacity is compared with the current installed RE capacity in the state (see ***Figure 1.15***), it is apparent that there will be a jump of more than 200% in by 2021-22. The individual RE source wise targets as well as the overall consolidated picture are also depicted in the same Figure.

1.3 About Decentralized Renewable Energy

The term "Decentralized Renewable Energy (DRE)" has been in use since more than four decades. Some definitions for the term are compiled in the ***Table 1.12*** below:

Table 1.12 - Definition of DRE by different sources

Definition of DRE	Source
Decentralized (or distributed) renewable energy (DRE) refers to any system that uses renewable energy to generate, store (in some cases) and distribute power in a localized way. Three categories of RE systems could be included in this definition: • *Small stand-alone devices (such as solar lanterns or advanced biomass cooking stoves);* • *Integrated home systems (SHS) which power multiple devices or appliances for a single household; and* • *"Small" generation and storage resources (typically between 1 kW and 10 MW) 2 that feed isolated or localized distribution networks (mini-grids or micro-grids)*	*REEP*[26]
It broadly refers to energy that is generated off the main grid, including micro-renewables, heating and cooling. It can refer to energy from waste plants, combined heat and power, district heating and cooling, as well as geothermal, biomass or solar energy.	*Carbon Trust*[27]
A decentralized energy system is characterized by locating of energy production facilities closer to the site of energy consumption.	*UNESCAP*[28]

The general sense coming out of the above definitions is that the acronym DRE refers to localized generation and consumption of electricity in areas not fed by a "centralized" grid. In very early times, decentralized energy generation was in the form of diesel or kerosene based gensets installed in remote inaccessible areas. However, the term became more commonplace with the advent of renewable energy sources and was used in context of situations where local production and consumption of energy was achieved through a locally installed renewable energy based device.

With renewables now becoming a significant source of energy in the country's energy mix, the situation is now changed and so has the context in terms of usage of the term "decentralized energy". The changed circumstances are given in ***Table 1.13*** below:

Table 1.13 - Decentralized Energy connotations (Earlier and Current Context)

Earlier Context	Current Context
Electrical Energy Supply was the sole domain of the Government. Power generation by private players was not legally permissible	Generation of power by private parties is now legal and technology/fuel neutral.
The country had multiple grid networks having their own generating power stations (mostly thermal) set up for servicing different regions	All regional grids are now interconnected into a single National Grid, which is continuously being expanded to cover more and more areas.
Power production for distribution through the grid was completely mandated and managed by the Government's agencies	Although distribution is still predominantly managed by the Government, the National Grid receives power from Government owned as well as private power producers. In specific areas, even distribution has been privatized
Only large power producing plants were deployed to feed into the grid	As per latest policies, even small and tiny power producers (like rooftop solar) are eligible to feed power into the grid. Contributors of power are

[26] https://www.reeep.org/sites/default/files/Scale_and_Sustainability_PowerInIndia_ForScreens.pdf
[27] https://www.carbontrust.com/news/2013/01/decentralised-energy-powering-a-sustainable-future/

[28] https://www.unescap.org/sites/default/files/14.%20FS-Decentralized-energy-system.pdf

Earlier Context	Current Context
	now eligible to receive attractive compensation for the power contributed by them to the Grid
The distribution network was sparse and did not reach several large tracts of the country	The distribution network has been extended and expanded so much that it has now covered almost the entire country
It was easy to distinguish between "Centralized Energy Supply" and "Decentralized Energy Supply":	In the current situation, there are several overlaps which make it difficult to classify any particular situation as "Centralized" or "Decentralized". For instance:
Any power produced that fed into the Grid was "Centralized";	• Since Grid is available almost everywhere and anyone can feed into it irrespective of the size of their power plant, would everything be called "Centralized"
Any energy production that happened locally and served a localized user base not served by the Grid was "Decentralized"	• Some prevailing examples of "Decentralized Energy Supply" consist of large and extensive local grids supplying multiple villages, habitations and even industries. • People have started using small decentralized systems such as solar lanterns, solar home systems, solar pumps in areas which are also connected to the Grid. Would it be appropriate to categorize them as "Decentralized"?

For purposes of this report and in light of the above discussion, it has been decided to adhere to the prevailing definition of the term "Decentralized Renewable Energy" as *power from renewable energy sources which is produced and consumed locally. However, it is also recognized that in the current changed situation, the owner / manager of the DRE installation will have the discretion to feed all or part of the power produced to the grid.*

2. Methodology and Data Collection

The assignment began with an initial round of internal discussions at Delhi office of CLEAN to understand the overall objective and scope. The Project Team followed up with a series of meetings with key UREDA officials, officials from relevant line departments including field visits to selected locations in Dehradun district with a view to understand the State Government's vision with respect to DRE applications for the State. An additional aim of the exercise was to collect primary data and information to support the plan preparation.

Understanding the State's Vision

Consultation with UREDA officials provided some clarity on their perspective towards DRE applications in the State. It was noted that the State Government's *primary* focus was on fulfilling its promise to the people of providing 24×7 power for all. *Secondly*, it was looking at reliable options to enable and ensure maintenance of a certain basic level of uninterrupted power supply services to remote and inaccessible areas of the State particularly during major natural calamities or disasters, to which state is highly prone, especially during monsoons. *Thirdly*, it was also looking at options to leverage the intended improved energy security it has resolved to create through DRE to foster gainful and sustainable rural livelihood activities amongst the marginalized.

Against the above backdrop, the following five emerged as sectors of interest from the point of view of preparation of the DRE Plan: (i) Agriculture; (ii) Institutional buildings; (iii) MSME; (iv) Livelihoods; and (v) Domestic energy applications.

Primary Data Collection

Following are the key sources tapped for collection of primary data:

(i) Consultation Workshop with NGOs/CBOs - A consultative workshop with local/ regional NGOs, working for livelihoods and energy sectors, is organized on July 4, 2018 at UREDA premises to discuss the livelihood activities presently being undertaken and existing grassroot challenges. The objective includes:

a) To understand the scope and coverage of livelihood activities being undertaken in the state presently;
b) To assess whether energy is a limiting factor for any of the livelihood activities and possible reasons for the same;
c) To collect the primary data/ information regarding challenges being faced by NGOs/ CBOs in the existing intervention/s and their repercussions;
d) To brainstorm on how to tackle the existing challenges focusing the role of energy.

(ii) Meeting with UREDA – UREDA being the nodal department for which the plan is being prepared was consulted for their insights and perspectives. Besides, relevant data such as estimated RE potential, budget allocation, installed capacities for RE etc. were also obtained from UREDA to feed into the preparation of this plan.

(iii) Meetings with other Government Departments – Meetings were also lined up with certain relevant departments and institutions such as Department of Industries, Confederation of Indian Industries, State Rural Livelihoods Mission, Uttarakhand Power Corporation Limited, etc. to seek their input/s and collect primary and secondary data/ information on relevant aspects. Details pertaining to the abovementioned meetings are provided at ***Annex-I: Meetings with UREDA and Government Departments*.**

(iv) Field Visits – The team undertook field visits to 6 MSMEs to get an idea of aspects like energy requirements, sources of energy, costs incurred and challenges, if any. Details are presented in

(v) ***Annex-II: State level NGOs*** *Workshop***.**

Secondary Data Collection and Analysis

Desk review of various reports published by Uttarakhand Government, Government of India, related NGOs and Research organizations is done with the following perspectives:

(i) Situation assessment of Uttarakhand in accordance with sectoral goals/ objectives
(ii) Calculation and estimation of important determinants of energy situation pertaining to various sectors relevant to this report

Preparing the Plan

The steps involved in DRE Plan preparation will be as follows:

(i) **Step-1**: Reviewing secondary literature and preparation of a baseline (relevant to DRE) for the five selected sectors, namely Agriculture, Institutional Buildings, MSME, Rural Livelihoods and Domestic Energy Applications
(ii) **Step-2**: Analysis of the above to arrive at a DRE Plan with a planning perspective till the year 2025

3. Baseline for DRE Action Plan

Key Sectors for DRE Interventions
As per initial directions from CLEAN and UREDA, the DRE Plan for Uttarakhand is to cover five important sectors that could potentially benefit from DRE interventions. These are:

1. **Agriculture**: Activities related to farming that could benefit from DRE
2. **Institutional Buildings**: There are several institutional buildings and campuses for which energy requirements could be met through DRE
3. **Micro, Small and Medium Enterprises (MSME)**: These are small industries that could gainfully utilize DRE to enhance their products and maximize profits
4. **Rural Livelihoods**: These are tiny entrepreneurial activities or cottage based vocations pursued by villagers for earning their livelihoods
5. **Domestic or Household Level Energy Consumption**: Energy consumption in domestic chores such as cooking, lighting and operation of domestic appliances

The rationale for selection of these sectors becomes clear from ***Figure 3.1*** below which depicts the trend of electricity consumption in these sectors in the previous years in Uttarakhand.

The trends of 2 fiscals are indicative of the fact that Industries sector consumes most of the energy (55%) followed by Domestic sector (23%). Lowest in the category is Agriculture which consumes 14% of the electricity[29]. It can also be noted that the variation in the consumption over the two FY compared shows minimal difference for all the sectors. A slight decrease in industrial consumption though, indicates the use of energy efficient equipment and increased use of solar rooftops as a result of government interventions to promote clean energy in the state. However, since all these sectors are fairly energy intensive, it is reasonable to expect that DRE interventions could play a significant role in not only enhancing their performance but also reducing emissions thereby contributing towards a sustainable tomorrow.

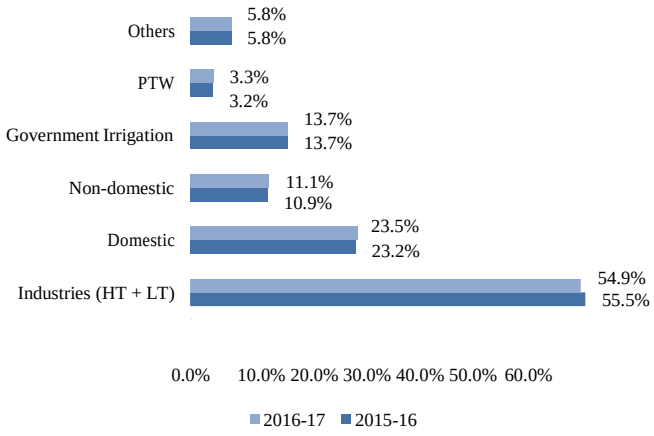


Figure 3.1 - Electricity consumption (%) by different sectors in Uttarakhand (Source: UPCL Tariff Order, Mar-2018)

[29] https://www.upcl.org/wss/downloads/TariffApr_2315.pdf

3.1 Institutional Buildings

Premises of existing institutional buildings can be ideal from the DRE applications[30] point of view. This section attempts to compile available data on Educational institutions, Heath centres, Anganwadi centres, Gram panchayats and Common Service Centres in Uttarakhand where DRE installation could be considered.

3.1.1 Educational Institutions

Schools

The total number of schools in Uttarakhand is 23,675. As can be seen from ***Table 3.1*** below, about 27.5% of these are unelectrified as of 2016-17. Chamoli and Pittoragarh districts of hilly region seem to have highest number of un-electrified schools whereas in Haridwar and Udham Singh Nagar districts (in the plains) around 90% of the schools are electrified. Incidentally, the enrollment in most schools is satisfactory which is indicative of the fact that availability of electricity does not have any major impact on enrollments in Uttarakhand.

Table 3.1 - Status of electricity in Uttarakhand Schools

S. No.	Districts	Number of Schools				% schools with electricity	Overall Literacy Rate (%)
		Govt.	Private	Madarsas & Unorganized schools	Total		
1	U S Nagar	1140	882	113	2135	91.5	74.4
2	Dehra Dun	1379	1045	33	2457	91.2	85.2
3	Haridwar	926	893	129	1948	88.7	74.6
4	Nainital	1413	549	31	1993	82.6	84.9
5	Pauri Garhwal	2237	423	0	2660	76.5	82.6
6	Bageshwar	816	154	0	970	72.7	80.7
7	Rudraprayag	804	197	0	1001	71.2	82.1
8	Uttarkashi	1113	237	2	1352	69.7	76.0
9	Tehri	2069	407	12	2488	64.6	75.1
10	Almora	1866	347	15	2228	61.3	81.1
11	Champawat	716	134	2	852	60.8	80.7
12	Pithoragarh	1649	266	41	1956	49.4	82.9
13	Chamoli	1386	233	16	1635	45.2	83.5
	Total	**17514**	**5767**	**394**	**23675**	**72.5**	**79.6**

Source: Elementary Education School Report Card, U-DISE (2016-17)

As about 27.5% of the schools amounting to about 6,629 numbers are not connected to the grid. These schools could be potential for immediate DRE applications. Nevertheless, the electrified schools could also opt for installing DRE for improving their supply quality as well as for selling to the grid.

Further, most Government run schools are expected to provide midday meals (MDM) to the students. For this the usual fuel used was firewood. However, lately the Government has started providing subsidized LPG cylinders to schools for the midday meals program.

[30] Mikul Bhatia and Nicolina Angelou, BEYOND CONNECTIONS. Energy Access Redefined (Energy Sector Management Assistance Program | The World Bank, 2015) https://openknowledge.worldbank.org/bitstream/handle/10986/24368/Beyond0connect0d000technical0report.pdf?sequence=1

Table 3.2 - Number of Schools using LPG and Firewood for Cooking MDM

Uttarakhand	LPG	Firewood	Total
Schools with MDM facility	10,302	7,362	17,664
% w.r.t. total	58%	42%	

Source: MDM Division, GoU (June 2018)

As per latest updates, the GoU has already provided LPG to 58% of the schools (***see Table 3.2 above***). There is no information available at present on projections or plans for further enhancing LPG coverage in the state. However, the cooking cost of a midday meal per child per day is Rs.4.00 to Rs.6.00 per day[31] which is predominantly the fuel cost. It is therefore clear that even if LPG is provided to all schools, it will not completely offset firewood. Most schools still prefer to do the basic cooking such as boiling rice, dal, etc. on a biomass cook-stove and use the LPG stove only for the garnishing. Therefore, an improved biomass cook-stove is still relevant.

Energy requirement in Education facilities

It is an established fact that reliable power supply to educational facilities tends to increase the time students and teachers spend there[32]. With the advent of computers and smart classes the use of electricity has now expanded from mere lighting and air circulation to improved pedagogy. Use of computers in administrative functions and laboratory equipment also now demands power supply etc. Also as discussed above, schools have energy (fuel) requirement for cooking midday meals. This is provided by LPG and/or biomass.

Besides, the state government is also focusing on utilizing solar energy in schools to fulfil the daily cooking requirements. In light of this, about 6419 Dish type solar cookers have already been installed in the state till 2015-16, mostly in institutions like schools. ***Figure 3.2*** below gives the district-wise distribution on concentrating type solar cookers installed in the state. These solar cookers may have more utility value as they are able to create high temperatures within lesser time.

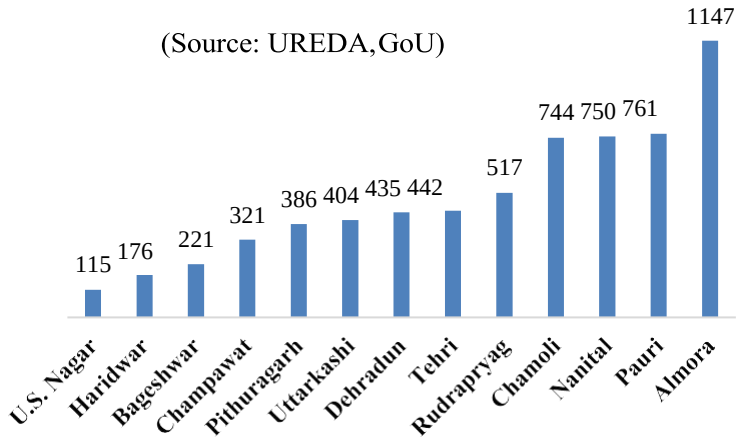


Figure 3.2 – Dish type Solar Cooker installed in Uttarakhand (2015-16)

According to an estimate, a rural primary school typically requires 4kWp and 25kWh/day as peak and daily mean power requirements [33]. It is also theoretically estimated that rooftop solar systems of 3kWp capacity could meet around 70% of the power requirement at primary schools at marginal operating costs. Therefore, off grid solar PV systems, can be installed for reliable power supply to the 27.5% schools which are yet to be electrified (as per U-DISE, 2016-17).

[31] http://mdm.nic.in/Files/PAB/PAB-2018-19/States/UK/4_FINAL-Appraisal%20note_UK--2018-19.pdf
[32] Mikul Bhatia and Nicolina Angelou, BEYOND CONNECTIONS. Energy Access Redefined (Energy Sector Management Assistance Program | The World Bank, 2015)

[33] Solar powering for Health and Education in India, Oxfam India (2016)

3.1.2 Health Institutions

Health facilities in Uttarakhand are located in the districts, sub-division, blocks and selected GPs. It is the sub-centres, Primary Health Centres (PHCs) and Community Health Centres (CHCs) that are relevant from the DRE applications point of view. A district wise compilation of the health facilities in Uttarakhand is given in ***Table 3.3.***

Table 3.3 - Health Centres in Uttarakhand

S. No.	District	Sub Centres	PHCs	CHCs	Total
1	Almora	206	28	4	238
2	Bageshwar	84	12	2	98
3	Chamoli	110	13	5	128
4	Champawat	68	6	2	76
5	Dehra Dun	175	23	7	205
6	Haridwar	160	28	6	194
7	Nainital	143	19	8	170
8	Pauri	239	32	5	276
9	Pithoragarh	155	18	4	177
10	Rudraprayag	68	13	2	83
11	Tehri	204	28	5	237
12	U S Nagar	153	27	6	186
13	Uttarkashi	82	10	4	96
	Total	**1847**	**257**	**60**	**2,164**

Source: HMIS, Rural Health Statistics, March 2017

Lowest value w.r.t. column

Highest value w.r.t. column

It can be seen from the table that the total number of health facilities in the state is 2,164 of which sub-centres are the most in number at 1,847.

According to a district level facilities survey done by GoI in 2012-13[34], it was found that 42% of the PHCs in Uttarakhand function without electricity or no regular power supply. In Udham Singh Nagar, only 12% of the PHCs were found to have regular power supply followed by 33% in Champawat and 43% in Tehri Garhwal. Over the years, the situation is improved but still there are many health centres devoid of desired power supply. According to HMIS statistics (Mar, 2017), 33% of 1847 sub-centres and 2.3% of 257 PHCs are operating without electricity (***see Figure 3.3***).

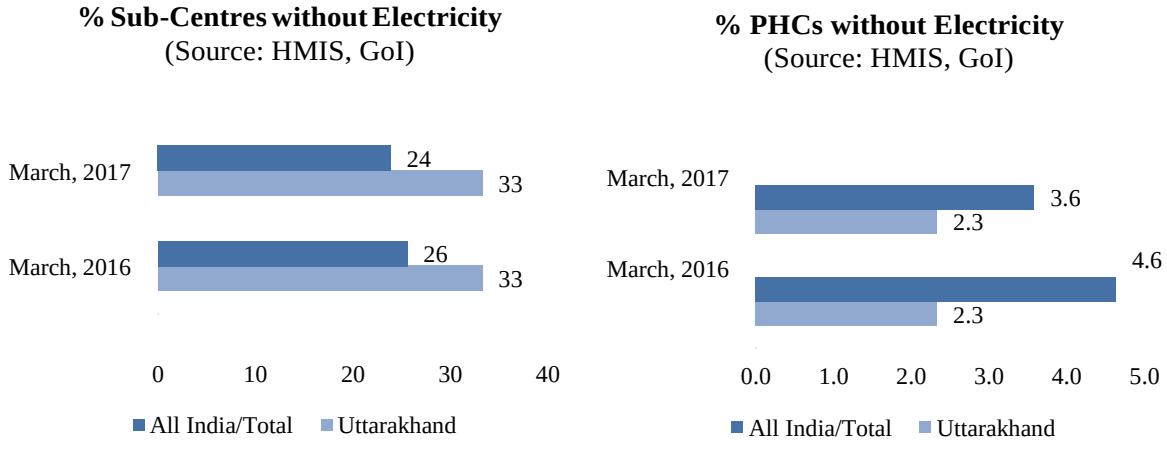


Figure 3.3 - Electricity status in Health Centres (India Vs. Uttarakhand)

[34] DLHS Facility Survey, GoI (2012-13)

Energy requirement in Health facilities

The National Health Policy 2017 reiterates the commitment to improve primary healthcare by strengthening infrastructure. Energy access in health facilities is a critical enabler of delivery of health services as various machineries/ equipment being used in the treatment are dependent of electricity. Lighting, air circulation, operation of diagnostic and administrative equipment and water heating are most important energy applications in health facilities. Health facilities also need to maintain a cold chain to store certain vaccines and pharmaceuticals. For these, uninterrupted power supply is essential. Last but not the least, Health Facilities also require appropriate fuel for cooking meals for inpatients.

As in the case of schools, a typical PHC requires about 7.5 kW of power and consumes about 45.8 kWh/day[35] of electricity. Another estimate by CEEW, recommends solar systems sized at 5 kW_p for PHCs, 1 kW_p for sub-centres and 8 kW_p for CHCs[36]. In addition, the PHCs and CHCs also have functional kitchens to serve meals to the inpatients. Therefore, there is fuel requirement for cooking, which may be provided by LPG or biomass.

3.1.3 AWCs, Panchayat Bhawans and Common Service Centres

Gram Panchayat buildings are available in most GPs from where various services of the GP are rolled out. In a GP office building, energy is required is for lightning, air circulation and operation of office equipment.

Anganwadi Centres (AWCs), provide care and services to pregnant and lactating mothers as well as infants and children up to 6 years of age. In case of AWCs, energy is required for lighting, air circulation and preparation of meals for children and pregnant / lactating mothers.

Common Service Centres established under the Digital India Program are another intervention of the GoI to link the community with e-Governance services. These centres assist the public in getting services for making Government identification documents. In most places, the Common Service Centre may be located in the GP office building or near it. The services of the CSCs are normally outsourced to private service providers who also invest in the premises and equipment. It is intended to establish at least one CSC in each GP of Uttarakhand. Accordingly, 8056 centres are ultimately likely to be established in the state. It is gathered that currently there are 3853 functional CSCs in the state as of 20 June 2017[37]. The Ministry guidelines necessitate each CSC to have a minimum of 1 laptops, 1 printers, one camera, one biometric scanner, broadband connectivity, power back-up and appropriate furniture, lights, fans, etc. Since most CSCs are likely to be located in GP offices, there is no need to consider them as a separate group of institutions for purposes of DRE planning as the DRE plan for the GP office will subsume the energy requirements of the CSC as well.

Table 3.4 below provides consolidated summary of all institutions present in the state. It is apparent that Champawat district has lowest penetration with respect to Schools, Health institutions and AWCs while Pauri Garhwal has highest penetration for Schools, Health institutions and Gram Panchayats.

[35] Solar powering for Health and Education in India, Oxfam India (2016)
[36] https://www.thehindu.com/opinion/op-ed/powering-rural-healthcare/article21419655.ece
[37] Ministry of Electronics and Information Technology, GoI 2017 (http://meity.gov.in/writereaddata/files/STATE-UT-WISE%20and%20DISTRICT-WISE%20CSC%20ROLL%20OUT%20STATUS%20AS%20ON%2030%20JUNE%2C%202017.pdf)

Table 3.4 - Overview of Institutions in Uttarakhand

District	Schools (incl. Govt., Private & Unorganized)	Health Centres (Incl. PHC, CHC, Sub-centres)	Operational AWCs	Gram Panchayats
Almora	2228	238	1190	1167
Bageshwar	970	98	558	416
Chamoli	1635	128	723	641
Champawat	852	76	397	313
Dehra Dun	2457	205	1654	460
Haridwar	1948	194	2845	304
Nainital	1993	170	1032	511
Pauri Garhwal	2660	276	1082	1216
Pithoragarh	1956	177	655	689
Rudraprayag	1001	83	459	339
Tehri	2488	237	1256	1108
U S Nagar	2135	186	2191	388
Uttarkashi	1352	96	666	504
Total	**23675**	**2164**	**14708**	**8056**

Source: Compiled from respective websites/reports of GoU (2018)

Lowest value w.r.t. column
Highest value w.r.t. column

Energy requirements of AWCs, Panchayat Bhawans and Common Service Centres

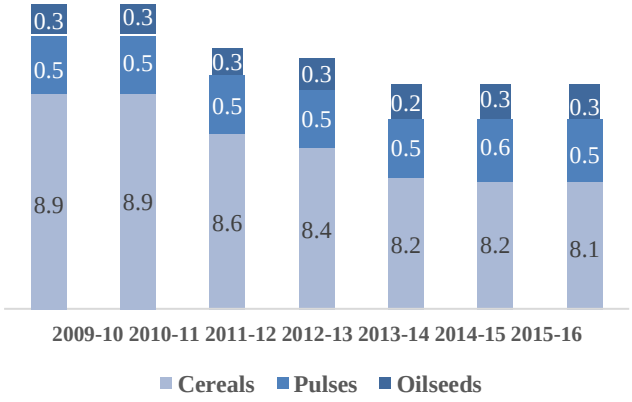
There are no set guidelines available for energy requirements of AWCs, Panchayat Bhawans and CSCs. However going by the equipment installed in them (***refer Annex-III: Equipment Installed in different Institutional Buildings***), their power requirements are likely to be as below:

1. Anganwadi Centre : 0.3 kW
2. Panchayat Bhawan : 1 kW
3. CSC : 0.5 kW

3.2 Agriculture

Agriculture is an important sector in the economy of Uttarakhand. The soil and weather conditions of Uttarakhand are widely varied and they support an equally varied mix of crops (depending upon location, of course) such as Basmati rice, wheat, soybeans, groundnuts, coarse cereals, pulses, mustard and other oil seeds. The terrain in Uttarakhand also favours several horticultural crops like apples, oranges, pears, peaches, litchis and plums. The hilly areas of the state are also suitable for cultivation of vegetables, mushrooms, medicinal plants and fodder. Given the pristine environmental conditions in the state, there is considerable scope for organic farming, which is becoming more and more popular.

Area under the major crops in Uttarakhand (In lakh hectares)
(Source: Statistical Abstract, GoUK; 2015-16)



Production of major crops in Uttarakhand (In '000' Metric Ton)
(Source: Statistical Abstract, GoUK; 2015-16)

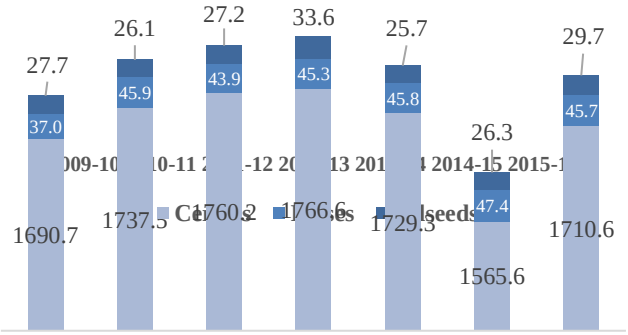


Figure 3.4 - Area and Production trend of Major Crops in Uttarakhand

Figure 3.4 above shows that that cereals are the most widespread crop in the state accounting for almost 90% of the cropped area in the state. Trends apparent from the Figure show that there has been a steady decrease in the area under three major crops: cereals, pulses and oilseeds[38]. Similarly, in terms of production also, cereals constitute the majority. Sugarcane is another significant crop from the plains of Uttarakhand. Current area under sugarcane is 100,737 hectares and its production in 2015-16 was 5,656,014 MT as against 6108965 MT during 2014-15. However, as per the Economic Survey Report (2017-18) of GoU the net sown area in the state has gone down from 7.7 lakh hectares in 2001-02 to 7 lakh hectares in 2015- 16.

3.2.1 Horticulture and Floriculture

Fruits, vegetables, spices and flowers are the major products in this category cultivated in Uttarakhand. Details of area, production and productivity of major Horticulture crops in the state are given in ***Table 3.5*** as under (2015-16):

[38] http://des.uk.gov.in/files/Statistical_Abstract_Book_-_All.pdf

Table 3.5 - Horticulture and Floriculture: Area and Production

Crops	Area (Thousand ha)	Production (Thousand MT)	Productivity (MT/ha) State	Productivity (MT/ha) National level	Rank in the Country-in terms of productivity	Rank in the Country-in terms of production
Fruit	175.3	659.1	3.76	11.70	30th	18th
Vegetable (including Potato)	89.8	945.4	10.52	17.30	23th	19th
Spices	12.6	85.7	6.82	1.80	01st	19th
Flowers (loose)	1.3	1.7	-	-	-	8th
Total	**279.06**	**1691.9**				
Flowers (cut)	*Area Included in above*	*Production- 14.71 Crore (no.)*				*2nd*

From the ***Table 3.6*** below which gives district wise details on fruit, vegetable and flower production, it is notable that area under and quantum of production of these commodities in Uttarakhand is substantial. While fruits and potatoes seem to be concentrated in the hill districts vegetables are mostly produced in the plains. Flowers are also predominantly produced in the plains while production of spices seems to be spread more or less evenly over hill and plains districts. Although spices and flower production may not be very significant from the National perspective, it is still substantial given the relatively thin population in the state.

Table 3.6 - District wise details of Horticulture Statistics in Uttarakhand (2015-16)

Horticulture Status in Uttarakhand (2015-16)												
S. No.	District	Fruits		Vegetables		Potato		Spices		Flowers		
		Area	Production	Area	Production	Area	Production	Area	Production	Area	Production	
											Spikes (lakh No)	Loose Flower (MT)
1.	Nainital	10835	109389	5877	59700	1835	26473	1425	8770	62	338	200
2.	US Nagar	7556	53138	7437	89986	2757	61036	1107	9341	99	184	55
3.	Almora	24162	175647	4436	43511	2444	53813	1222	9070	23	53	7
4.	Bageshwar	3538	12633	1577	8227	3490	5613	436	3532	14	0	4
5.	Pithoragarh	15717	46030	5359	72344	1783	45718	493	4826	5	02	6
6.	Champawat	8178	13471	3095	20965	1100	11670	660	4163	6	11	2
7.	Dehradun	26408	40059	9669	70755	2552	14853	1083	9002	195	101	506
8.	Pauri	20781	33330	4773	34508	1008	13973	791	3724	35	7	103
9.	Tehri	20943	28510	8221	73896	2528	49118	2435	16550	13	0	84
10.	Chamoli	3633	15212	2038	12217	539	6026	511	2687	37	0	11
11.	Rudraprayag	3110	2367	1005	3085	691	8720	545	2283	61	2	62
12.	Uttarkashi	15133	30626	6301	37371	3559	27927	767	2804	20	1	0
13.	Haridwar	15336	98683	4158	60552	1604	33304	1088	8987	767	771	709
	Total	**175330**	**659094**	**63945**	**587119**	**25890**	**358244**	**12564**	**85739**	**1335**	**1471**	**1748**

Source: State Horticulture Mission, GoU(http://shm.uk.gov.in/pages/display/6-state-profile)

**Area in ha and production in MT*

NOTE - All % are w.r.t. column-wise totals

Lowest value w.r.t. column

Highest value

Another important horticultural crop produced in Uttarakhand is mushrooms[39] in which DRE can play a substantial role. As can be seen from ***Table 3.7*** below, almost one tenth of India's mushroom production stems from Uttarakhand

Table 3.7 - Mushroom production in Uttarakhand and India (Metric Tonnes)

Types of Mushroom	Button mushroom	Oyster mushroom	Milky mushroom	Other mushrooms	Total
Uttarakhand	8,189	1,228	819	0	10,236
All India	94,676	21,272	3,184	10,650	129,782

Source: ICAR-DMR, Solan official data 2016

Since all these are short term perishable products, the need for an effective cold chain in the state seems justified, particularly underscoring the need to adequate cold storage facilities.

Medicinal Plants

There is considerable scope for growing medicinal plants in Uttarakhand. Currently the Government of Uttarakhand has appointed a nodal agency[40] to promote production and export of medicinal plant products in six districts: Chamoli, Dehradun, Haridwar, Pithoragarh, Udham Singh Nagar and Uttarkashi. Emphasis is on 10 high value species, which will be cultivated on about 500 ha land.

3.2.2 Livestock

Figure 3.5 summarizes the district wise status of livestock in the state. Interestingly, it can be seen that almost 31% of the state's livestock is concentrated in just one district: Udham Singh Nagar while other districts have between 3 and 10% of the livestock population in the state. DRE applications in respect of livestock are very limited in the Indian context as there are no energy intensive activities undertaken in its context requiring use of complex machinery such as milking machines, etc.

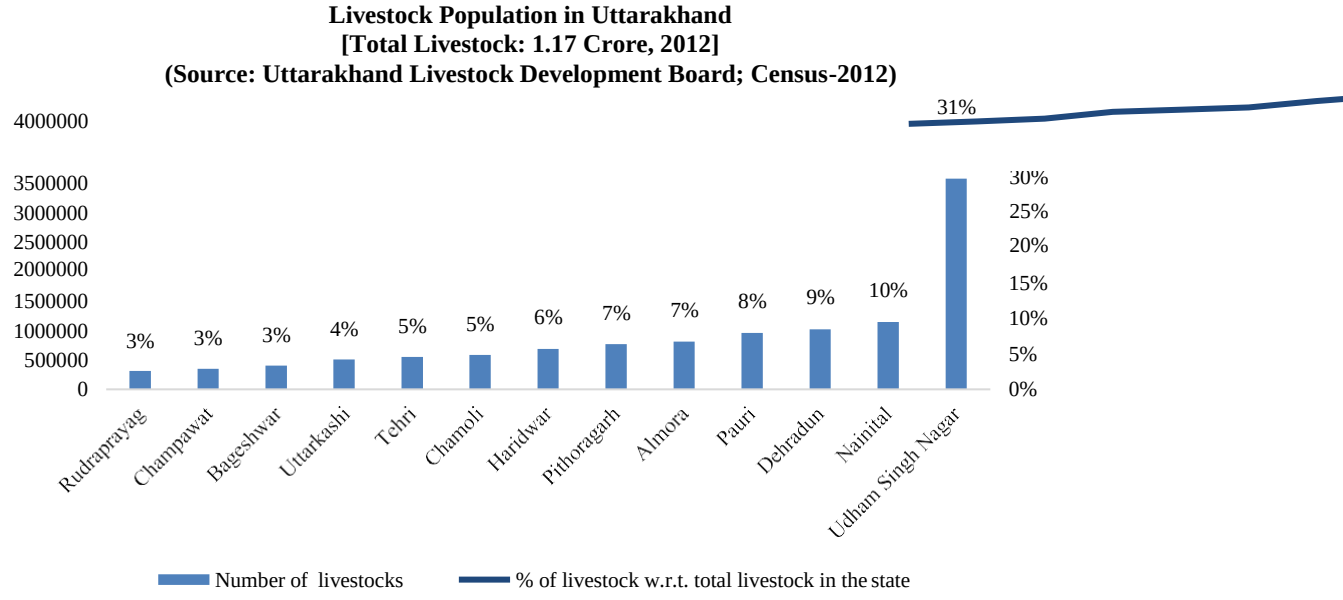


Figure 3.5 - District-wise livestock population in Uttarakhand

[39] https://www.researchgate.net/publication/322520732_Status_of_mushroom_production_in_India

[40] http://www.ijpab.com/form/2018%20Volume%206,%20issue%202/IJPAB-2018-6-2-455-464.pdf

3.2.3 Economic Categories of Farmers

Table 3.8 below gives the various economic categories of the farmers in Uttarakhand based on the land owned by them.

Table 3.8 - Economic categories of farmers in Uttarakhand

S. No.	Farmer Category	Size range of land holding (Ha)	Total Holdings		Area	
			Number	%	Ha	%
1.	Marginal	< 1.0	672138	73.65	295556	36.23
2.	Small	1.0 - 2.0	157330	17.24	225124	27.60
3.	Semi-medium	2.0 - 4.0	64781	7.10	175381	21.50
4.	Medium	4.0 - 10.0	17302	1.90	94220	11.55
5.	Large	> 10.0	1099	0.12	25401	3.11
	Total		**912650**	**100**	**815682**	**100**

Source: Statistical Abstract Uttarakhand, GoU (2015-16)

It is interesting to note that almost 90% of the land holdings of less than 2 hectares in size in the state belong to small and marginal farmers. The number of such holdings is more than 8 lakh. Again, the total aggregated area held by these two segments of farmers is more than 500,000 hectares. This scenario is quite suited for DRE applications as most small and marginal farmers live at scattered locations and there are challenges in providing reliable energy access to them.

3.2.4 Irrigation

Gross Irrigated Area of the state is only about 50% of the cropped area while the Net Irrigated area is only 30% of the total cropped area. Gross irrigation coverage is 94% in the plain areas of the state[41] but only 13% in the hilly regions.

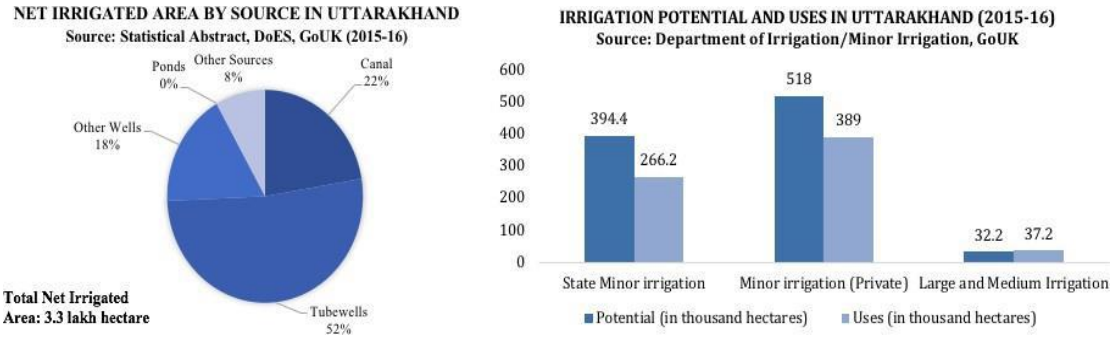


Figure 3.6 - Irrigation Status in Uttarakhand

While only about 30% of the overall cropped area in the state is irrigated, it can be seen from ***Figure 3.6*** that the most common mode of irrigation is minor irrigation which comprises of small irrigation schemes having a command area of less than 2000 hectares. Minor irrigation schemes may source water from small check dams or tubewells and may have a distribution system consisting of small watercourses or canals or even pipelines. Canals and tubewells are the main sources of irrigation in the plains. The most common source of irrigation (see ***Figure 3.6***) covering almost 52% of the irrigated area is tubewells followed by other wells and canals (40%). In the hills irrigation is done mostly by diverting water from streams or springs and conveying them to lower elevations through a network of small channels. Around 67% to 75% of the total potential for minor irrigation in the state has been tapped so far (see ***Figure 3.7)*** through government and private led interventions.

[41] Economic Survey Report (2017-18), GoU

Canals

Canals service about 22% of the irrigated area (mostly in the plains). The total length of canals in the state is more than 12,420 km of which 281 km are lift canals. The district wise lengths of irrigation canals in the state are given in ***Figure 3.7***. As expected, major lengths of irrigation canals are situated in the three districts located in the plains. These canals offer a good opportunity for installing canal top solar power plants.

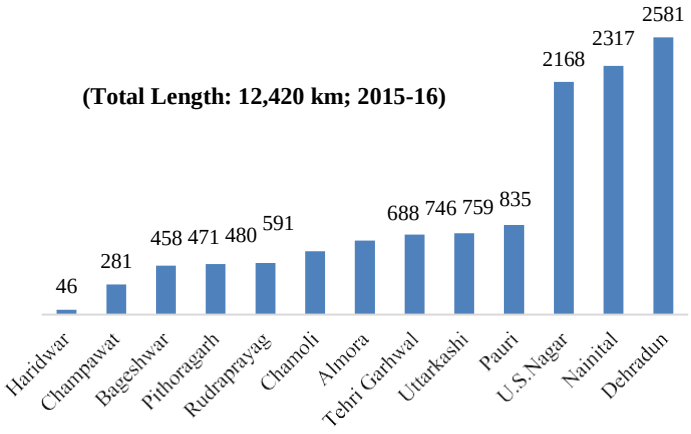


Figure 3.7 - Length of Canals (in Km) in Uttarakhand

3.2.5 Energy Applications in Agriculture

(i) Agricultural Pump-sets and other Minor Irrigation aspects

According to an estimate irrigation pump sets are the most predominant form of farm machinery typically used by farmers in Uttarakhand. They constitute 86% of the farm machinery used in the state[42]. The state has around 1500 tube wells for providing irrigation services to farmers in the state[43]. In addition, many farmers privately deploy irrigation pump-sets on their fields. In 2015-16, there were more than 55,000 pump sets in Uttarakhand, many of which were privately owned and 726 Government owned electric tube wells to support the minor irrigation works in the state (see ***Table 3.9***).

Table 3.9 - Status of Minor Irrigation Works in Uttarakhand (2015-16)

Districts	Boring Pump-sets/ Free Boring (No.)	Electric Tubewell (No.)	Hydram (No.)	Water Tank (No.)	Constructed Gool Length (km)
Almora	0	0	191	4614	2747.89
Bageshwar	0	0	93	1513	1467.63
Chamoli	0	0	171	3054	2430.95
Champawat	22	0	84	2750	1178.51
Dehradun	4	3	162	1769	3611
Haridwar	27437	251	0	0	147.32
Nainital	312	94	178	3660	2281.05
Pauri	75	0	184	7058	4507.45
Pithoragarh	0	0	191	4308	2011.06
Rudraprayag	0	0	34	550	549.05
Tehri Garhwal	0	0	77	5500	6041.6
Udham Singh Nagar	27291	378	0	0	419.48
Uttarkashi	0	0	112	2745	2824.47
Total	**55141**	**726**	**1477**	**37521**	**30217.46**

Source: Statistical Abstract (Department of Minor Irrigation), GoU (2015-16)

It can also be seen from the above table that maximum number of irrigation pump-sets are concentrated in Haridwar and Udham Singh Nagar districts. In addition to the above, the state also has a considerable number of hydrams (more than 37,000) though their operational status and area served were not immediately verifiable. The state also has a substantial network of informal/traditional micro irrigation channels called Gools, the total length of which is currently

[42] TERI Energy and Environment Data Diary and Yearbook 2016/17

[43] Irrigation Department, 2015-16

more than 30,000 km. Energy from decentralized renewable sources could not only help in realizing the untapped irrigation potential of the state but also trigger an increase in the gross and net irrigated area in the state.

(ii) Sprinkler and drip systems

Uttarakhand has 696 ha under drip irrigation[44] and another 316 ha under sprinkler irrigation systems (see ***Table 3.10***).

Table 3.10 - Area under sprinkler and drip irrigation in Uttarakhand (hectares)

	Drip	Sprinkler	Total
Uttarakhand	696	316	1,012
India	3,919,780	4,707,004	8,626,785

Drip systems in particular are very favorable for DRE applications. Given the significant area under drip, the state could consider DRE applications for drip irrigation at the policy level.

(iii) Tillage and Interculture

Most tillage related operations (ploughing, levelling, furrowing) are highly energy intensive and are usually undertaken through draft animal power or mechanized tillage equipment, interculture operations like weeding, spraying, dusting, etc. do not require very high energy inputs. In particular, interculture operations such as spraying are now finding DRE applications. One specific niche for DRE applications is what is known as Ultra Low Volume (ULV) spraying wherein the quantity of insecticide required is very low. The sprayers use for ULV spraying are very small, lightweight and handy. They are most suited for DRE applications.

(iv) Harvesting and Threshing

Harvesting and threshing operations require substantial energy and DRE applications in these operations may not be cost effective. However, winnowing (blowing of chaff by mechanically operated fan) is one sub-operation during threshing that is very suitable for DRE applications. Mostly hand operated winnowers are used by the farmers. These could easily be converted to solar energy

(v) Post-Harvest: Cold Storage

Discussions during the consultation with NGOs revealed that there is considerable lack of post-harvest cold storage infrastructure for fruits, vegetables and dairy products as well as limited accessibility of transportation in the hilly region. Both these together tend to limit productivity and sometimes cause heavy losses to farmers as well as other stakeholders. According to PHDCCI, nearly 35-40% fruits and vegetables perish every year due to lack of cold storage facility in the state[45]. With 46 cold storages, the cold storage capacity in the state is 1.6 lakh MT in 2016-17[46]. In addition to this, GoI has further sanctioned 20 additional cold storages in 2017-18, of which 16 have already been established. Typically, these facilities operate on grid power and are subject to irregular supply timings and incur substantial energy costs which are almost 20 to 30% of the total operational costs[47]. Though, some recent developments indicate that technology for solar cold storages has been developed, the capacity of these is considerably small and they may not be suitable for storing large quantities of agricultural produce. Currently there are only 10 solar-based cold storage facilities in the country (Chandrasekaran 2016) which serve small niche requirements only.

[44] Department of Agriculture, Cooperation & Farmers Welfare, GoU (https://eands.dacnet.nic.in/PDF/Glance-2016.pdf)
[45] https://www.hindustantimes.com/dehradun/officials-scuttle-cold-storage-plan-say-u-khand-has-enough/story-IT0rHI7RV1PdxDMm45HRdJ.html
[46] http://pib.nic.in/newsite/PrintRelease.aspx?relid=168990
[47] https://energy.economictimes.indiatimes.com/news/renewable/kor-energy-installs-solar-power-systems-at-cold-storages-in-haryana/61282859

3.2.6 Leveraging the Agriculture Sector for Energy Production

The Agricultural Sector now offers substantial scope for DRE production. Prominent amongst these are the following:

(i) Canal-Top and Canal Bank solar and SHP from Canals

This application has emerged fairly recently and has shown considerable degree of success. It is one example where the DRE infrastructure not only produces energy but also contributes to reduction in evaporative water losses in the canals thereby making additional quantity of water for irrigation available to the farmers. As mentioned in an earlier section, there are 12,420 km of canals in Uttarakhand which could easily be leveraged for this purpose. GoU has installed about 1 MW of Canal-top solar and another 19 MW of Canal bank solar in the state by 2017[48].

Similarly, it is possible to produce power from specific locations on the canal system through small hydro. However, this type of hydro-power production requires low head turbines which can be costly and large in size. Therefore, the potential for such tapping of energy is limited.

(ii) Solar Power Plants on Unculturable Waste Lands

Considerable stretches of land (almost 4% of the State's total area) are categorized as unculturable waste land (***see Figure 3.8 below***). Some of these may be privately owned, some are owned by village panchayats while others are owned by the Forest Department. Detailed ownership information on such waste land is not available. In case of the former two, DRE based energy production are very much possible.

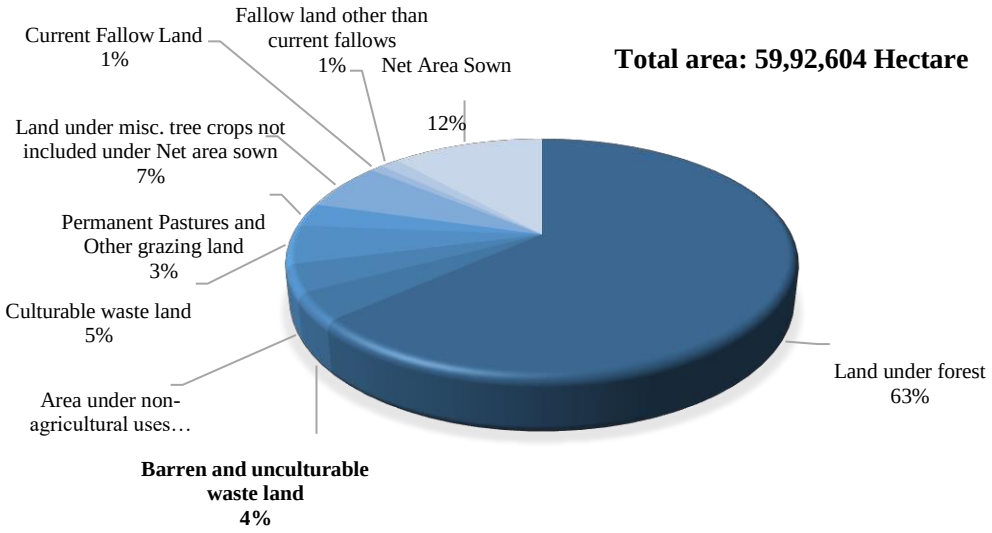


Figure 3.8 - Land use in Uttarakhand (2015-16)

Comments and Inferences

The Government of Uttarakhand has taken significant steps to support the agriculture, especially in hilly regions. Apart from various existing support schemes, the state government has recently obtained a World Bank loan of Rs.715 crore for development of agriculture in hilly regions of the state, which is expected to enhance livelihood avenues for the local population, thereby helping in reining the migration trends from these regions.

Table 3.11 - Summary of DRE applications in Agriculture

SUMMARY: DRE APPLICATIONS IN AGRICULTURE/HORTICULTURE		
SN	**Aspect**	**Description**

[48] Press Information Bureau, GoI (http://energyinfrapost.com/wp-content/uploads/2016/05/Factsheet-on-Canal-

top-scheme.doc)

1.	Irrigation	Operation of irrigation pump-sets on solar energy including those servicing drip and sprinkler irrigation systems
2.	Interculture	Operation of spraying and dusting equipment on solar power (particularly ULV spraying)
3.	Interculture	Protection of crops from wild animals through solar fencing
4.	Harvesting	Threshing and winnowing
5.	Post-Harvest	Solar / Biomass based drying
6.	Post-Harvest	Solar based mini cold storages
7.	Post-Harvest	Biomass/Biogas/LPG based heat applications for food preservation
8.	Post-Harvest	Dairy applications: milking of cattle, milk chilling, pasteurization
9.	Post-Harvest	Manufacture of processed foods / ingredients

Table 3.12 - Possibilities of leveraging Agriculture sector for DRE applications

POSSIBILITIES OF LEVERAGING AGRICULTURAL SECTOR FOR DRE APPLICATIONS		
SN	**Aspect**	**DRE Leverage Possibilities**
1.	Irrigation Canals	Canal top solar power production (12,420 km)
2.	Irrigation Canals	Mini-micro hydro power production
3.	Unculturable waste lands	Installation of solar power plants
4.	Crop Residue	Biomass based power production
5.	Crop Residue	Production of briquettes for industrial / domestic use

3.3 Rural Livelihoods

With progressively increasing GSDP and per capita income levels higher than the national average (***refer section-1.1.4***); Uttarakhand seems to project a picture as a relatively economically advanced state, holding the 6th rank in the country in terms of per capita income. However, in reality picture is rather skewed: development has predominantly taken place in the plains while the hill districts are lagging behind significantly as explained earlier. Variance in growth / development patterns between hilly and plain regions in the state has led to creation of a significant gap between the per capita incomes of people inhabiting the two regions[49].

In Uttarakhand, around 70% of the total population is involved in agriculture, primarily subsistence agriculture[50] and in case of almost all the hill districts, this is the only major economic activity. Now, being a farmer in the hilly districts of Uttarakhand is quite a difficult proposition as most fields (mainly terraces) are difficult to access by motorized transport. Then there are huge distances as well as elevation differences between the fields, grain markets and the farmers' residences. On account of the above constraints, agriculture is on a steady decline (***refer section-3.2***) as more and more farmers are opting to migrate to plain regions in search of alternative jobs or vocations[51]. Thus, one major challenge confronting the Government of Uttarakhand is the creation of sustainable alternative livelihoods so as to prevent these migratory trends from becoming a norm in the state (***refer section-1.1.5***).

Creation of sustainable livelihoods is a focus area of several NGOs active in the state. In addition, the Government has launched programs like the National Rural Livelihoods Mission (NRLM) and State rural Livelihoods Mission (SRLM) aimed at creating local rural livelihood opportunities for the people of Uttarakhand. The livelihood opportunities could be in the form of individual or group economic activities. However, one important factor affecting the viability and sustainability of such rural livelihood activities is availability of energy, which is hard to find in rural areas. Consequently, most small livelihood activities undertaken by rural inhabitants tend to not generate adequate returns or completely fail. It is DRE could play a major role in bridging this gap and foster lucrative and sustainable livelihoods in Uttarakhand. This section deals with possible rural livelihoods that could be enhanced through DRE applications.

3.3.1 Self Help Groups (SHGs)

The concept of self-help groups is not new and has been used to promote group savings that enable individual group members tide over financial crisis. Later, the idea of leveraging SHGs and their collective savings to enable members to undertake income generating activities was also mooted. Currently Uttarakhand has more than 4000 SHGs as of 2017, which is 84% of the target set for the year[52]. Latest data on SHGs penetration and activities indicates that more than 80% of the total SHGs in the state are functional in 5 districts majority of which are in plain regions i.e. Nainital, US Nagar and Dehradun. Presently many interventions for livelihoods creation are underway in the state under SRLM/NRLM initiatives, which include organic farming, dairy activities, animal husbandry, small commercial activities (shops, etc.), eateries and women managed enterprises. Animal husbandry, poultry, dairy, agriculture and small commercial activities like shops seem to be the most popular rural income generating activities, forming a major part (80%) of the rural livelihoods mix (***see Figure 3.9 below***). Some NGOs

[49] https://www.firstpost.com/india/uttarakhand-growth-inequality-is-emptying-out-villages-in-indias-sixth-richest-state-3326538.html

[50] Joshi, K.; Bhardwaj, N. Women and natural resource management: A study of 'communities of practice prevailing in women farmers' community management of water and forests of lesser Himalayan region in India. Int. J. Adv. Res. 2015, 3, 363–374.

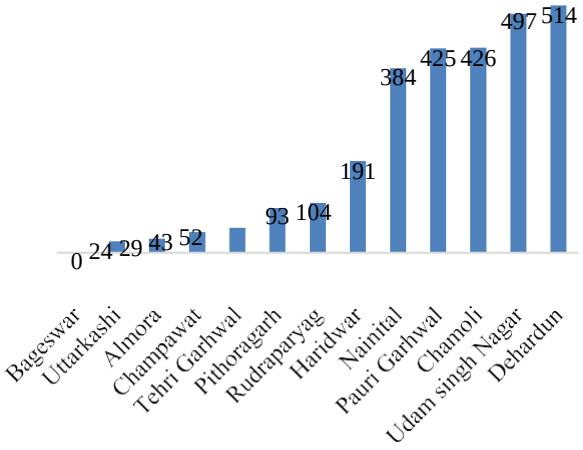
[51] https://www.dailyo.in/variety/uttarakhand-migration-ghost-villages-trivendra-singh-rawat-bjp-congress-yogi-doval-bipin-rawat/story/1/23026.html

[52] http://www.mospi.gov.in/sites/default/files/publication_reports/TPP_Apr_Dec2017_11july18.pdf

like *Sanjeevni* and *Nav Nirman Samiti* are utilizing the existing network of SHGs for promoting eco-friendly interventions such as improved cook-stoves and organic farming.

Table 3.13 - Livelihood activities being undertaken by SHGs in Uttarakhand

Districtwise operational SHGs in Uttarakhand (Total: 2782)
(Source: SRLM-2018, GoUK)



% of total SHGs involved in different livelihood activities in Uttarakhand
(Source: SRLM-2018, GoUK)

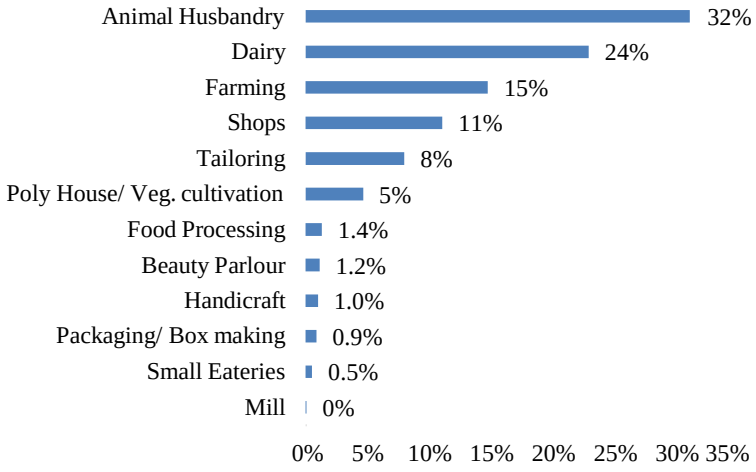


Figure 3.9 – (a) SHGs in Uttarakhand; (b) Distribution of SHG's by livelihood activities

S. No.	Districts	NUMBER OF SELF HELP GROUPS												
		Farming	Animal u b n	Food Processing	Dairy	Shops	Beauty Parlour	Poly House/ V	Tailoring	Handicraft	Packaging/ Box	Small Eateries	Grain Milling	Total
1.	Dehardun	91	27	8	152	82	2	96	21	17	13	5	0	514
2.	Bageshwar	0	0	0	0	0	0	0	0	0	0	0	0	0
3.	Chamoli	78	201	0	38	38	0	13	58	0	0	0	0	426
4.	Almora	13	10	0	6	0	0	0	0	0	0	0	0	29
5.	Champawat	10	17	0	11	0	0	5	0	0	0	0	0	43
6.	Haridwar	59	70	0	38	18	0	6	0	0	0	0	0	191
7.	Nainital	67	149	18	35	70	21	0	12	0	12	0	0	384
8.	Pauri Garhwal	21	94	2	209	0	10	3	74	0	0	10	2	425
9.	Pithoragarh		29	10	54	0	0	0	0	0	0	0	0	93
10.	Rudraprayag	49	25	0	13	0	0	10	7	0	0	0	0	104
11.	Tehri Garhwal	23	18	0	7	0	0	0	4	0	0	0	0	52
12.	US Nagar		240	0	91	108	0	0	46	12	0	0	0	497
13.	Uttarkashi	10	8	0	0	0	0	0	6	0	0	0	0	24
	Total	**421**	**888**	**38**	**654**	**316**	**33**	**133**	**228**	**29**	**25**	**15**	**2**	**2,782**

Source: Calculation based on data provided by UKSRLM, GoU (primary data directly collected from the field)
NOTE: All % are w.r.t. respective column totals
Highest value w.r.t. column

Table 3.13 above gives further details on various types of SHG based livelihood activities being promoted under the SRLM. It is to be noted here that the activities mentioned in the table pertain to those undertaken by SHGs only. There are several similar economic activities undertaken by individuals or commercial entities that are not included in this table.

3.3.2 Watermills

Uttarakhand has had a long history of watermills which have been in use since centuries. It is estimated that there are about 15,499 watermills[53] in different locations in Uttarakhand. Over the years more and more of these traditional watermills became defunct because of the following reasons:

- Very low operational efficiency (of the order of 10% - 15%)
- Difficulty in accessing location
- Low throughput or productivity
- Diversion of water for agricultural purposes during certain parts of the year
- Drying up of water source permanently

In contemporary times better and upgraded versions of the watermills have been designed which have an efficiency of as much as 45%. The Government has launched a special program for supporting upgradation of watermills in the state in which about 1341 watermills have been upgraded to a more efficient design and retrofitted mostly for electricity production although some have also been equipped for mechanical work such as grinding. The total number of watermills upgraded in the state is given in ***Table 3.14*** below:

Table 3.14 - Upgraded watermills in Uttarakhand

S. No.	District	Upgraded Water Mill (as on August 2013)		Total
		Electrical	Mechanical	
1	Pauri Garhwal	59	3	62
2	Tehri	102	124	226
3	Chamoli	185	113	298
4	Uttarkashi	80	28	108
5	Rudraprayag	47	1	48
6	Dehradun	64	91	155
7	Nainital	90	21	111
8	Almora	36	6	42
9	Bageshwar	55	0	55
10	Pithoragarh	132	18	150
11	Champawat	47	39	86
	Total	**897**	**444**	**1341**

Source: http://www.ureda.uk.gov.in/pages/display/133-improved-watermill-programme

These upgraded watermills could also be retrofitted for electricity generation or applications other than grinding such as oil expelling, rice hulling, However, in view of grid being extended to all areas in Uttarakhand the electricity generated from these watermills could be fed into the grid thereby enabling the owners to obtain some additional income.

Useful data on small informal economic activities undertaken by people residing in the villages is scarce. Several NGOs are promoting livelihoods either in the form of individual entrepreneurial activities or value chains involving several individuals. However, these activities are restricted to small pockets and not very extensive yet and again, hardly any structured data or information is available pertaining to these as well. Moreover, the NGOs give a consistent feedback that the profitability and sustainability of the livelihood activities being promoted by them are gravely affected due to irregular electricity supply and shortage of energy. Under these circumstances it becomes very difficult to conduct any kind of analysis to feed into the DRE Plan.

[53] http://www.ureda.uk.gov.in/pages/display/133-improved-watermill-programme

The DRE Plan for this sector therefore, has been compiled on basis of qualitative information obtained from freewheeling interactions with selected NGO representatives from Uttarakhand. Given below are some livelihood activities that could potentially be lucrative in Uttarakhand and possible DRE packages that could be used in them.

Table 3.15 - Summary of DRE applications in Rural Livelihoods

SUMMARY: DRE APPLICATIONS IN LIVELIHOODS SECTOR		
SN	**Livelihood Activity**	**Possible DRE Package**
1.	Pickles and Jams	• Improved cook-stoves (commercial size) • Solar power pack for lighting, fans, operating small electronic equipment such as weighing machines, RO water purifier, etc. • Small solar pump for water supply
2.	Milk Products, Sweets, snacks	• Improved cook-stoves (commercial size) • Solar power pack for lighting, fans, operating small electronic equipment such as weighing machines, RO water purifier, tablets / computers, etc. • Small solar pump for water supply
3.	Provision Shops	• Solar Power Pack for lighting, fans and tablets / computers
4.	Beauty Parlour	• Solar Power Pack for lighting, fans and low wattage equipment
5.	Poly-house veg products	• Solar Power Pack for blower(s), mist applicators, lighting
6.	Tailoring / Garment making	• Solar Power Pack for operating electric sewing machines, lights, fans, buttoning machines, washing machines, etc.
7.	Handicrafts	• Solar Power Pack for lighting, fans and low wattage equipment
8.	Small eateries / tea stalls	• Improved cook-stove (commercial size) • Solar power pack for lighting, fans, operating small electronic equipment such as weighing machines, RO water purifier, etc. • Small solar pump for water supply
9.	Grain milling	• Solar Power Pack for operating mill, lighting, fans and low wattage equipment
10.	Knitting / woollens products	• Solar Power Pack for operating knitting machine, lighting, fans and other low wattage equipment
11.	Spices products	• Solar or biomass dryer for drying of spice ingredients • Solar Power Pack for operating spice mill, lighting, fans, packaging / sealing machine and other low wattage equipment
12.	Handloom products	• Solar power pack for lighting and fans
13.	Apricot processing	• Improved cook-stoves (commercial size) • Solar power pack for lighting, fans, operating small electronic equipment such as weighing machines, RO water purifier, tablets / computers, etc. • Small solar pump for water supply
14.	Medicinal Plants products	• Improved cook-stoves (commercial size) • Solar power pack for lighting, fans, operating small electronic equipment such as weighing machines, RO water purifier, tablets / computers, etc. • Small solar pump for water supply
15.	Petty repair services	• Solar power pack for lighting, fans and low wattage equipment

SUMMARY: DRE APPLICATIONS IN LIVELIHOODS SECTOR		
SN	**Livelihood Activity**	**Possible DRE Package**
16.	Eco-Tourism	• Solar power pack for lighting, fans and low wattage equipment • Solar / biomass water heater for hot water • Improved biomass cook-stoves for cooking • Solar pump for water supply • Biomass based space heaters for space heating
17.	Poultry	• Egg incubators (solar based) • Chick brooders (biomass based) • Solar lighting
19.	Cyber café / CSC	• Solar power packs for lighting, fans and computer equipment

Note: Refer to ***Annex-IV: Technologies and their costs*** for details on various DRE technologies that could be applicable in the above livelihood options

3.4 Micro, Small and Medium Enterprises

The MSME sector in Uttarakhand was not highly evolved till recently. Contribution of Industries/ Secondary sector in the Uttarakhand's GDP in 1999-2000 when the state was carved out of Uttar Pradesh was 19.7%. It increased to more than 39% in 2013-14 and further to 50%[54] in 2017-18. The growth of industries is among the crucial factors which contributed to putting Uttarakhand on 11th rank in Ease of Doing Business[55], 2017. The state, so far, has invested Rs.11,800 Crore in establishing more than 56,000 MSMEs which have provided employment to 2.8 lakh people. ***Table 3.16*** summarizes district wise, the MSME units present in Uttarakhand along with some key attributes like investment and number of persons employed.

Table 3.16 - MSMEs in Uttarakhand since inception (Feb, 2018)

S. No.	Districts	MSME Units	Employment (No. of persons)	Investment (Rs. in Crore)	% w.r.t. respective totals		
					MSME Units	**Employment**	**Investment**
1	Haridwar	9,479	81,490	4,529	16.80%	29.40%	38.38%
2	Dehradun	7,995	46,393	1,061	14.17%	16.74%	8.99%
3	Udham Singh Nagar	7,030	59,687	4,088	12.46%	21.53%	34.64%
4	Pauri	5,536	18,951	4,030	9.81%	6.84%	3.42%
5	Tehri Garhwal	4,125	11,687	221	7.31%	4.22%	1.87%
6	Nainital	3,979	18,989	887	7.05%	6.85%	7.51%
7	Uttarkashi	3,890	7,260	94	6.90%	2.62%	0.80%
8	Almora	3,713	8,208	160	6.58%	2.96%	1.36%
9	Chamoli	3,028	6,461	86	5.37%	2.33%	0.73%
10	Pithoragarh	2,876	6,509	75	5.10%	2.35%	0.63%
11	Rudraprayag	1,737	4,486	86	3.08%	1.62%	0.73%
12	Bageshwar	1,620	3,433	45	2.87%	1.24%	0.38%
13	Champawat	14,08	3,633	67	2.50%	1.31%	0.57%
	Total	**56,416**	**2,77,187**	**11,800**			

Source: Department of Industries. GoU

From the table above, it is clear that more than 82% of the total investment is concentrated in 3 districts viz. Haridwar, Dehradun and Udham Singh Nagar with 43% of the total units. It is because of ease of operation and resource accessibility as these districts are located in the plain regions as compared to other districts. This is the reason why 68% employment is also generated in these districts thereby causing people from the other districts to migrate to these districts. For the same reason, people from the hill districts also tend to migrate outside state in search of employment.

In order to promote investments in MSME sector, prevent migration of people from hilly regions and to promote establishments based on local resource availability for community-based employment generation, the state government has introduced MSME Policy, 2015. It will be effective till March, 2025. As a result of this policy, 1430 new units were established in hilly districts in 2016-17 and this figure increased to additional 1475 units in 2017-18.

State government has brought in many other reforms like single window system for easy clearances, Start-up Policy-2018 and Women Entrepreneurs special encouragement scheme and Ease of doing business. Currently there are about 56,416 MSME units in Uttarakhand as per data obtained from the Department if Industries, Government of Uttarakhand. District-wise distribution of MSME units in the state is given in the ***Table 3.16*** above. It is apparent from the

[54] Economic Survey Report (2017-18), GoU
[55] Annual Report (2017-18), Department of Industries, GoU

figure that almost 43% of the MSME units are present in the three districts located in the plains: Haridwar, Dehradun and Udham Singh Nagar.

The complete data available on the website of the Department was obtained and analyzed. It was found that there were several blank entries for "type of unit" due to which it was impossible to determine any potential for DRE applications. Further, certain other entries pertained to trades where DRE applications are not suitable. The entire data set was filtered based on the above criteria and ultimately about 25,801 MSME units were identified that could potentially suit DRE applications. The overall pattern of these units by trade type is given in ***Figure 3.10***.

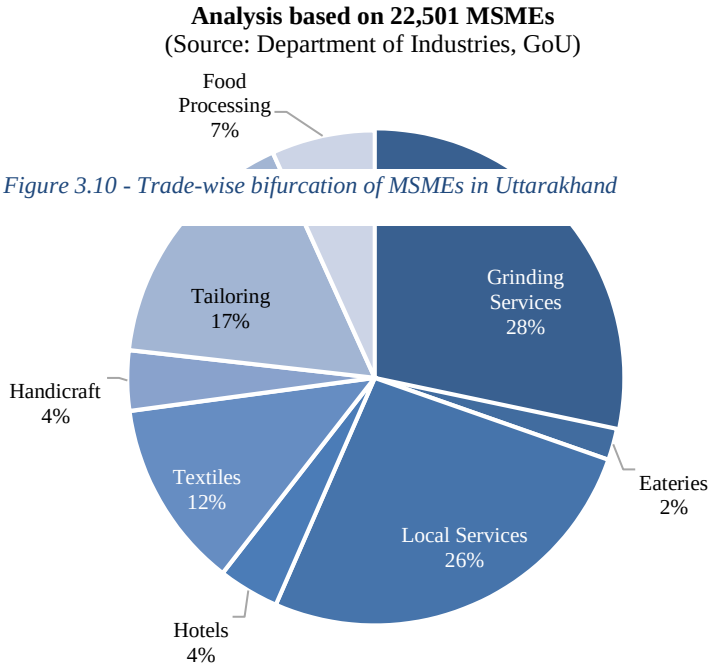


Figure 3.10 - Trade-wise bifurcation of MSMEs in Uttarakhand

**Local Services* include Beautician, Electronic repair, Cyber Café, Telecom, Lighting & Catering, PCO, Xerox and other local*

District wise pattern of MSME units involved in selected trades as per ***Figure 3.10*** above in Uttarakhand is given in ***Table 3.17*** below.

Table 3.17 - Trade-wise and district-wise distribution of MSMEs in Uttarakhand

S. No.	Districts	Grinding Services	Eateries	Local Services	Hotels	Textiles	Handicraft	Tailoring	Food Processing	Total
1	Almora	171	49	47	88	28	18	132	12	545
2	Bageshwar	358	43	247	50	103	92	132	14	1039
3	Chamoli	548	22	247	66	971	10	174	90	2128
4	Champawat	356	40	286	20	60	17	67	51	897
5	Dehradun	196	39	846	91	621	211	1304	343	3651
6	Haridwar	463	13	659	34	227	116	308	91	1911
7	Nainital	97	2	103	15	22	12	15	35	301
8	Pauri	1522	71	761	82	139	61	572	195	3403
9	Pithoragarh	332	65	291	53	173	121	81	34	1150
10	Rudraprayag	349	27	339	78	44	16	198	76	1127
11	Tehri	452	32	425	175	136	38	265	104	1627
12	U S Nagar	1283	55	1293	46	148	159	264	412	3660
13	Uttarkashi	240	7	348	98	103	13	188	65	1062
	Total	**6,367**	**465**	**5,892**	**896**	**2,775**	**884**	**3,700**	**1,522**	**22,501**

Source: Team analysis using data provided by Department of Industries, GoU (2018)

Lowest value w.r.t. column

Highest value w.r.t. column

An analysis of trades that MSMEs in the state are engaged in (see ***Table 3.17*** and ***Figure 3.10***) reveals that grinding services like Flour and Spice mills (6367 in number, 25% of total) are the most numerous MSMEs in the state followed by local services (like repair services, telecommunication, salon etc. 5,892 in number equivalent to 23%). The third major sector is tailoring services (3700 in number, 14%) that include weaving, knitting and stitching. Food processing sector accounts for 6% whereas hotels and eateries together account for only 5% of the total MSMEs in the state, which seems to be quite small considering the substantial tourism activities of the state.

Baseline for DRE Action Plan

Energy (electricity or heat or both) is being used by every industry. Depending upon the industry, predominant use of energy could be in the production stages, packaging stages,

management functions or transport. Certain industries like garment making/ textiles, tailoring, grinding and food processing services have significant potential for DRE applications. Further, the hotel industries have major energy requirement for water heating and space heating in addition to general lighting and operating appliances. Therefore, they are yet another avenue for using DRE technologies. Some potential industry segments having potential for DRE applications are tourism, agriculture, forestry and pharmaceutical sector. ***Table 3.17*** above gives number of industries engaged in different trades which could be assessed for possible DRE applications. Further, most industries have rooftop area of their buildings or industrial sheds which could be exploited for solar power generation for feeding into the grid.

Table 3.18 - Summary of DRE applications in MSME sector

SUMMARY: DRE APPLICATIONS IN MSME SECTOR		
SN	**Aspect**	**Description**
1.	Lighting	General illumination of work facility
2.	Lighting	Illumination of work spaces and work stations
3.	Office Equipment	Operation of office equipment and gadgets
4.	Production Equipment	Operation of production equipment
5.	Process Heat	Requirement of energy for process heat applications. Could be partially met through biomass
6.	Water heating	Usually coal or diesel fired boilers are used. Electricity is also a possibility. However, there is considerable scope for solar water heaters
7.	Process steam	Typical sources of energy for these applications are coal, diesel, natural gas, LPG or even electricity for small applications. Biomass is a promising substitute and solar concentrators also hold considerable promise.

Table 3.19 - Possibilities of leveraging MSME sector for DRE applications

POSSIBILITIES OF LEVERAGING MSME SECTOR FOR DRE APPLICATIONS		
SN	**Aspect**	**DRE Leverage Possibilities**
1.	Industrial sheds	Roof top solar power production

3.5 Domestic Sector

3.5.1 Lighting

As far as domestic lighting is concerned, 87% of households in Uttarakhand use grid electricity as the main energy source followed by 11.08% households using Kerosene oil (***see Figure 3.11 below***). Usage of kerosene for lighting is higher amongst rural households with almost 15% still depending upon it.

Clearly, the performance of Uttarakhand with regard to domestic lighting is better than the whole of India. With the Government's hard push towards 100% electrification in the country, most pending issues pertaining to domestic lighting are also expected to get addressed in near future. However, as mentioned in earlier sections as well, considerable distance remains to be covered for reaching the benefits of electrification to each and every household. To close this gap, it is necessary to tackle affordability and supply reliability issues.

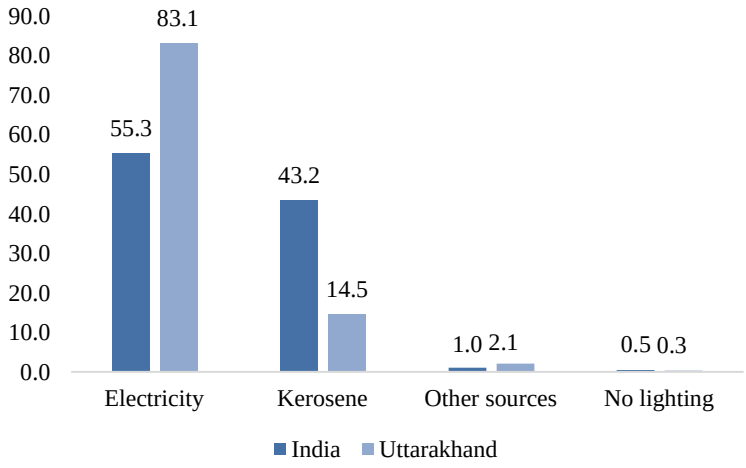


Figure 3.11 - Energy use for domestic lighting in India and Uttarakhand

Interestingly, solar energy is also now one of the popular energy options for domestic lighting. MNRE Statistics (Dec, 2017) on solar SPV systems installed in the state indicate that usage of solar lights and lanterns has picked up momentum.

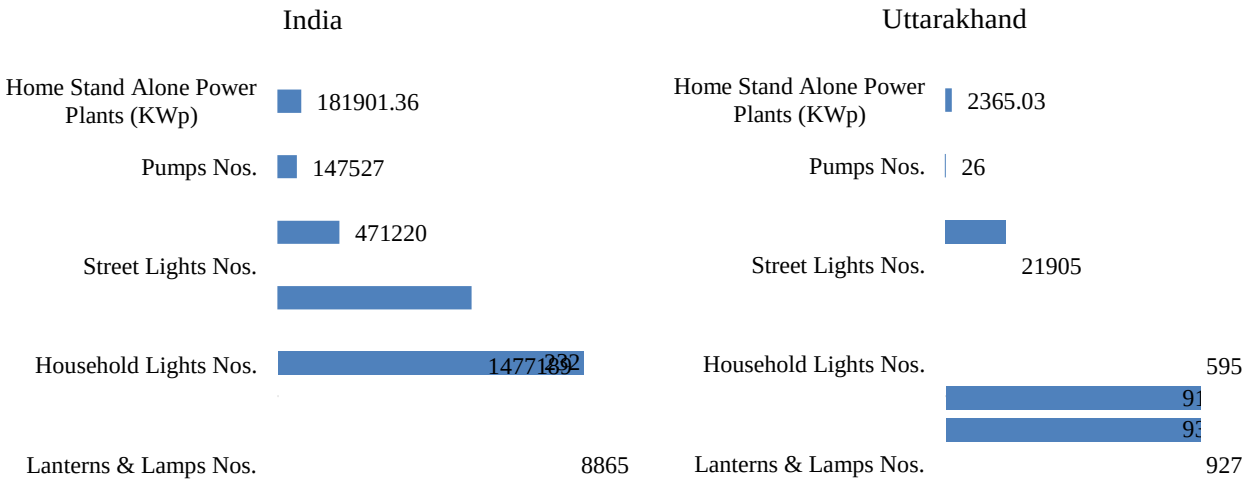


Figure 3.12 - Number of various solar lighting devices in India and Uttarakhand

(i) Solar Lanterns

As can be seen from ***Figure 3.12*** above, there are about 93,297 solar lights in the state. Usage of Solar lanterns in the state suddenly peaked in the aftermath of the disastrous flash flood of 2013 when electricity got cut-off from several locations. As a part of the disaster response, about 79213 solar lanterns were distributed immediately after the disaster continuing up to May,

2014[56] to meet the immediate lighting requirements of the affected population.

[56] http://ureda.uk.gov.in/files/Solar_Pv.pdf

(ii) Solar Home Systems

In Uttarakhand, solar home systems were quite popular because of absence of grid power in most rural areas. However of late, due to improvement in penetration of the grid and quality of energy supply services, the dependency on solar home systems seems to be on the decrease.

Table 3.20 - Solar LED Based Home Light System Installed in Uttarakhand

As can be seen from the ***Table 3.20***, the number of solar home systems in Uttarakhand seems to have peaked in 2009-10 but has decreased after that. Also, the number of solar home systems deployed in the state seems very small with respect to the population residing in the rural areas. Looking at the district wise trends, it is interesting to note that Pauri Garhwal and Champawat are the districts having maximum deployment of solar home systems, exceeding 1000, in the state although over the years this trend seems to have been reversed and lesser systems are now being installed. Bageshwar shows a steady increase in the number of solar home systems deployed which is probably indicative of lack of appreciable improvement in the power situation in the district.

Sl. No.	District	2008-09	2009-10	2010-11
1	Dehradun	62	84	108
2	Haridwar	20	75	0
3	Tehri	52	92	0
4	Uttarkashi	10	10	0
5	Pauri	381	1053	300
6	Rudraprayag	64	46	0
7	Chamoli	287	57	101
8	Pithoragarh	173	0	40
9	Champavat	135	1174	551
10	Almora	354	0	0
11	Bageshwar	52	200	355
12	Nainital	126	96	0
13	U.S Nagar	75	265	242
	Total	**1791**	**3152**	**1697**

Sc

(iii) Solar Street Lights

Stand-alone solar street lights have been one of the earliest and most popular applications of DRE mainly because they are easy to install and require minimal maintenance. Available data from the year 2013 (see ***Figure 3.13*** below) shows that more than 6000 solar stand-alone street lights have been installed in the state. A look at the district-wise figures indicates that with more than 1000 units, Almora district has the largest number of solar stand-alone street lights installed in the state. The other districts with considerable numbers of solar stand-alone streetlights are Champawat, Tehri Garwhal and Pauri Garwhal.

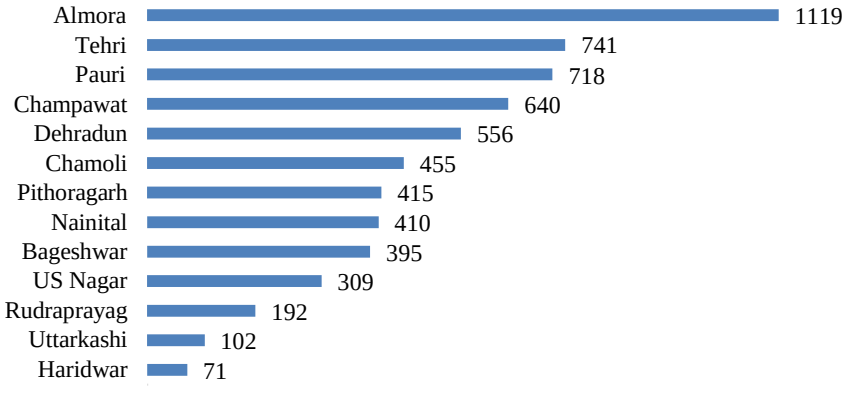


Figure 3.13 – Number of Solar lights distributed/ installed in Uttarakhand (2013)

3.5.2 Cooking

As per Census 2011, 48.6% of the households in Uttarakhand are dependent entirely on firewood for cooking. Another 44.2% of them have access to LPG (***see Figure 3.14 and Figure 3.15***). If only rural households of the state are considered, the percentage using firewood for cooking further increases to 63.29%. This is due to easy accessibility of biomass or agricultural residues at zero cost from nearby wooded areas or agricultural farms. Seemingly the dominance of firewood over LPG is also because 10 of the 13 districts are in the hills where firewood is available in abundance, considering 65% area under forest cover. However, since

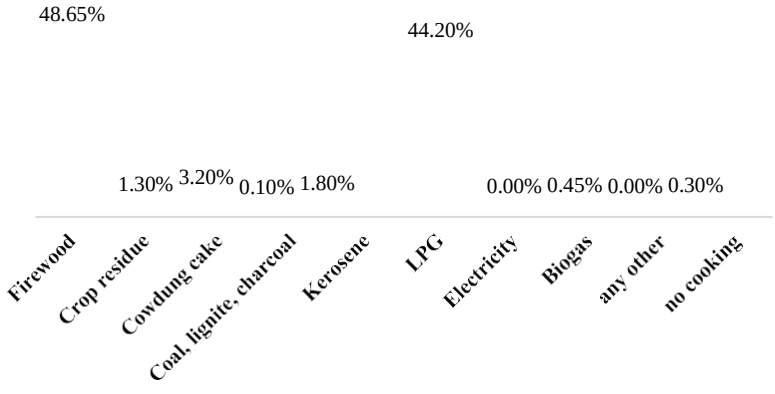


Figure3.14-Distributionofhouseholdsbytypeoffuelusedforcookingin Uttarakhand

traditional cook-stoves are inefficient and cause considerable smoke, the health of women in particular is seriously compromised as they are constantly exposed to smoke, low oxygen levels, carbon monoxide and particulate matter during cooking, causing respiratory ailments and lung diseases like tuberculosis.

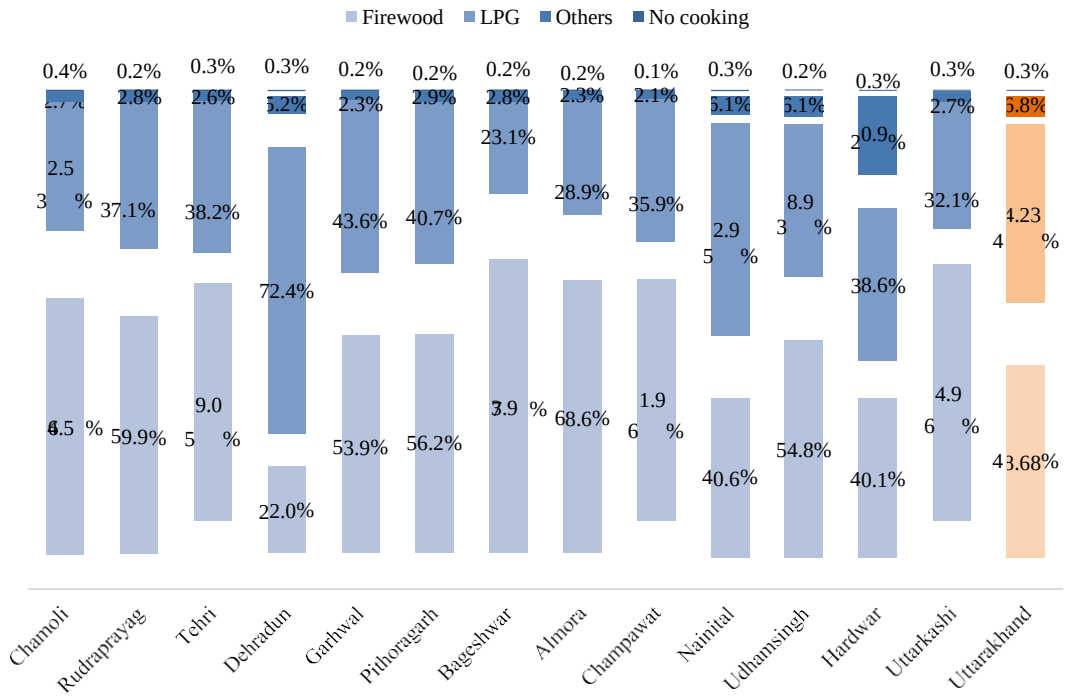


Figure 3.15 – District-wise HHs (%) using different fuels for cooking in Uttarakhand

Source: Census of India, 2011

LPG is the second most widely used fuel for cooking in the state with 44.2% households dependent on LPG (Census, 2011). The percentage of LPG using households in urban areas is 79.42% and for rural areas it is 29.40% in 2011. Since 2014, the government has put considerable emphasis on promotion of LPG at a subsidy to people residing in rural areas. This

is expected to avoid exposure to smoke and associated emissions associated with biomass cook-stoves and have a positive impact on the health of women.

(i) Improved Biomass Cook-stoves

India has a long history of attempts to promote improved biomass cook-stoves. Several programs were launched to promote and propagate improved biomass cook-stoves over the past three decades, the latest being the "Unnat Chulha Abhiyan" which was launched around 2014. About 36,940 family type and 849 community / commercial type cook-stoves were installed during this program. The current total number of MNRE approved models of improved biomass cook-stoves is 39 as per the following classification[57] (***see Table 3.21***)

Table 3.21 - Improved Cook-stove models in India

Types of ICS	Domestic size	Community Size
Natural Draft	17	2
Forced Draft	11	9

In earlier programs, cook-stoves were constructed *in situ* by masons. However, in current times, the pattern is shifting towards centralized manufacture by private manufacturers and subsequent distribution to prospective users. Most improved biomass programs have not yielded the desired results in full yet. The main reasons for this lukewarm acceptance level are unwieldy construction of some models, hindrance to traditional cooking methods or practices, need for processing biomass (cutting, etc.) before it could be used in the cook-stove, etc.

Fuelwood consumption of households[58] varies considerably over the year depending upon the season. While it is mostly used for cooking, in winter, fuelwood is also used for space heating. The consumption levels are given in ***Table 3.22*** below.

Table 3.22 - Per capita fuelwood use in Uttarakhand (2014)

Fuelwood Consumption Parameters	**Fuel wood/Capita/day**		
	Summer (Apr-Jun)	**Winter (Oct-Feb)**	**Rainy (Jul-Sep)**
Fuel wood/Capita/Day (kg)	2.08	3.15	1.53
Fuel wood/Capita/Season (kg)	189. 28	475.65	140.76
Fuel wood Consumption/ Capita/ year			0.806 MT*
Fuel wood Consumption/HH/yr			4.33 MT
Fuel wood Consumption/HH/day			1.19 kg

**Family/HH size taken - 5.38 as per demographic data*

Another important reason for continued dependency on biomass for cooking and space heating energy needs is that it costs nothing. It only requires some collection effort. Going by the price sensitivity of the rural people in India as well as in Uttarakhand and their consequent emphasis on affordability, it is not difficult to understand why biomass would continue to find use in most rural households.

(ii) LPG

Presently, with 22.4 lakh active LPG connections in the state as on Apr, 2018 and estimated annual sales of LPG in 2017-18[59] have touched 2,34,000 MT.

However, this clean fuel comes to the user at a cost, albeit subsidized; but is an additional load in the user's monthly budget as no corresponding cost was incurred on cooking fuel earlier. Further, due to difficult terrain of hilly districts in the state, the transport of LPG cylinders, particularly over the last mile, is still a big challenge. Therefore the community is still likely to

[57] https://mnre.gov.in/file-manager/UserFiles/approved-models-of-portable-improved-biomass-cookstove-manufactures.pdf
[58] https://mer.markit.com/br-reg/services/processDocument/downloadDocumentById/103000000055968
[59] Petroleum Planning and Analysis Cell Report on LPG Marketing, Apr-2018 (http://ppac.org.in/WriteReadData/Reports/201805290110218094341DataonLPGMarketing01042018.pdf)

continue using biomass irrespective of availability of options such as LPG - dependency on firewood cannot be undermined. This is illustrated from field visits to certain remote areas of Uttarakhand where even villagers having access to LPG were found to continue using firewood for cooking meals while the LPG was used only for preparing snacks and tea since it was costly.

(iii) Biogas

Biogas for cooking is used by 0.47% of households[60] in the state. It is only in the rural areas of Nainital and Udham Singh Nagar where biogas is utilized in more than 1% households. The best case of use of biogas is of rural Nainital where 4.27% of the households depend on biogas for cooking.

(iv) Solar Cookers

Box type solar cookers have been promoted in Uttarakhand but there are no statistical figures available to determine the extent of penetration of these devices in the state. Also, going by the fact that most parts of the state are hilly with uneven topography and experience harsh winters, it is difficult for such devices to be used on a continuous basis.

3.5.3 Space and Water Heating

The hilly regions of Uttarakhand experience extended periods of sub-zero winters every year. Consequently, there is considerable requirement for hot water for bathing / clothes washing and space heating inside houses and public buildings[61]. For both applications, biomass is the most popular fuel. Water is heated on open fires made from burning biomass. People use stored collected biomass: twigs and wood (collected from nearby wooded areas) or crop residue / dung cakes stocked up for the winter. Electric water heaters as well as space heaters are now being increasingly deployed, especially by commercial players such as hotels. Popularity of solar water heaters seems to be on the rise in the state with the state's total solar water heater installed capacity experiencing a quantum jump from 167,425 LPD in 2010-11 to 503,750 LPD in 2015-16[62](***see Table 3.23***), most of which is in the commercial sector.

Table 3.23 – Cumulative Solar water heater installed capacity in Uttarakhand

S. No.	Year	Capacity Installed in LPD	Approx. Area in m^2
1	2010-11	167425	2999
2	2011-12	316575	5224
3	2012-13	520300	8152
4	2013-14	520000	8211
5	2014-15	462000	7090
6	2015-16	503750	7575

Source: UREDA 2011

Although solar water heaters can benefit individual households immensely, they require structurally strong roofs and substantial roof area which unblocked access to sunshine. Such conditions may prevail in urban or peri-urban settings but difficult to find in rural areas where houses tend to be small and grouped in a very congested manner. Moreover, many of them may not necessarily have structurally strong roofs.

For space heating, people generally tend to huddle around bonfires outside their houses. Some of the houses may have a fireplace or people may just gather around the traditional biomass cook-stove in the kitchen. There are no proven improved technologies available for space heating due to which this need is being fulfilled in the age-old traditional manner only. There

[60] Census 2011

[61] https://www.tribuneindia.com/news/uttarakhand/community/state-can-use-geothermal-heat-to-beat-cold-prof-dimri/80933.html

[62] UREDA, GoU (http://ureda.uk.gov.in/pages/display/135-solar-water-heater)

is considerable scope for research and innovation in designing an effective product for this application.

3.5.4 Strategic Analysis of Domestic Sector in Uttarakhand

In the domestic sector, availability of energy and the reliability of energy services is highly critical. Affordability is also an important consideration – extent of adoption of any particular form of energy services or technologies by the population depends squarely on energy costs. Inadequate and unreliable energy supplies have been dogging this sector, particularly the rural areas, for decades. The most important, inescapable and essential domestic chore is cooking for which biomass is the most popular fuel mainly because it does not involve any cost, despite substantial drudgery and time investment involved in its collection, stocking and processing.

Therefore, the domestic sector was always considered quite a good fit for DRE applications. Since long, promotion of DRE in the rural domestic sector has been underway through a host of cost subsidy schemes or other financial support packages on devices such as solar lanterns, solar home lighting systems, solar street-lights, solar power plants / mini-grids, biogas, biomass gasifiers (for power and for heat), solar water heaters, box type solar cookers, concentrating type solar cookers, improved biomass cook-stoves, etc. The extent of success achieved has been at best, limited. ***Table 3.24*** and ***Table 3.25*** below attempts to tabulate the key limitations experienced with these technologies thereby leading to limited success levels. The tables given below summarizes DRE technologies for the domestic sector, associated constraints and their current viability in view of changed circumstances due to grid extension and LPG distribution.

Table 3.24 - Domestic Sector: Electrical Applications - Challenges and Scope

TECHNOLOGY	CONSTRAINTS	VIABILITY IN CURRENT CONTEXT
Stand-Alone		
Solar Lanterns	• Limited illumination • Affordability	• Utility will be limited due to grid extension • With solar PV becoming cheaper, they will still be competitive in the market • Will remain very relevant in times of natural calamities and disasters
Solar Home Lighting Systems	• Battery maintenance and replacement • Affordability	• Use will be more relevant in off-grid areas only • In grid served areas, grid feeding may be an option but returns will be attractive only for relatively large capacities • Will still be useful during natural disasters
Solar Stand-alone Streetlights	• Battery maintenance • Theft	New models have been launched that work on sealed maintenance free batteries and have theft-preventing features. Hence these may continue to be relevant and probably a cheaper option over grid connected streetlights
Mini-Grids		
Solar Power Plants / Power Packs	• Difficulty in obtaining community contribution for operation and maintenance • Difficulty in accessing technical support in case of malfunction • Battery Bank maintenance • High initial costs	• These could still remain relevant in areas that suffer from erratic power supply from grid • Grid feeding facility will be attractive in terms of offsetting operational costs

TECHNOLOGY	CONSTRAINTS	VIABILITY IN CURRENT CONTEXT
Biomass Gasifier based Mini-grids	• Collection and stocking of biomass in adequate quantity • Space limitations for stocking biomass and associated fire hazard • Complexity of gasifier operation and maintenance • Soot/tar deposition, engine clogging, engine maintenance and operational problems • Difficulty in getting technical support • Difficulty in obtaining community contribution for operation and maintenance • High initial, operational and maintenance costs	Likely to lose relevance in favor of grid power supply, which is comparatively hassle-free
MMHP based Mini-grids	• MMHP sites are not necessarily in conveniently accessible areas. Therefore, there are major constraints in ferrying equipment, construction material, etc. to set up the plant • Major seasonal variations in stream discharge: could dry up completely or carry as much as 900% more discharge with debris that could damage the MMHP plant • Constraints to laying distribution lines which might have to be long in some cases adding to prohibitive costs • Frequent wearing out of turbine impellers or clogging of inlets/ penstock due to high silt content/ debris in water or due to corrosion • Unavailability of skilled technical manpower for operation of plant in multiple shifts • Difficulty in getting technical support • Difficulty in obtaining community contribution for operation and maintenance • High initial, operational and maintenance costs	• Likely to lose relevance in favor of grid power supply, which is comparatively hassle-free • However, may still be able to provide some benefits if used for grid feeding
Hybrid Mini-grids	• Technology related constraints as above • Complexity of switching between multiple energy producing sources and operating complex automation for optimizing energy output • Difficulty in getting technical support • Difficulty in obtaining community contribution for operation and maintenance • High initial, operational and maintenance costs	Not likely to remain an attractive option because grid feeding is attractive enough for justifying individual DRE technologies. Hybridization, which was mainly conceptualized to add a dimension of reliability will not be that useful any more

Not relevant any more in present context
Limited relevance in present context
Remains relevant
No technology available

Table 3.25 - Domestic Sector: Direct Heat Applications - Challenges and Scope

TECHNOLOGY	CONSTRAINTS	VIABILITY IN CURRENT CONTEXT
Cooking		

TECHNOLOGY	CONSTRAINTS	VIABILITY IN CURRENT CONTEXT
Box Type Solar Cookers (for household use)	• Unwieldy to use • Takes up considerable storage space when not in use • Food production timings do not match food consumption timings • Cooking quality affected by sudden changes in insolation levels • Prone to breakage	Not much useful in current context for domestic applications, particularly in view of increasing penetration of LPG
Concentrating Type Solar Cookers (Domestic Size)	• Very unwieldy to use • Takes up considerable space • Requires close supervision while in operation • Cooking quality affected by sudden changes in insolation levels • Highly prone to breakage, difficult to stow when not in use • High initial cost	Not much useful in current context for domestic applications, particularly in view of increasing penetration of LPG
Concentrating Type Solar Cookers (Community / Institutional Size)	• Power back-up required to ensure optimal cooking quality despite sudden fluctuations in insolation levels • High initial cost	• These can be useful if initial costs are arranged for • Can result in substantial savings in terms of operating expenses (fuel)
Solar based Induction Cook-top (Domestic use)	• Performance of induction cook-top will depend upon insolation levels • User has to invest in fresh set of "induction friendly" utensils	• The technology is new and will be useful only if the power supply from solar is reliable, which is difficult on account of fluctuations in insolation • It is not possible to get solar power at night. Using batteries can make the cooking process unwieldy especially of batteries have not been able to store adequate power on certain cloudy days • Initial costs, including the fact of procuring a new set of utensils can be a put-off particularly because of easy availability of LPG
Improved Biomass Cook-stoves – Natural Draft (Domestic Size – fixed and portable)	• Cooking without being able to see the fire is not preferred by users • Blockage of flue passages leading to excess smoke generation and loss of efficiency	• LPG proliferation may make then less attractive • However, due to operating costs, LPG may be used only for small cooking jobs – for larger cooking jobs the improved cook-stove may still be an option
Improved Biomass Cook-stoves – Forced Draft (Domestic Size – mostly portable)	• Requirement of processing biomass (cutting to a specific size) is not liked by users • Height of these cook-stoves is generally more than traditional ones and therefore uncomfortable for the user • Failure / malfunction the fan or its power supply arrangement (solar/battery) is always a problem	• High initial costs make them prohibitive • Easy availability of LPG may lead to people adopting a combination of LPG stove and a cheaper biomass cook-stove for their cooking requirements
Improved Biomass Cook-stoves – Natural	• No major constraint	• Since LPG is costly, these cook-stoves may continue to be relevant for community cooking applications

Baseline for DRE Action Plan

TECHNOLOGY	CONSTRAINTS	VIABILITY IN CURRENT CONTEXT
Draft (Community Size)		
Improved Biomass Cook-stoves – Forced Draft (Community Size)	High initial costs	Easy availability of LPG may lead to adoption of a combination of LPG stove and a cheaper biomass cook-stove rather than a forced draft model
Biomass Gasifier (producer gas) based cooking (Community size)	• Gasifier operation and maintenance is unwieldy • Soot / tar deposition in gasifier pipelines • Hazard from carbon monoxide exposure	These are attractive options for large cooking tasks and will continue to remain so, but the designs need to be adapted and standardized before they can be marketed
Water Heating		
Solar Water Heater (Domestic Size)	• Requires considerable open space • Output is dependent upon and subject to changes in insolation levels • Scaling and clogging of collector tubing • High initial costs	• Remains relevant as it saves considerable electricity / fuel costs • Newer models have become available which have lesser scaling / clogging issues
Solar Water Heater (Community Size)	• Requires considerable open space • Output is dependent upon and subject to changes in insolation levels • Scaling and clogging of collector tubing • High initial costs	• Remains relevant as it leads to considerable cost saving • Solutions to scaling / clogging available now • Quite popular in commercial sector, particularly hotels
Space Heating		
No proven technology available yet	• Space heating is a requirement mostly confined to higher altitudes • Since heating requirement is considerable, currently only biomass can be harnessed for generating that much heat in absence of any other viable alternative • Burning of biomass in open fires is inefficient, however no technology alternative is available • Electrical and LPG based heaters are available but their initial and operational costs are prohibitive	• There is need for developing an efficient technology for space heating, preferably biomass based • Pine needles as a fuel could be an option

Not relevant any more in present context
Limited relevance in present context
Remains relevant
No technology available

The above observations have been used in preparation of the DRE Plan proposed for the Domestic Sector in Uttarakhand which is discussed in the next section.

4. DRE Plan of Action

4.1 DRE Plan for Institutional Buildings

4.1.1 SWOT Analysis

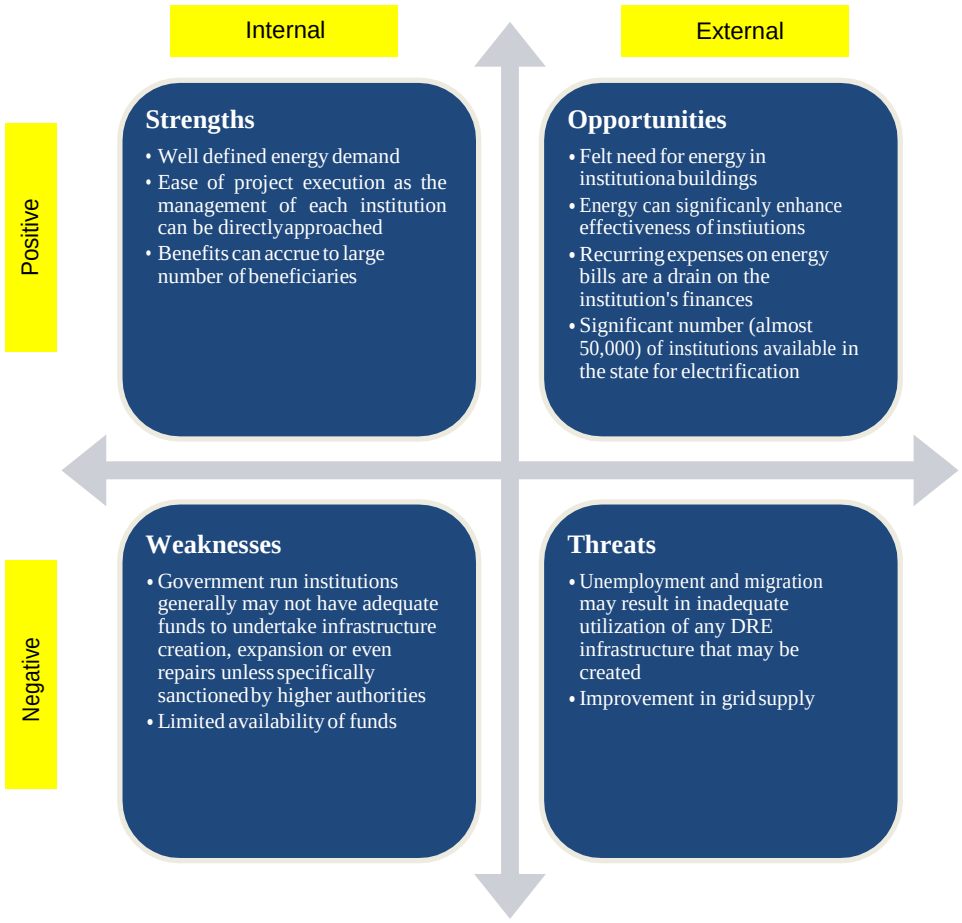


Figure 4.1 - SWOT Analysis of Institutional Buildings

4.1.2 Strategy

Suggested strategy for enhancing utility of public institutional buildings through DRE is as follows:

- Ensure all public institutional buildings have the necessary infrastructure to maintain adequate electrical power supply and/or to meet their direct heat requirements for optimal discharge of their public service functions
- Provide DRE to off grid Institutional buildings on priority
- Create awareness amongst managements of all institutions on the possibility of doing energy assessment of their respective institutions and the benefits of reducing operational costs through DRE applications
- In areas serviced by the Grid, leverage the option of feeding to the Grid thereby offsetting part of the energy consumption of the institutional building

4.1.3 Targets

1. All off grid institutions to be energized through DRE by 2025
2. Grid connected institutions to be given technical and financial assistance to install DRE and reduce their operational costs. 25% of them to be converted to DRE by 2025

4.1.4 Suggested Technology Packages and their Financial Implication

Table 4.1 - Technology Packages and Cost (Institutional Buildings)

S. No.	Institutions	Total Units (Institutions)	Suggested DRE Technology	Purpose	Capacity/Size	Technology Cost		Total cost/ Investment required (Rs. in Crore)	Assumptions
						Amount (Rs.)	Unit		
Educational Institutions									
1	Off grid schools	6510*	Solar PV Power Plant	Electricity for lights, fans and computers	2 kW_p	1,10,000.00	Rs. per kWp	143.22	Only Govt. schools have been considered
2	On Grid Govt. Schools	11448	Solar PV Power Plant	Electricity when required + Additional Grid Feeding	2 kW_p	1,10,000.00	Rs. per kWp	251.86	
3	Schools providing MDM (firewood)	7362	Improved Cook-stove (commercial size)	Cooking with Clean fuel	2-4 units	25,000.00	Rs. per Cookstove	73.62	
4	Schools providing MDM (with LPG)	10302	Improved Cook-stove (commercial size)	Cooking at less cost	2 units	25,000.00	Rs. per Cookstove	51.51	
Health Institutions									
5	Community Health Centres (CHCs)	60	Solar PV Power Plant	Electricity when required + Additional Grid Feeding	8 kW_p	20,000.00	Rs. per kWp	0.96	
			Solar Water Heater	Water heating	400 LPD	20,000.00	Rs. per 100 LPD	0.48	
			Improved Cook-stove (if LPG is not available)	Cooking	3 units	25,000.00	Rs. per Cookstove	0.005	Assuming that LPG is not available in 10% of CHCs
6	Primary Health Centres (PHCs)	257	Solar PV Power Plant	Electricity for lights, fans and computers	5 kW_p	20,000.00	Rs. per kWp	0.05	
			Solar Water Heater	Water heating	200 LPD	20,000.00	Rs. per 100 LPD	1.03	
			Improved Cook-stove (if LPG is not available)	Cooking	2 units	25,000.00	Rs. per Cookstove	0.32	Assuming that LPG is not available in 25% of PHCs

7	Sub-Centres (Off-grid)	616	Solar PV Power Plant	Electricity for lights, fans and freezer	1 kW_p + 2 kWp for solar freezer	20,000.00	Rs. per kWp	3.69
				Solar freezer for storage of vaccines	0.3 kWp	65,000.00	Rs. per unit	4.00
			LPG stove	Sterilization	1 unit	500.00	Rs. per unit	0.06

DRE Plan of Action

S. No.	Institutions	Total Units (Institutions)	Suggested DRE Technology	Purpose	Capacity/Size	Technology Cost		Total cost/ Investment required (Rs. in Crore)	Assumptions
						Amount (Rs.)	Unit		
8	Sub-Centres (on-grid)	1231	Solar PV Power Plant	Electricity for lights, fans and freezer	1 kW_p	20,000.00	Rs. per kWp	2.46	Assuming 10% of the total sub-centres are facing power supply issues
				Solar freezer for storage of vaccines	0.3 kWp	65,000.00	Rs. per unit	0.8	
			LPG stove	Sterilization	1 unit	500.00	Rs. per unit	0.04	Assuming that LPG is not available in 30% of Sub-Centres
Others									
9	AWCs	2278	Solar PV Power Plant	Electricity for lights and fans	0.5 kW_p	20,000.00	Rs. per kWp	2.28	Only Govt. owned AWCs buildings have been considered
10	GP Offices/ CSCs	8056	Solar PV Power Plant	Electricity when required + Additional Grid Feeding	3 kW_p	20,000.00	Rs. per kWp	80.56	
					Total Amount Required			**616.95**	

4.1.5 Recommendations

- A composite Energy Infrastructure Development Program (EIDP) targeting educational and health institutional buildings in Uttarakhand could be conceptualized. The Program could be handled directly by UREDA with cooperation from the respective line ministries / departments. The primary aim of the EIDP would be to ensure appropriate and functional energy infrastructure in all institutional buildings in the education, health and PRI sectors and also ensure reliability of the energy /power supply to these buildings.
- Some salient features of this program could be
    - Technical support for assessment, design and installation of DRE infrastructure in the respective institution(s)
    - Financial support for bearing the cost of equipment and installation
    - Capacity building support for capacitating institutional staffs in operation and maintenance of the DRE infrastructure

DRE Plan of Action

- The implementation methodology of the EIDP will be based on:
    - Generic Energy Assessments (GEA) for each type of institutional building to be conducted by experts and documented
    - The GEAs will guide the specific energy infrastructure planning for each individual institutional building and will be fine-tuned for each specific case by experts. The fine-tuned energy assessment for each individual building will be termed as Energy Assessment (EA)
    - Based upon findings and recommendations of the EA, an Energy Infrastructure Plan (EIP) will be developed for each individual building. The EIP will contain design details, budgets, timelines and works execution procedures for each individual building
    - Funds allocation will be such that (a) off grid institutional buildings will get preference in energy infrastructure planning and (b) off grid institutions get full funding for energy infrastructure creation (c) Grid connected institutions could be offered partial funding for covering energy infrastructure creation costs. They will also be entitled to sell their excess power to the grid

4.2 DRE Plan for Agriculture

4.2.1 SWOT Analysis

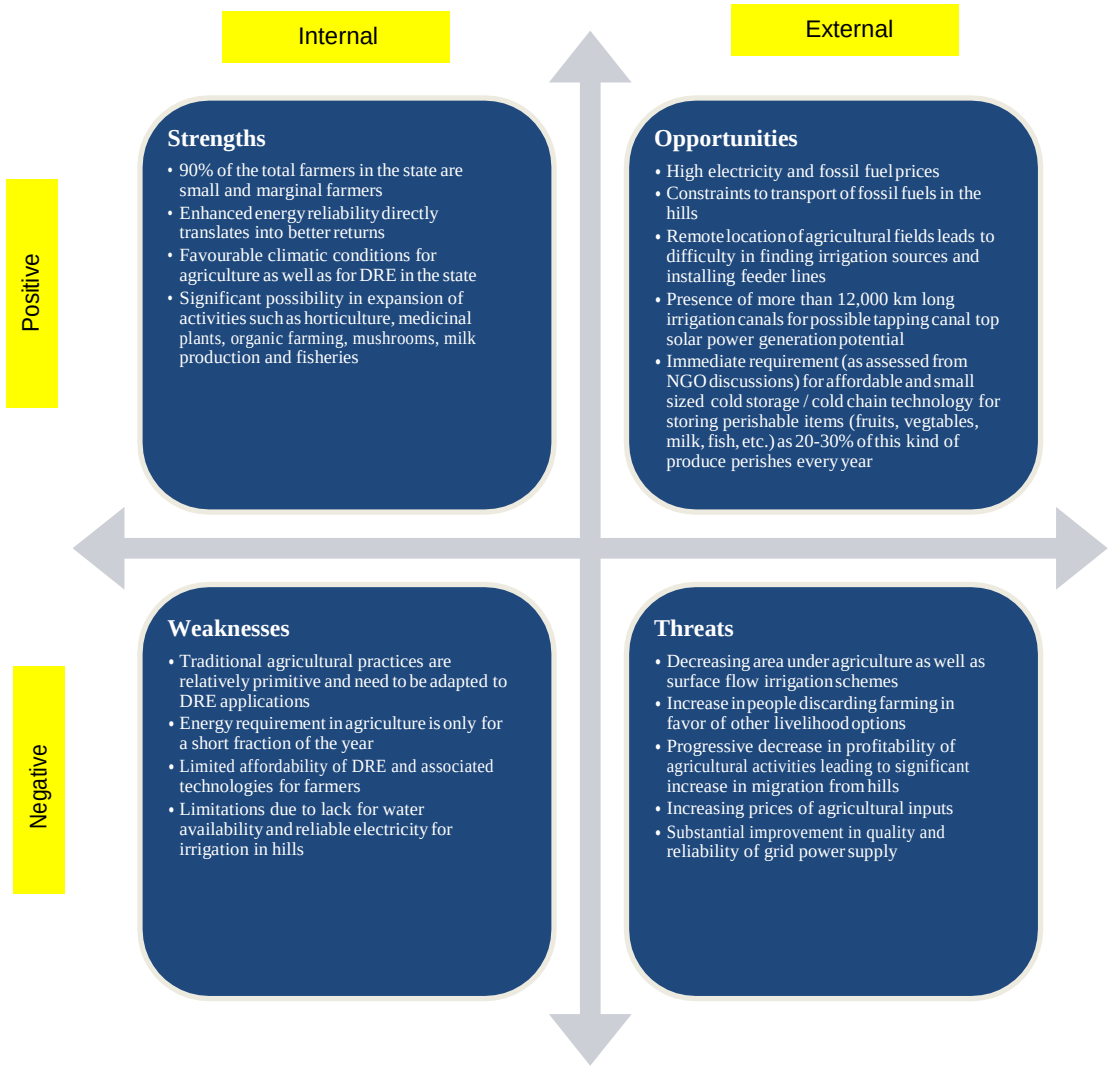


Figure 4.2 - SWOT Analysis of Agriculture

4.2.2 Strategy

From energy applications and utilization angle, Agriculture Sector is not a very significant sector in Uttarakhand as the quantum of energy use in this sector is very less compared to other sectors. Nevertheless, energy is crucial in certain stages of crop production, particularly for irrigation as also during harvesting/post-harvest. Again, while agriculture is the most prevalent economic activity in the state, almost 90% of the people engaged in it are small and marginal farmers. It is imperative therefore, that any energy related programs designed for the agriculture sector in Uttarakhand should focus on the small and marginal farmer segment. The other two important aspects that energy interventions in the agriculture sector for Uttarakhand should focus on are (a) irrigation and (b) cold storage. This is because irrigation is the single most important factor responsible for a good harvest. Similarly, there is conclusive feedback from the farmers on loss of produce due to unavailability of adequate cold storage space in the state which causes heavy losses of the tune of 20% to 30% of their total production to them.

4.2.3 Targets

1. Solar pumps to be installed in 500 group irrigation collectives[63] by 2025
2. 1000 drip farmers to start using solar pumps for drip irrigation by 2025
3. 100 shared small cold storage units to be installed by 2025
4. 6 MW of canal top solar to be installed by 2025
5. 1 MW of aggregate solar capacity to be installed on unculturable waste lands by 2025

[63] Group irrigation is proposed considering the affordability issues and abundance of small and marginal farmers in the state

4.2.4 Suggested Technology Packages and their Financial Implication

Table 4.2 - Technology Packages and Cost (Agriculture)

S. No.	Particulars	Total Units	Suggested DRE Solution	Proposed Quantity	Purpose	Capacity/ Size	Technology Cost		Total cost/ Investment required (Rs. in Crore)	Assumptions
							Amount	Unit		
Energy for Agricultural activities										
1	Pump-sets	55141	Solar pumps	500	Improve reliability of irrigation specifically for small and marginal farmers and save irrigation costs	NA 5 kWp	1,00,000.00 20,000.00	Rs. for piping etc. Rs. per kWp	6.00	Assumption is that grid power becomes reliable in the state and only few isolated areas will have unreliable power supply. Avenues for collective group irrigation of adjoining small/marginal farmers' fields could be explored
2	Drip Irrigation area (in hectares)	696	Add Solar pump to drip system or install new drip system with solar pump	200 hectares or 1000 Solar pumps	Pump operation for drip irrigation	0.3 to 1 kWp	1,25,000.00	Rs. per kWp	12.50	Assuming that grid is being extended to most areas, solar pumps can help save energy costs and even generate additional income if energy is fed to the grid during off season.
3	Cold Storages	66	Solar based cold storage facility (5 MT capacity)	100	Preserving Fruits and Vegetables	5 MT	8,00,000.00	Rs. per unit	8.00	Small sized cold storages are in demand particularly in the hills
Leveraging Agricultural Infrastructure for Energy Production (DRE)										
5	Irrigation Canals length (in Km)	12420	Canal top Solar PV Power Plant	6 km	Power production	1 MW per km	2,00,000.00	Rs. per kWp	120.00	Assuming 0.05% of the total canal length to be covered by solar panels
6	Barren and Unculturable waste land (in hectares)	239704.16	Installation of multiple Solar PV Power Plants on Barren and Unculturable waste land	1 ha	Power production	various sizes based in local site conditions	2,00,000.00	Rs. per kWp	20.00	Assuming a lumpsum amount on excess side becausee of possible accessibility issues for reaching such lands
						Total Amount Required			**166.50**	

4.2.5 Recommendations

A composite program for DRE based Agriculture Sector Improvement (DASI) in Uttarakhand could be conceptualized and launched. The objective of this program will be to launch appropriate DRE interventions in the agricultural sector as identified in this DRE plan to realize substantial returns for the small and marginal farmers of Uttarakhand. The Program will comprise of the following activities / interventions:

- Facilitating collective irrigation of amongst farmers groups having adjoining land holdings through a jointly owned tube-well and solar pump. The Program could be designed to pick up up to 90% of the capital cost of a solar based collective irrigation system.
- Promoting use of solar pumps in conjunction with drip irrigation systems wherever feasible. Attractive subsidy could be offered to farmers desirous of integrating solar pump with their drip irrigation system
- Small solar based cold storages could be provided to farmers groups desirous of using them as a collective asset. Up to 90% of the cost could be picked up by the Program.
- Wherever possible, existing canals and unculturable waste lands could be used to locate solar power plants and produce energy. The land / canal for the power plants could be provided by the land owner while the cost of equipment could be borne by an external investor. The income from sale of energy produced by these plants could be shared between the land / canal owner(s) and the investor. The Program could bear part cost of scoping or DPR preparation

4.3 DRE Plan for Rural Livelihoods

4.3.1 SWOT Analysis

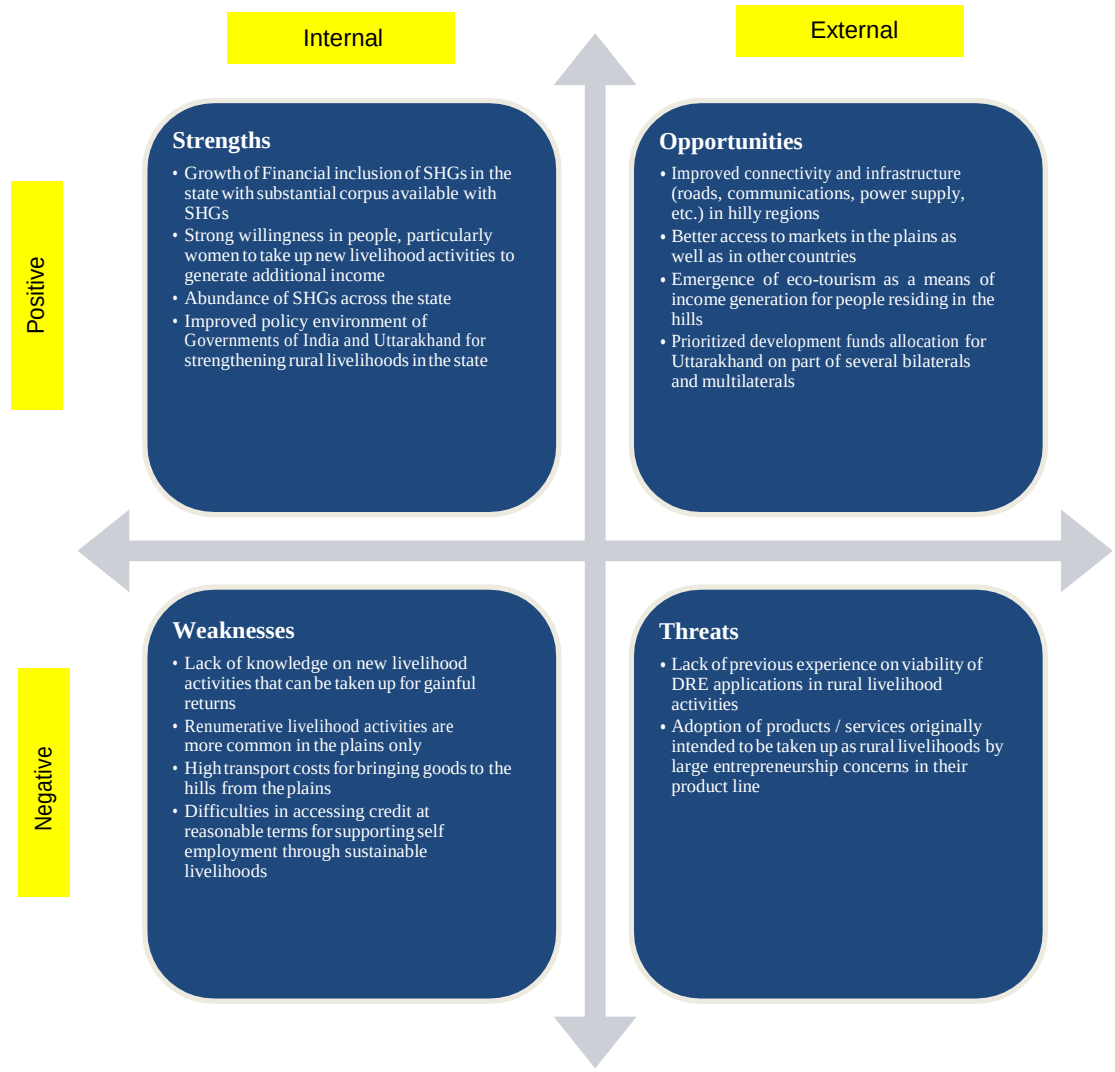


Figure 4.3 - SWOT Analysis of Rural Livelihoods

4.3.2 Strategy

Given the scarcity of information available, relative vulnerability of this class of people and trends in out-migration from the state, it is important that the rural livelihoods sector is addressed in a way that enables the target people transcend barriers and make good use of their skills and available opportunities. Some prominent hurdles faced by people of weak economic background in rural areas in respect of livelihoods are:

- Inadequate information on market demand (local as well as distant) for various products
- Inadequate skills on important aspects such as production planning, marketing, etc.
- Very limited capability for capital investment
- Inadequate access to reliable energy services
- Vulnerability to exploitative elements in the supply chain

Now, it is well known and established that enhanced access to energy and reliable energy services can go a long way in increasing viability and profitability of such livelihood activities. Further, if the energy

services come through DRE, it adds to the sustainability as well. It is therefore imperative that any strategy for integrating DRE into the rural livelihoods sector cannot focus solely on DRE applications. Rather, it should focus on all round facilitation of the target persons, which would include:

- Hand holding in planning and setting up the business including aspects like market assessment, business planning, etc.
- Help in designing the DRE intervention technically and operationally
- Financial support to help establish and kick-start the livelihood activity

It is evident that activities undertaken by groups of individuals would be more attractive from the financing point of view. In that respect, established Community Based Organizations (CBOs) such as self-help-groups would be definitely be preferred options. Hence the broad strategy for introducing DRE in the rural livelihoods sector could be on the following lines:

- Involve NGOs who are already into establishment of rural livelihoods – either individually or through value chains
- Select 10 livelihood activities/ value chains that are proven to be successful, have considerable expansion potential and are established and thriving
- Assess the feasibility of DRE applications in the livelihood activities / value chains and assess implications of the same on the returns / profitability. This will include market assessment and business planning
- Design an intervention / program based on the results of the above exercise

4.3.3 Suggested Technology Packages and their Financial Implication

Figure 4.4 - Technology Packages and Costs (Rural Livelihoods)

S. No.	Particulars	Total Units	Suggested DRE Solution	Purpose	Technology Cost		Total cost/ Investment required (Rs. in Crore)	Assumptions/ Remarks
					Amount (Rs.)	Unit		
1	DRE Integration pilots on Livelihood activities/ value chains as per details in ***Table 3.13***	650	Improved cook-stove (commercial size), Solar power pack, Small solar pump , small low wattage equipment, fans, etc.	Improved livelihood opportunities	5,00,000	Rs. per DRE package	32.50	Estimated 50 pilots per district in each (13) district at the rate of Rs. 5 lakh which includes DRE cost for one livelihood activity
2	Business enrichment studies	1	NA	To add value to the economic activities subsequent to integration with /DRE	NA	NA	2.00	Lumpsum
3	In-depth study on watermills to explore • livelihood potential and • grid feeding potential with 2 pilots		Improved Watermills	To improve the livelihood opportunity for watermill owners	NA	NA	3.5	Study to cover 4 districts, 2 in Garwhal, 2 in Kumaon. The aim would be to identify existing issues and explore solutions to make them viable rural enterprises
4	Capacity building		NA	To train the stakeholders engaged in implementing pilots	NA	NA	2.00	Lumpsum
5	Monitoring of 650 pilots		NA		NA	NA	1.05	Lumpsum
				Total Amount Required			**41.05**	

4.3.4 Targets

- 50 functional livelihood activities to be established per district (total: 650 pilots) on a pilot basis. Each pilot should demonstrate successful integration of DRE with the respective trades (individual or collective)
- A detailed study of watermills as a means of livelihood to determine the prevailing issues (technical as well as economic) so as to help design a program for their possible revival.

4.3.5 Recommendations

It is recommended that a holistic program with the aim of enhancing rural livelihoods including instilling DRE applications in select rural livelihoods activities in Uttarakhand be developed. The program will be conceptualized on the following lines:

1. Conduct an assessment of the livelihoods programs being undertaken by different NGOs in all districts of Uttarakhand to identify successful and viable livelihood activities with adequate potential for replication
2. For the livelihood activities identified in the above assessment, undertake detailed enrichment exercises such as market assessment, prospects for future market expansion, preparing business plans, etc.
3. Integration of DRE with the livelihood activities so as to enhance their viability and profitability
4. Monitoring performance of the livelihood activities / value chains post DRE integration

The program will be implemented through two-line departments with clearly divided responsibilities as follows:

Department of Industries/HRD

It will oversee all work on

1. Identification of successful livelihood activities based on various performance parameters
2. Enrichment studies on selected livelihood activities
3. Monitoring financial performance post DRE implementation

UREDA

It will oversee work on:

1. DRE integration with selected livelihood activities
2. Monitoring of technical performance of the DREs post integration

In addition, the respective NGOs will be responsible for:

1. Overseeing ground level implementation and ensuring proper compliance to design and production procedure
2. Providing hand holding guidance to the respective CBOs in implementing the program
3. Monitoring the implementation activities at the micro level
4. Undertaking / facilitating capacity building activities as and when required

4.4 DRE Plan for MSMEs

4.4.1 SWOT Analysis

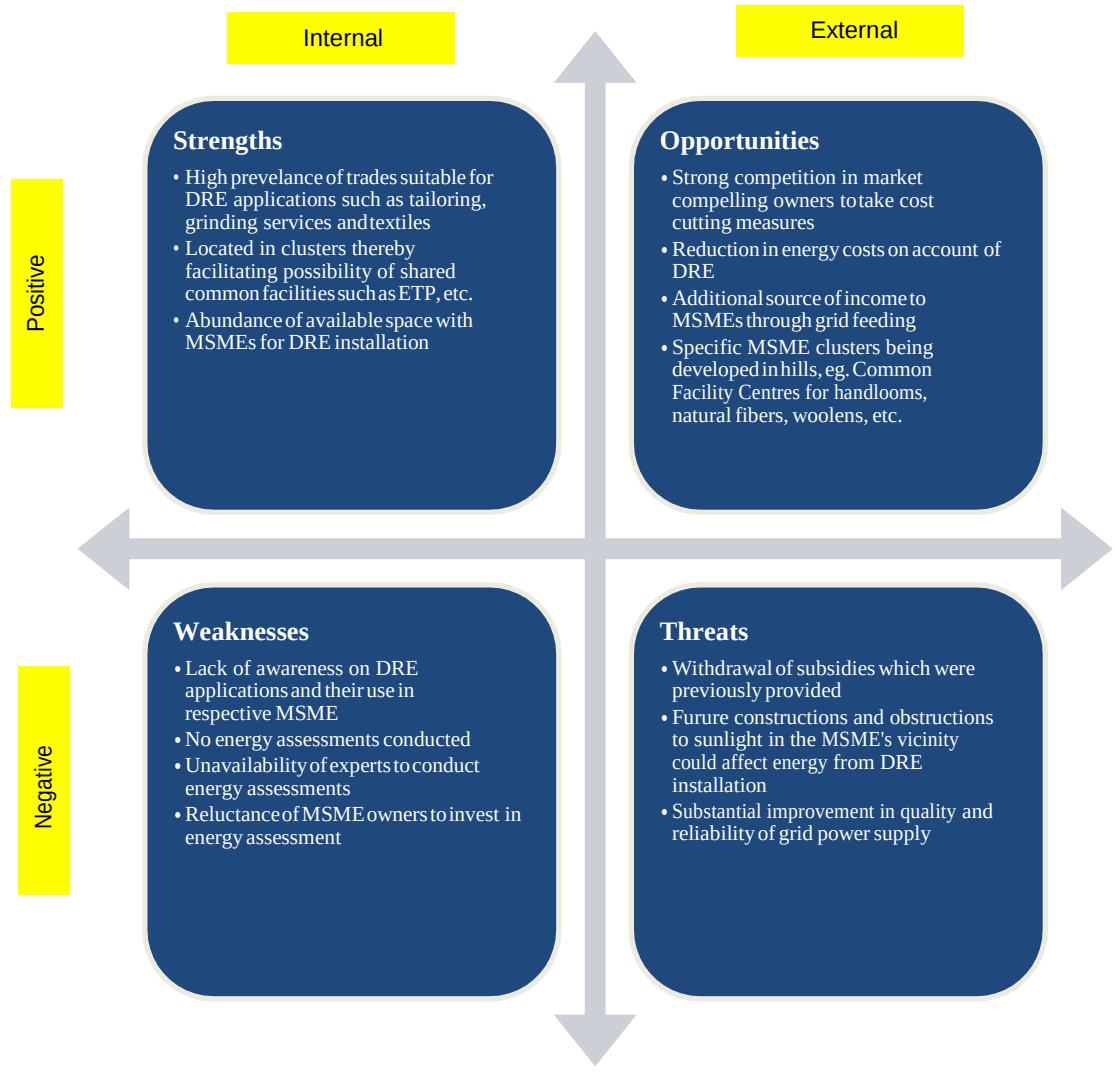


Figure 4.5 - SWOT Analysis of MSMEs

4.4.2 Strategy

MSMEs in Uttarakhand can benefit substantially from DRE interventions. However, most of the owners of these units are not aware of DRE possibilities and the associated benefits. While several MSME owners also have a certain level of investment capabilities, albeit limited, they also tend to have a certain degree of reluctance or inhibition towards investing in or adopting DRE mainly because of lack of reliable information on the scale of returns that might be generated. The same inhibition also prevents them from going in for a detailed assessment or scoping of DRE possibilities in their respective units.

In view of this, it is suggested that the strategy for promoting DRE applications in this sector:

- Should focus on micro or tiny industries which are more suited to direct DRE applications
- Should not comprise any element aimed at providing financial support for capital expenses associated with DRE as DRE has the potential to pay back for itself if planned and used properly
- Rather, DRE Pilots should be promoted in selected industries to demonstrate its effectiveness

4.4.3 Targets

1. To achieve 100% integration of DRE in 200 MSME units on a pilot basis till 2025
2. To closely monitor usage and performance of the DRE installation and corresponding benefits accrued to the respective MSMEs and

4.4.4 Suggested Technology Packages and their Financial Implication

Table 4.3 - Technology Packages and Cost (MSMEs)

No.	Particulars	Units	Solution	Size	Quantity	Purpose	Technology Cost Amount		Total cost/ required Crore)	Assumptions/ Remarks
Technology Packages for different categories of MSMEs										
1	Grinding Services	6367	Solar Power Plant and Inverter	2-5 kWp	100	Operate grinding mills	1,10,000.00	Rs. per kWp	5.50	DRE packages to be preferably piloted in grinding mills of total investment lesser han Rs. 50,000/-
2	Eateries	465	Solar PV Power Plant	1-2 kWp	50	Electricity for lights and fans + Grid feeding	1,10,000.00	Rs. per kWp	1.10	DRE to be piloted in eateris located in off grid areas
			Improved biomass cook-stoves	2-4 unit commercial size	50	Cooking	25,000.00	Rs. per Cookstove	0.50	
3	Local Services	5892	Solar Power Plant with batteries and inverter	1-3 kWp	100	For lighting and operating small equipment	1,10,000.00	Rs. per kWp	3.30	Candidates for pilot to be selected on basis of their size (small will be preferred) and location in off grid areas
4	Hotels	896	Solar Power Plant with batteries and inverter (for lighting and internet only)	5 kWp	20	Electricity for lights and fans + Grid feeding	1,10,000.00	Rs. per kWp	1.10	Hotels for demonstration to be selected on basis of remoteness of location and altitude (sample to be distributed amongst different altitude)
			Solar Water Heaters	1-2 units; 200 LPD	20	Water heating	20,000.00	Rs. per 100 LPD	0.16	
			Improved biomass cook-stoves (commercial size)	2 - 4 unit commercial size	20	Cooking	25,000.00	Rs. per Cookstove	0.10	
5	Textiles	2775	Solar Power Plant	5 - 10 kWp	50	Lighting	1,10,000.00	Rs. per kWp	5.50	Units located in off grid areas to be given preference
			Biomass based boiler (Retrofit the existing boiler/s)	1 per unit; 50-100 kg/hr	50	Process heat generation during dyeing etc.	10,00,000.00	Rs. per boiler for retroffiting	5.00	
6	Handicraft	884	Solar Power Plant with inverter and batteries	1 kWp	100	Electricity for lights and fans + Grid feeding	1,10,000.00	Rs. per kWp	1.10	Units located in off grid areas to be given preference

DRE Plan of Action

S. No.	Particulars	Total Units	Suggested DRE Solution	Capacity/ Size	Proposed Quantity	Purpose	Technology Cost		Total cost/ Investment required (Rs. in Crore)	Assumptions/ Remarks
							Amount (Rs.)	Unit		
7	Tailoring	3700	Solar Power Plant with inverter, batteries	2 - 5 kWp	100	For lighting, operating sewing machines + Grid feeding	1,10,000.00	Rs. per kWp	5.50	Units located in off grid areas to be given preference
8	Food Processing	1522	Solar Power Plant for lighting	2 - 5 kWp	50		1,10,000.00	Rs. per kWp	2.75	Varied kinds of end products to be included in sample
			Improved biomass cook-stoves (commercial size)	2 - 4 unit commercial size	50		25,000.00	Rs. per Cookstove	0.50	
			Solar based cold storage facility	1-2 units; 5 MT	50	Preserving Fruits and Vegetables	8,00,000.00	Rs. per unit	8.00	
9	All MSMEs (having potential for DRE integration)	22501	Energy Assessment of identified 1% MSMEs	Variable	200	DRE integration to save energy cost	3,00,000.00	Rs. per unit	6.00	Applications may be invited from MSMEs for assessment
10	Selected 200 MSMEs	NA	Performance Monitoring of the 200 MSMEs selected for energy assessment and DRE intervention for 1 year	Variable	200	Performance Monitoring	NA	NA	0.50	An agency may be hired for this routine monitoring of 200 identified MSMEs for a year. A dedicated team of 20-25 personnel may be deployed for the same.
11	Interest Subsidy for DRE Installation	Interest subsidy, if opted for, will have to be worked out by concerned stakeholders on basis of options provided in the ***Table 4.4*** below								
						Total Amount Required			**46.71**	

4.4.5 Recommendations

1. Conduct a pilot in 200 MSMEs led by UREDA wherein DRE is integrated into selected MSMEs. These pilots will act as a demonstration for other MSME units who could also later opt to benefit from DRE on similar lines.
2. The terms and conditions for these pilots could be on the following lines:
   a. UREDA will invite all MSMEs to apply for becoming part of this intervention wherein about a pilot featuring DRE integration with selected MSMEs will be launched.
   b. From amongst the applicant MSMEs, UREDA will select 200 MSMEs based on predetermined criteria such as product line, investment, energy demand, size of workforce, annual production and sales, earlier financial performance, market reputation, available budget etc.
   c. Energy Assessments will be carried out on all selected MSMEs resulting in a DPR for installation of DRE in the unit. The Energy Assessments will be commissioned by UREDA, who will also bear the associated cost.
   d. Subsequent to energy assessment of all selected MSME units, work will begin on installing DRE in each unit as per recommendations of the energy assessment
   e. UREDA may decide to support the capital investment cost of integration of DRE in the selected MSME units (as per technical details recommended in the respective Energy Assessments) and offer interest subsidy on the balance. Alternatively, it may offer only interest subsidy. The owner of the MSME unit will have to give an undertaking that the recommendations of the Energy Assessment will be fully implemented by the Unit.

Table 4.4 - Suggestive cost contribution by UREDA and MSME in DRE integration

	UREDA's Contribution	MSMEs' Contribution
Option-1	Capital Investment Cost of DRE integration. It will include the initial assessment cost and partial cost (as agreed upon cost sharing pattern) of DRE appliances	Partial cost of DRE appliances to be repaid in installments as the repayment tenure agreed upon Regular reporting w.r.t. performance monitoring for 1 year
Option-2	Facilitate loans to identified MSMEs with subsidized/zero interest for energy assessment and DRE appliances	Full investment cost (with subsidized interest) to be repaid in installments as the repayment tenure agreed upon Regular reporting w.r.t. performance monitoring for 1 year

   Possibilities of tying up with International Donor organizations or Carbon Credit firms could be explored for picking up the interest subsidy costs mentioned under Option-2 above.
   f. Subsequent to installation and commissioning of the DRE equipment, the energy performance of the unit will be closely monitored, analyzed and documented by UREDA for a period of 1 year from the date of commissioning. The unit owner will have to agree to permit monitoring of energy performance of the unit for the stipulated period
3. Subsequent to the culmination of the monitoring period, UREDA may publish the results of the experience and use the same for its outreach efforts to convince other MSMEs to adopt the same strategy.

4.5 DRE Plan for Domestic Sector

4.5.1 SWOT Analysis

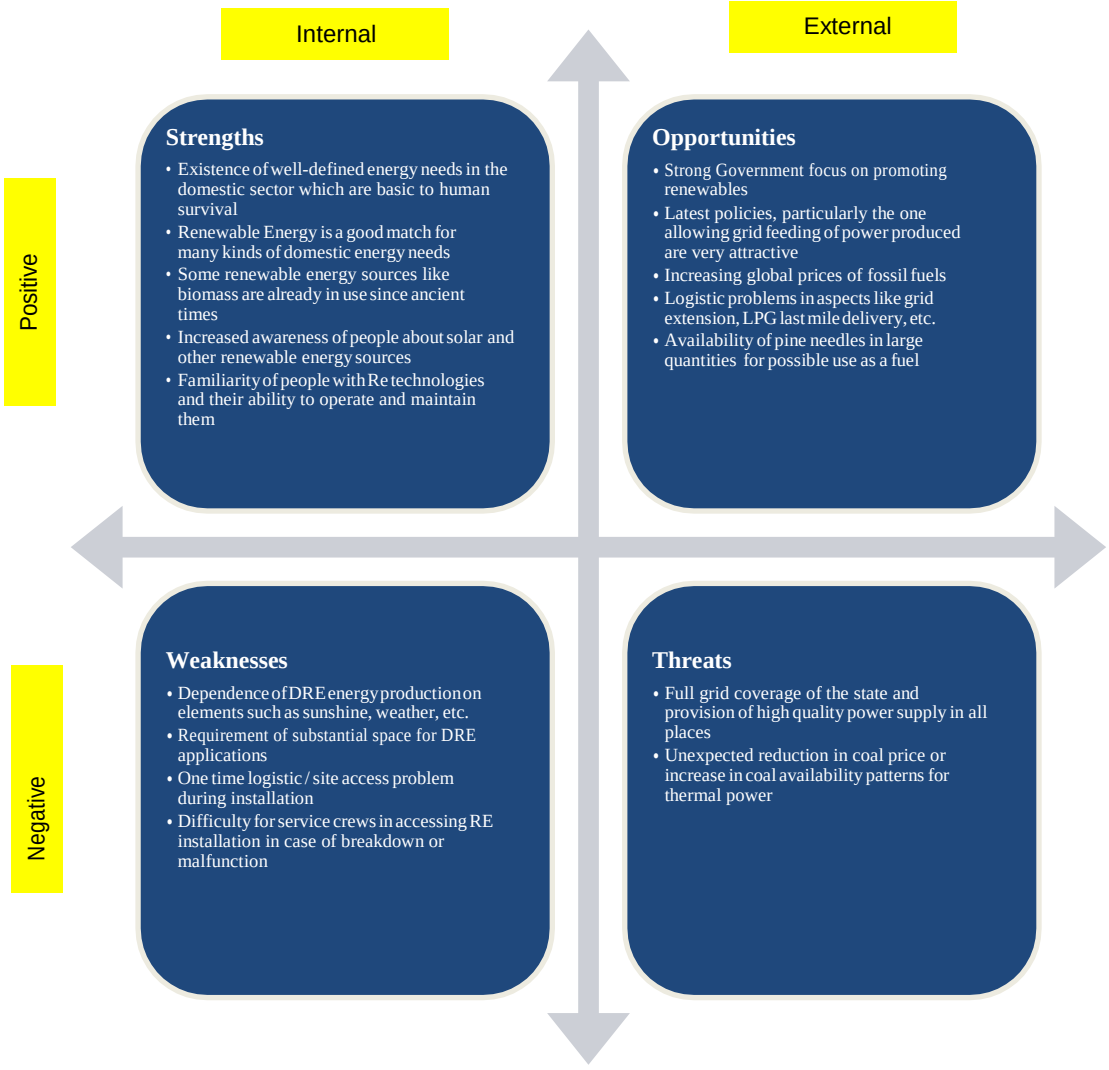


Figure 4.6 - SWOT Analysis of Domestic Sector

4.5.2 Strategy

As can be seen from ***Section-3.5*** on Domestic Sector and the SWOT analysis above, the Domestic Sector consists of energy applications that are essential for maintenance of routine but basic human subsistence needs. Based on the analysis shown in the section, it becomes more or less obvious that any future planning for the sector should consider the following:

- **Stand-alone Solar Systems**: Continue promotion and distribution of solar lanterns, solar home lighting systems and solar stand-alone streetlights particularly as a fallback option in case of disasters
- **Mini-grids**: Only solar mini-grids will continue to remain somewhat relevant. Such mini-grids should be promoted for off-grid applications. In grid connected areas also, solar mini-grids could be promoted but the installation should be in grid feeding mode. MMHP mini-grids may not be relevant any longer but they could be converted for grid-feeding applications only. Biomass (based on crop residue and firewood) and hybrid systems are no longer relevant unless better options emerge and support for the same could be stopped for now.
- **Technologies for Cooking**: Improved Biomass Cook-stoves, particularly natural draft

ones, will continue to remain relevant despite competition from LPG. Promotion of

these cook-stoves should continue for domestic as well as commercial use. Solar cookers (box type as well as concentrating type) are not much in demand and therefore need not be pushed in the market. Solar induction cook-tops are an interesting possibility but should be tested on an experimental scale before any elaborate planning is done.

- **Water Heating**: Solar water heaters are a time-tested technology option both for domestic as well as commercial applications and their promotion should be continued with renewed vigor.
- **Space Heating**: There is no technology available for space heating. Consequently, it would be useful to launch an effort to develop such a technology, preferably one that uses locally available biomass as fuel.
- One major constraint encountered in respect of all the technology options for the DRE sector is the lack of adequate technical support. Future DRE planning should consider building a foundation for such technical back-up services in the state.

4.5.3 Estimated Financial Implication of suggested interventions

Table 4.5 - Estimated cost of suggested interventions

S. No.	Particulars	Units	Unit Cost (Rs.)	Total Cost (Rs. in Crore)	Assumptions/ Remarks
1	Solar lanterns stock for disaster preparedness created for GP	80,560	1,500	12.08	Assuming 10 solar lanterns to be given to each GP
2	Creation of revolving fund for facilitating adoption of biomass cookstoves through carbon credit mechanisms	1,00,000	2,100	21.00	The amount provided to identified HHs for purchasing the cookstoves will be reversed through carbon credits accumulated. Amount collected by selling carbon credit will serve as corpus fund for the purchase of next 1 lakh cookstoves
3	Pilot study of solar PV based induction cookers in 10 HHs	10	NA	6.00	Lumpsum including cost of cookers and cost of procuring an agency for study
4	Research for biomass based improved space heating technology including one pilot. Biomass tested for this technology should include pine needles	NA	NA	20.00	Lumpsum. Study will involve design and successful pilot trial of appropriate biomass based space heating technology. One of the kinds of biomass to be included in the design parameters is pine needles
5	Research study on designing a biomass power plant based on pine needles with one pilot. Pilot to include mechanism for collecting and stocking pine needles	NA	NA	14.70	Lumpsum, Study will include two components: (1) Designing and pilot testing (including economics) of a pine needle based biomass power plant (2) Designing and pilot testing (including economics) of a pine needle collection and storage mechanism
	Total (Rs. in Crore)			**73.78**	

4.5.4 Recommendations

1. Launch a program wherein a pool of say up to 5 solar lanterns is created in the GP office of every GP in the state. In remote off-grid areas, this pool may be increased to say 10 solar lanterns. The primary intention of keeping the lanterns is for disaster preparedness. However, in the meantime, the lanterns may be provided on lease to desirous individuals on a daily or weekly basis. This will also be a source of revenue to the GP.
2. Continue ongoing policies, programs and targets for solar streetlights
3. Study the project on promotion of improved biomass cook-stoves on carbon credit being implemented by the NGO Sanjeevani and explore avenues of expanding their success story to other parts of Uttarakhand. The Government could consider setting aside a fund for supporting purchase of say 100000 improved biomass cook-stoves in say 2 selected districts. The cook-stoves could be distributed to beneficiaries as per the methodology developed by the NGO and subject to their monitoring protocol for leveraging of carbon credits. Once the same amount is recovered back through carbon credits, the same could be invested in some other districts and so on.
4. Conduct a pilot study on use of solar photovoltaics based induction cooking systems on 10 selected families in different zones of Uttarakhand
5. Continue ongoing policies, programs and targets for solar water heaters
6. Sanction a research project on product development and pilot testing of a biomass based portable space heating device for the upper hill ranges. One of the fuel options for this research should be pine needles
7. Sanction a research project on design and development of a pine needles based biomass power plant with a pilot trial (in grid connected or off-grid mode) that would include documentation of operating costs. The project should also have another component aimed at designing an affordable collection and storage mechanism for pine needles which will be pilot tested along with the main power plant.

5. Other Possibilities

Land Neutral Solar

This is an upcoming technology where solar photovoltaic arrays mounted on floats are placed on the surface of still water bodies such as ponds and lakes. Power produced from such power plants can be supplied to the grid through a nearby substation. Uttarakhand has considerable number of still water bodies that could be leveraged for such land neutral solar applications provided applicable statutory compliance requirements are met.

District-wise available surface area of water bodies in the state[64] is given in ***Table 5.1*** below:

Table 5.1 - Area Under Water Bodies in Uttarakhand

District	Area under water bodies (km^2)
Udham Singh Nagar	77.89
Almora	0
Tehri Garhwal	25.76
Haridwar	0.73
Pithoragarh	0.38
Chamoli	0.49
Nainital	9.67
Uttar Kashi	5.29
Dehradun	0.62
Pauri Garhwal	75.05
Bagheshwar	0

[64] http://bhuvan.nrsc.gov.in/gis/thematic/tools/document/LULC502/MAP/UK.pdf

District	Area under water bodies (km^2)
Champawat	0.04
Rudraprayag	0.25
Total	**196.17**

Source: Forest Survey of India 2011-12

It can be seen from the table that more than 196 km^2 of aggregate still water surface area is available in the state. It can be reasoned that even if 0.05% of this area, which will be just below 1 km^2 is brought under land neutral solar, almost 100 MW of power could be produced, which is substantial. It is recommended that the State should explore the feasibility of exploiting this tremendous potential by commissioning detailed scoping and assessments so that the ball could be set rolling on harnessing this vast resource.

6. Annexes

Annex-I: Meetings with UREDA and Government Departments

1. Meetings with Selected Officials in Various Government Departments

1) UREDA (Mr. A. K. Tyagi, CPO)

On the objectives and output of the DRE plan, Mr Tyagi suggested that the main focus should be on the following: (i) identify income generating activities based on DRE; (ii) technologies present or needed for these activities and (iii) investment needed. Innovative applications such as the traditional water mill also need to be studied for making them income generating. He also emphasized the need to explore further potential for emerging fuels such as the Pine Needles and the Government's recent policy intervention for encouraging such themes. He further agreed to provide relevant data and information on current status of DRE applications in Uttarakhand.

2) CII (Mr. Sumanpreet Singh, Director & Head Uttarakhand State Office)

CII mainly represents the larger industrial units such as Hero Motors, Tata, Mahindra, Jubilant Pharma etc. The membership is around 60 and represents engineering, hospitality, pharma and herbal etc. Several amongst these units already have plans to implement energy efficiency and renewable energy in their respective premises. However, the tiny units in organized or unorganized sector also have considerable relevance in terms of RE applications. The team was pointed towards the Department of Industries, MSME division, which would be the appropriate agency to give information about such units.

3) MSME

The MSME Department under the Directorate of Industries is responsible for implementing the policies and programmes for the industrial development of the state. The main aim of the Directorate is to provide a comprehensive framework for enabling a facilitating and investor friendly environment for industrial development. It also maintains district-wise list of units registered in the state. This list is available in the public domain. It also coordinates the activities of the District Industries Centres for each district.

This list has been downloaded by SusTech and subjected to analysis to determine the number of such industrial units in various sub-categories. Further analysis is underway to determine which categories have more relevance for RE applications and to estimate the possible DRE potential.

2. Visits to MSME Production Facilities

1) Numero Uno Clothing Ltd.

2.1.1. ***Description of Unit***: This is a leading national brand of garments and has a wide product range that includes garments, jeans, shirts, T-shirts
Production process and machinery used: The unit is equipped to undertake the entire range of production activity from washing of textile material to final finishing and packaging. Machinery includes washing machines, cutting and stitching machines and other accessories such as buttoning machines and table presses. These are all manually operated mechanical machines. The unit runs one general shift at present.
Other equipment includes Boilers and Air-conditioners

2.1.2. ***Energy sources currently in use by the unit***: The unit draws its entire requirement of power from the grid. It has a sanctioned load of 450 kW. The cost of power in total production cost: 15-20%. The unit also maintains a full power back up through a diesel genset. Further, the unit also deploys a large diesel powered boiler for providing process hot water or steam

2.1.3. ***Prospects in terms of DRE applications***: The unit has 15,000 sq ft of covered area and around 3500 sq ft of open space available. The total plot size is 8848sq m. This is suggestive of considerable potential for installing Solar Power Plants either as a captive power plant or in dual mode – for internal consumption as well as for selling to the grid. The main power requirement of the plant is for lighting purposes and running of stitching machines, a large portion of which could be met through RE/DRE. Further, there is considerable potential for converting the diesel powered boiler to biomass fed one. Hence, use of RE or DRE could significantly impact the profitability of the unit in a positive manner.

2) Cooper Pharma

2.2.1. ***Description of Unit***: This is one of the oldest pharma unit in the country. It manufactures tablets, capsules, syrups, ointments and injectables. It has a state-of-the-art manufacturing unit, with latest and best in class HVAC, Water purification and other Utility Systems, Effective water and waste management and Good Manufacturing Process Records. Equipment for manufacturing and packaging includes Capsule Filling Equipment, Pharmaceutical Ampoule Filling Machine; Liquid Filling equipment; Tube Filling/cream Filling Machine, etc. Other equipment includes Boilers run on LDO.

2.2.2. ***Energy sources currently in use by the unit***: The unit depends primarily on power from the grid supply. The main consumption is for Air conditioning of the facility and running of various equipment. The unit's sanctioned load is 700 kW and peak load is 1000 kW. Since it has a continuous manufacturing process, the unit also has a 100% Diesel Genset back up.

2.2.3. Prospects in terms of DRE applications

The unit is built on a plot size of 7400 sq m. Roof area is 4500 sq m which is indicative of a significant RE generation potential. However, since its own consumption is quite high and it requires highly reliable power supply, the DRE capacity, if installed will not suffice its requirements. It can however, offset some of its energy costs if fed to the grid.

3) GP Electricals (Mr Mahesh Sharma)

2.3.1. ***Description of Unit***: It is medium size unit manufacturing Distribution Transformers.

Manufacturing process involves winding of copper wires, assembly, drying in an oven, oil filling, painting and testing. There are 30-40 manufacturers of distribution transformers in the state. The equipment required in the production of transformers is Coil winding machine, Oven for drying and compressor.

2.3.2. ***Energy sources currently in use by the unit***: The sanctioned load for the unit is 40 kW. Its peak load is 45 kW. The main power consumption is for operating the Oven. The unit draws its entire power supply from the state power grid.

2.3.3. ***Prospects in terms of DRE applications***: The unit is built on a plot size of 444 sq m., with a roof area of 2300 sq ft. This is not very significant from DRE point of view. However, it the unit opts to install RE, it can certainly offset some of its energy costs.

4) Small scale Garments Production Unit

2.4.1. ***Description of Unit***: This is a small scale manufacturer of shirts, T-shirts etc. The unit undertakes job work for other units. The production process involved is stitching of fabric and this is done on a few JUKI stitching machines

2.4.2. ***Energy sources currently in use by the unit***: The unit entirely operates on grid power.

2.4.3. ***Prospects in terms of DRE applications***: Although the roof area is not too large, there is still considerable potential for running the stitching machines on solar energy by installing a roof-top solar plant as the inherent load of the unit is quite low.

5) VM Corp

2.5.1. ***Description of Unit***: it is a major unit manufacturing Car Seat Covers and other auto accessories. It has another sister unit engaged in the same line of business. The production process involves cutting of material (PU, rexine or leather), lamination and stitching and the equipment used consists of stitching machines and Lamination machine. The unit has production lines consisting of more than 50 stitching machines and auxiliary equipment.

2.5.2. ***Energy sources currently in use by the unit***: All operations are carried out by power supply drawn from the grid. The sanctioned load is 75 kW for mainly for operating the lamination machine as well as the manufacturing operations and office air-conditioning and lighting.

2.5.3. ***Prospects in terms of DRE applications:*** The proprietors of the unit are interested in setting up Solar energy power plant. The plot size 1344 sq m and roof area is 3500 sq ft. The unit is keen to explore the possibility of using solar power for commercial use and is likely to take it up as a pilot project at their second unit.

6) Shiva Packaging

2.6.1. ***Description of Unit***: Thus unit manufactures corrugated paper boxes. Equipment used are corrugating machines, stitching machines, testing machines and dye printing machines

2.6.2. ***Energy sources currently in use by the unit***: The current sanctioned load 60 kW and all its power is derived from the grid.

2.6.3. ***Prospects in terms of DRE applications***: Roof area of the unit (700-725 sq.m.) is considerable and it is interested in tapping solar energy. If planned properly, the unit can offset considerable portion of its energy costs through RE generation and feeding to the grid.

Annex-II: State level NGOs Workshop

NGO Workshop – Key insights and takeaways

An NGO workshop was organized under the aegis of UREDA on 4 July 2018 with the main aim of understanding challenges faced by them in their livelihoods' programs on account of unavailability of energy. Given below are the key insights compiled from the four NGOs that attended this workshop.

1) Peoples Science Institute

S. No.	Livelihood Activity	Income generating potential (Rs./ person/ year)	Current no. of beneficiaries	Is the activity constrained due to lack of energy?	Any suggestions/key challenges
1.	Vegetable & Spice cultivation	15,000-20,000	1000	Yes	Requirement of Small cold storages
2.	Lift irrigation	7000-8000	400	Yes	Solar/hydro power
3.	Off-farm activities	15,000-20,000	100	Yes	Weaving, processing, drying, heating
4.	Skill development	15,000-20,000	100	Yes	Computers, mobile, artisanal works

The NGO mentioned that there is considerable potential for enhancing the returns from the livelihood activities promoted by them if the energy availability scenario is improved.

2) CHIRAG

S. No.	Livelihood activity	Status, achievements & future plans	Constraints and challenges
1.	Established Section 8 company for the marketing of locally made handicrafts and other produce	Generates supplementary income to over 500 women (weavers/knitters/clippers) 325 farmers in 42 villages cultivating herbs. Rs.1.75 Crore turn-over in 2017-18	• Erratic supply of electricity in monsoon and peek winters • Hydro and solar energy technology • Not easily access of alternate energy at rural areas • Maintenance and spare parts are not easily available at rural areas • Lack of skill engineers/experts • Lack of Subsidy
2.	Cooperatives - (03) Dairy, CFC & cattle feed unit, Dal processing unit	Members 504 in 46 Villages	
3.	Micro Federations (03) -Dairy, Cattle feed, Vet. medicines	Members 328 in 19 Villages	
4.	Producer Company Marketing of temperate fruit, local pulses, local kitchen masala & Kitchen herb; Problem of C grade fruit.	Shareholders/Members 183 in 18 Villages Share capital: Rs.1,36,000 Turnover (2017-18) Rs.36,14,950 48.75 MT of fruits, vegetables and cereals sold in FY 2015-16. Total transaction amount: Rs.15.50 lacs	

5.	SHGs	162 SHGs with 1557 women Total saving of SHG Members Rs.61,45,778
6.	Agriculture & Horticulture support	50,000 farmers supported

Future Plans

- Reducing Cost of Cultivation, Increase productivity, Diversify risk, increase market access
- Agricultural Innovation and Entrepreneurship
- Soil health, Quality of planting material, Organic pest and disease management
- Providing enhanced Marketing services for Small and Marginal farmers
- Reducing commission and transport cost to Haldwani
- Increase the turnover of federations/producer company by at least 2-3 times by next 3 years by promoting
  - Alternate energy (Solar energy – Electrification, Water heater, Dryer, Lantern. etc.
  - Biogas
  - Micro Hydro activities
- Skill development of local youth in solar energy

3) Sanjeevani Vikas Evam Jan Kalyan Samiti (Sanjeevani) and Nav Nirman Samiti

The NGO plans to provide 100,000 Improved Cook stoves to rural households of Almora, Bageshwar and Nainital districts of Uttarakhand. These technology alternatives will replace energy inefficient and polluting methods of cooking thereby reducing GHG emissions that contribute to climate change. The project will also contribute to sustainable development of the communities in the project area. Interestingly, the project has made provision to leverage carbon credits ensuing from the use of these cook-stoves. Appropriate monitoring protocol for claiming carbon credits have been already prepared and approved by the relevant international authorities. In essence, once the carbon credits start accruing, the cook-stoves are likely to be virtually free to the users. Till date, about 6000 nos. of cook-stoves have been already distributed by the NGO. This is an interesting development model conceptualized by the NGO and seems to have significant potential for replication.

4) The Hans Foundation

S. No.	Livelihood activity	Status, achievements & future plans	Constraints and Challenges
1.	Undertaking on Farm and off farm-based activities	• 25,000 households in 420 villages, spread in 40 clusters in 10 districts. Work with 12 partners incl. Govt. of Uttarakhand • Provided employment opportunities to 800 youths though entrepreneurship development programme • Impact and achievements: Promotion of more than 800 SHGs/producer groups and 18 cooperatives with a turnover of approximately Rs.8 Crore. • Seed production: Onion, potato, paddy, wheat, mustard, garlic etc.	• Constraints are faced by partner organizations due to non-availability of energy • Non- availability of critical quality inputs in the area • Training facilities & capacities of staff • Climate change impacts • Damage of crop by wild animals • Lack of post-harvest management infrastructure • Road connectivity & transport • Limited Channels & options for Marketing
2.	Training of youth in trades like knitting, tailoring, electrician, mobile repairing, plumbing etc. Support provided to set up business		
3.	Generating 500 KW electricity by setting up of 50 power plants in remote villages of Pithoragarh and Almora districts. The destructive energy of pine needle will be used for setting up gasification-based power plants		
4.	• Setting up Common Facility Centres with MSME Department, Government of Uttarakhand		

Annexes

S. No.	Livelihood activity	Status, achievements & future plans	Constraints and Challenges
	• Production of various types of textile material using handlooms, processing of natural fibers, spinning and knitting of woolen products with marketing support.	• Crop diversification: Cash crops like tomato, capsicum, potato, beans, ginger, garlic • Medicinal and aromatic plants • Mushroom production • Farm mechanization: Power weeder, power tiller, multigrain Thresher, lifting pumps, seed drill, sprinkler, ploughs, various small tools • Production of various types of textile material using handlooms, processing of natural fibers, spinning and knitting of woollen products with marketing support. • Will work as a centre of excellence to provide support to the artisans in the state.	• Constraints faced by partner organizations due to unavailability of energy • Issue related to the optimum use of farm machines due to irregular supply of electricity and high input cost • Poor investment in infrastructure required for post-harvest management

Annex-III: Equipment Installed in different Institutional Buildings

Primary School (Rural)	
Equipment Particulars	**Units**
Tube Lights	53
Other/LED lights	14
Fans	25
Computers	2
Water Purifier	1

AWC	
Equipment Particulars	**Units**
LED Bulb	5
Fan	1
Power Sockets	2

Gram Panchayat Bhawan	
Equipment Particulars	**Units**
LED Bulb	4
Fan	2
Computer	1
Power Sockets	2

Common Service Centre	
Equipment Particulars	**Units**
Bulb/ Tube light	2
Fan	1
Computer	1
Printer	1
Genset/ Inverter	1

Primary Health Centre	
Equipment Particulars	**Units**
Tube light	6
LED Light	130
Fans	14
Exhaust Fan	8
Halogen Light	1
Mobile phone battery charging	5
Computer	3
Printer	1
Refrigerator (165 L)	2
Autoclave (19 L)	2
Small water pump	1
Vaccine refrigerator	1
Neonatal infant warmer	1
Centrifuge	1
Light Microscope	1
Portable Electro- cardiograph	1
Blood Glucose Monitor	1
Suction apparatus	2
Elisa Test Reader	1

Annexes

Annex-IV: Technologies and their costs

S. No.	Categories	Areas for productive use of energy	Suggested Technology	Indian/ Imported	Cost (INR)	Target Group
1.	Livestock breeding	Poultry incubators	1) Egg incubator WQ-42 Engokho	Imported	20,554	Smallholder poultry farmers
			2) Semi-automatic Poultry Incubator Lifeway Solar	Indian	40,000	
			3) Fully automatic Poultry Incubator Lifeway Solar	Indian	50,000	Medium-sized poultry farmers
			4) Egg Incubator NANS	Indian	NA	
		Milking machines	5) Solar Milking Machine Lifeway Solar	Indian	70,000	Dairy farmers
			6) Mobile Milking Machine Siddon Biotech	Indian	40,000	
			7) Mobile Milking Machine Wenzhou Marice	Imported	55,000 – 70,000	Cattle farmers
		Solar fences	8) Adjustable Solar Electric Fence Controller Thunderbold	Imported	5,000	Livestock farmers
			9) Solar Electric Fence Charger Zareba® (2 – 30 miles)	Imported	9,500 – 25,000	
2.	Food production	Water pumping – Surface Pumps	10) Solar Surface Slow Pump Dankoff	Imported	NA	Various pumping applications
			11) Surface Pump Dankoff SunCentric	Imported	NA	
			12) Surface Pump Dankhoff Solar Force Piston Pump	Imported	NA	
			13) Surface Pump Dankhoff Solaram	Imported	NA	
			14) Surface Pumps Lorentz PS-CS-F	Imported	NA	
			15) Surface Centrifugal Pumps Lorentz PSk2-CS	Imported	NA	
			16) Surface Irrigation system ONergy	Indian	NA	
			17) Pressure and Delivery Pumps SHURflo 2088	Imported	NA	
			18) Surface Irrigation Pump Sunflower	Imported	27,500	
		Water pumping – Submersible Pumps	19) Submersible and Surface Pump 3'' Grundfos SQFlex	Imported	NA	Various pumping applications
			20) Submersible Centrifugal Pump Grundfos SQFlex 4''	Imported	NA	
			21) Submersible Pump Lorentz PS Helical Rotor	Imported	NA	
			22) Submersible Centrifugal Pump Lorentz PS	Imported	NA	
			23) Submersible Irrigation Systems ONergy	Indian	NA	
			24) Submersible Pump SHURflo 9300	Imported	NA	

Annexes

S. No.	Categories	Areas for productive use of energy	Suggested Technology	Indian/ Imported	Cost (INR)	Target Group
			25) Submersible Pumps Sun Pumps SDS (Series D, Q, T)	Imported	NA	
			26) Submersible Pump Sun Pumps SCS	Imported	NA	
		Water pumping – Direct Drive /Pump Inverter	27) Pump Inverter EMPO-NI Solar Direct Drive SDD5.5-850-M	Imported	NA	Various pumping applications
			28) Pump Inverter MPP ILK	Imported	NA	
			29) Pump Inverter JUWI Solar Variable Speed Drive (sVSD)	Imported	NA	
3.	Food processing	Grain mills	30) Grain Mill AgriSol 750W	Imported	2,25,000	
			31) Grain Mill BOSS Pro Farina	Imported	4,00,000	
			32) Grain Mill Solar Milling	Imported	NA	
			33) BOSS Kit Pro Mill	Imported	NA	
		Huller, Sheller, Husker, Grater, Polisher	34) Rice Huller AgriSol RHT-1 AC, 250W	Imported	58,500 – 1,72,000	
			35) Rice Huller AgriSol 375W	Imported	2,07,000	
			36) Rice Polisher AgriSol 375W	Imported	69,000	
			37) Maize Sheller/Thresher AgriSol 100W	Imported	38,500	
			38) Cassava Grater AgriSol 250W	Imported	1,20,000	
		Oil-Press	39) Oil Press BOSS Kit Pro Press	Imported	NA	
4.	Food storage	Freezers	40) Freezer – Dulas solar VC series	Imported	3,02,000 – 4,15,000	Basic freezing applications
			41) Freezer – Phocos FR Series	Imported	1,66,000	
			42) Freezer – Steca PF 166/240	Imported	72,000 – 1,15,000	
			43) Freezer – SunDanzer DCF	Imported	50,000	
			44) Freezer – Smart solar ice maker (Steca PF166)	Imported	96,000	
		Refrigerators	45) Absorption Refrigerator Dometic RML 9430 / 9435	Imported	NA	
			46) Portable Cooling Box Dometic RCW42/RCW50	Imported	NA	Basic freezing applications (particularly vaccines cooling)
			47) Portable Cooling Box Dometic TCW3000 DC/TCW2000 DC BL53 POS	Imported	NA	
			48) Refrigerator Dulas Solar VC Series (battery driven)	Imported	3,02,000 – 4,15,000	

Annexes

S. No.	Categories	Areas for productive use of energy	Suggested Technology	Indian/ Imported	Cost (INR)	Target Group
			49) Refrigerator Dulas VC200SDD Solar Direct Drive	Imported	4,15,000 - 6,05,000	Basic freezing applications
			50) Refrigerator ONCool	Indian	NA	
			51) Refrigerator Phocos FR50R/FR165R/FR225R	Imported	NA	
			52) Refrigerator Solar Chill	Imported	80,000 – 1,05,000	
			53) Refrigerator Steca PF 166/240	Imported	72,000 – 1,15,000	Basic cooling applications
			54) Refrigerator SunDanzer DCR	Imported	48,000	
			55) Refrigerator Sure Chill GVR	Indian	2,78,000 – 3,75,000	Dairy farmers
			56) On-farm milk cooling system	Imported	2,80,000	Dairy farmers, milk collection centres, milk bars
			57) Small scale decentralized milk cooling	Imported	2,65,000	
		Walk in cold rooms	58) Walk-in Cold Room FarmFresh	Imported	10,41,000	Medium-scale cooling applications
			59) Cooling Container ILK	Imported	NA	
			60) Cooling Container ILK Milk Collection Center	Imported	NA	Liquid cooling applications (specifically dairy farmers, milk collection and distribution centres)
			61) Container ILK Solar Ice Maker	Imported	NA	Medium-scale ice-making applications (specifically for fisheries and livestock butcheries)
			62) Walk-in Cold Storage Room	Imported	NA	Medium-scale cooling applications
			63) Large Scale Refrigeration SunDanzer	Imported	NA	Large-scale cooling applications
5.	Food for sale	Kettles, Butter maker, Coffee maker	64) Butter maker	Imported	3,000	Catering and Cottage industry, Recreational industry
			65) Solar DC Kettle SE520	Imported	NA	
			66) Biosun Water Purification Systems	Imported	NA	
			67) Solar Kettle Stainless Steel 12V SE510	Imported	NA	
			68) Solar DC Kettle SE500	Imported	NA	
			69) DC Microwave WaveBox	Imported	23,000	
			70) AC/DC Microwave WaveBox	Imported	NA	

Annexes

S. No.	Categories	Areas for productive use of energy	Suggested Technology	Indian/ Imported	Cost (INR)	Target Group
			71) Kettle RoadPro 12-Volt 20oz Hot Pot	Imported	1,200	
			72) Coffee Maker RoadPro 12-Volt with 16oz. Metal Carafe	Imported	2,000	
6.	Tailoring	Sewing and Weaving machines	73) Sewing Machine CERAD	Imported	7,000	Basic tailoring and clothes production industry
			74) Weaving Loom Solar-powered charkha, MIGRI	Indian	NA	
			75) Sewing Machine ONSewing	Indian	NA	
			76) Sewing Machine retrofitted with DC motor – SELCO	Indian	18,000	
			77) Industrial Sewing Machine – SELCO	Indian	NA	
			78) Faison Stitch Sewing Machine – SELCO	Indian	40,000 – 50,000	
7.	Workshop tools	Cordless power tools	79) Rotary Hammer – Bosch RHS181	Imported	16,000	Mobile workshop, carpentry, etc.
			80) Drill – CIMCO 2 Gear Accumulator Impact Drill	Imported	NA	
			81) Rotary Hammer – Hilti TE 4-A18	Imported	25,000	
			82) Chain Saw Makita 18V x2 LXT	Imported	29,000	
			83) Oscillating multi tool-Bosch PS50	Imported	13,000	
			84) Bosch 18V Lithium Ion 4-Tool Combo Kit (CLPK414-181)	Imported	40,000	
			85) DeWalt 18V Max Lithium Ion 6-Tool Kit (DCK691M3)	Imported	69,000	
8.	Media and entertainment	IT secretarial services				
		Cinema				
9.	Energy services	Charging mobile phones and battery, DC/DC inverter	86) Charging ECOBOXX Qube 50/ 90/ 160	Imported	8,000 – 10,500	Panchayat offices, Rural areas, Community households, Small shops
			87) Charging Ready Set Solar Charger	Imported	NA	
			88) Charging Boss Kit Pro Fee	Imported	NA	
			89) Charging Sundaya	Imported	NA	Households,

	Charging station			small enterprises,
90)	Charging Kit Azad Power Pack	Indian	NA	schools, workshops

Annexes

S. No.	Categories	Areas for productive use of energy	Suggested Technology	Indian/ Imported	Cost (INR)	Target Group
			91) Solar Home System Griha On Shakti (75/100W)	Indian	NA	
			92) Inverter System Griha ON Shakti (200/400W)	Indian	NA	
			93) Solar Charging Station ONergy	Indian	NA	
			94) Portable charging station ECOBOXX 300	Imported	47,000	Small mobile charging business
			95) Portable charging station ECOBOXX 600	Imported	1,05,000	
			96) Portable Charging Station ECOBOXX 1500	Imported	1,05,000	
			97) Portable charging station BOSS Kit Port Able	Imported	2,15,000	
			98) DC/DC Converters Studer MDCI and MDC Series	Imported	NA	Rural areas
			99) DC/DC Converter Solaric Solar Optimizer	Imported	NA	
10.	Haircutting & other services	Haircutter				
		Hairdryer				
		Washing machines				

Source: Livelihoods for SHGs through Solar applications, CLEAN

CLEAN
Clean Energy Access Network

Energy off the Grid and of the People

CLEAN FOUNDINGMEMBERS

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The Nand & Jeet Khemka Foundation
UNITED NATIONS FOUNDATION
WWF

CONTACT DETAILS

Chief Executive Officer

p: +91-11-41601543 m: +91 9818844798 w: www.thecleannetwork.org
a: A-23, 2nd Floor, Behind Green Park Free Church,
Aurobindo Marg, Green Park Main, New Delhi-110016