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ENERGY PLANNING AND MANAGEMENT IN KULU DISTRICT, H.P., INDIA

A CASE STUDY

School of Planning and Architecture

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INTERNATIONAL CENTRE FOR INTEGRATED MOUNTAIN DEVELOPMENT

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School of Planning and Architecture,
New Delhi, India.

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International Centre for Integrated Mountain Development (ICIMOD)

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PREFACE

A programme on 'Strengthening Rural Energy Planning and Management in the Mountain Districts of the Hindu Kush-Himalayan Region' was organised during the period from January 1987 to November 1988, funded by the European Economic Community. Various activities were conducted under this programme. Six case studies, relating to 'Energy Management and Planning', covering five regional countries (Bhutan, China, India-2, Nepal, and Pakistan) were also conducted. These case studies provided inputs to develop energy management and to plan guidelines that could be used for training district level officers working in the field of energy-related issues. Dr. Ganesh Bahadur Thapa, a consultant, reviewed and improved the presentation of these six case studies.

This study is one among these six case studies and was carried out in Kulu District of the Himachal Pradesh Province in Northern India. It analyses issues in energy use and planning in Kulu District.

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List of Abbreviations

Tehsil	=	Sub-district
Chulla	=	Cooking stove
Tandoor	=	Furnace to heat the room
Pucca road	=	All weather macadam
Kutchha road	=	Seasonal road

Energy Content and Conversion Factors

	Natural Units	kcal ('000)	TOE	TOE	Others
Non-commercial					
Fuelwood	ton	4,000	0.57	0.39	1.43 m^3
	m^3	2,800	0.40	0.27	700 kg
Dried Dungcake	ton	2,600	0.37	0.25	--
Agricultural Residues	ton	3,000	0.43	0.29	--
Commercial Fuels					
Diesel					
	kl	9,080	1.29	0.88	0.826 ton
	ton	10,960	1.57	1.07	1,210 litre
Light Diesel Oil	kl	9,350	1.34	0.91	0.853 ton
	ton	10,960	1.57	1.07	1,172 litre
Petrol	kl	8,000	1.14	0.78	0.709 ton
	ton	11,290	1.61	1.10	1,411 litre
Kerosene	kl	8,660	1.24	0.84	0.778 ton
	ton	11,130	1.59	1.08	1,285 litre
Liquefied Petroleum Gas	ton	11,760	1.68	1.14	--
Coal	ton	6,000	0.86	0.59	--
Electricity	MWh	860	0.12286	0.083576	--
Other Conversion Factors					
1 TOE			1.00	0.680272	
1 TOE			1.47	1.00	

Heat Content of Different Fuel Types

1 kg wood	=	15 Megajoules (MJ)
1 kg coal	=	26.5 MJ
1 litre of kerosene	=	43.6 MJ
1 kWh of electricity	=	3.57 MJ

Introduction

Background

Fuelwood is the principal source of energy in the Himachal Pradesh hills of India. Electricity is widely used mostly for lighting. Considering the vast hydroelectric potential of the State, electricity is a promising alternative source of energy for cooking, lighting, and space heating. This report presents the findings of a case study on energy planning in the Kulu District of the Himachal Pradesh Province of India.

Objectives of the Study

The major objective of this study is to analyse issues in energy use and planning in the Kulu District of Himachal Pradesh. The specific objectives are as follows:

(i) to identify energy resources and the use of various energy forms in the district,
(ii) to analyse the energy consumption pattern in the district, and
(iii) to estimate biomass requirements for the district to meet fuel consumption needs.

Methodology

This study uses both secondary and primary sources of data. Secondary sources were used to collect information on population, social infrastructure, land use patterns, cropping patterns, agricultural productivity, livestock holdings, physical resources, and data on the consumption of energy. These sources included the district census handbook, village index cards, survey maps, and official data from government departments.

A survey of 10 selected villages was undertaken to collect data on energy consumption and energy resources and their use patterns. The distance of the village from the road and the river formed the basis for the selection of villages. Out of these 10 villages, four were identified for intensive study. Structured questionnaires were administered to collect specific information on energy such as the level of consumption of biomass (fodder and fuel), electricity, and other sources of energy; distance travelled to procure biomass; recycling of waste to produce energy; and knowledge about alternative technology. The survey also gathered information on important economic variables including location of agricultural land, volume of agricultural produce, livestock, seasonal employment, handicraft manufacture, and household income and expenditure patterns.

In addition to completing the questionnaires, notes were taken during the survey on the following factors: distribution of population within village systems with particular emphasis on the relationship of agricultural land and dwelling units; relationship of the village to the surrounding environment, particularly forest land; orientation of the village in relation to sun and wind; slope characteristics; techniques of constructing buildings; and building typology affecting energy consumption.

On the basis of the survey, the study formulated a stress matrix to demonstrate the levels of stress in the surveyed villages with a view to identifying priority areas of action. The stress matrix was formed by adding the various stress factors relating to facilities such as location, education, health, food, fodder, and fuel. Different weights were assigned to denote various levels of stress relating to these factors. The higher the total score, the greater is the stress of the village with respect to the factor under consideration. A comparison of total scores of surveyed villages helped in identifying areas for improvement.

Introduction to the Study Area

Kulu is one of the 12 districts of the mountainous State of Himachal Pradesh in Northern India. Physiographically, the State can be broadly divided into three regions: (i) The Outer Himalayas, (ii) the Inner Himalayas, and (iii) the Alpine Pastures. The annual average rainfall varies from 1,520 mm to 1,780 mm, in the Outer Himalayan Region, and from 780 mm to 1,020 mm in the Inner Himalayas. The Alpine Region is snow bound for 8 to 10 months of the year. Human settlements have concentrated in the river valleys and on mountain slopes up to 3,000 m a.s.l. above mean sea level (m.s.l.).

The State covers an area of 55,673 sq km. For administrative purpose, each district is divided into *tehsils* (sub-districts) and sub-*tehsils*. In 1981, it had a population of 4,280,818, with a population density of 77/km^2.

The road service in Himachal Pradesh is poor. The only railway system is a narrow gauge connection from Kalka to Shimla. The rest of the State is connected by two highways with limited vehicular capacity.

The State is predominantly rural. The proportion of urban to rural population in Himachal Pradesh is 7.61:92.39 compared to 23.7:76.29 for India as a whole. The majority of villages in the State are in the 200 to 500 population bracket.

Kulu District. The district of Kulu approximates the State average in terms of rural-urban population ratio and the average growth rate of population. The district is located centrally in the State and presents a wide variation of altitudes, similar to districts in the rest of the State. Thus, Kulu can be considered as a truly representative district for this study.

The district forms the transitional zone between the Lesser and Greater Himalayas. The altitude varies from 1,300 m to 6,000 m a.s.l. Broadly, the district can be divided into three distinct regions: (i) glaciated--north and north-east, (ii) rugged mountains--central part, (iii) gentle slopes--north-west and south-west parts.

The majority of settlements are located in the north-western and southern parts. The valleys of two major rivers (Beas and Sutlej) constitute the major settlement basin of the district. Kulu covers an area of 5,503 sq km. The district is divided into four *tehsils* with 169 villages and three towns. The villages are of various population sizes, ranging from less than 500 people to more than 4,000 people. In 1981 the district had a population of 238,734.

Socioeconomic Profile

The literacy rate of the district is 33.82 per cent, and that is lower than the State average. The urban literacy rate is 70 per cent compared to 31 per cent for rural areas. The economy is basically agrarian with 79 per cent of the population dependent upon agriculture. Because of the hilly topography only 7.45 per cent of the total area in the district is cultivable. Wheat, maize, paddy, and barley are the major cereal crops grown in the district. Diverse agroclimatic conditions provide the potential for growing cash crops such as pulses, potatoes, and fruits.

Livestock is the next most important source of income in the area. The livestock population has increased in Kulu at an annual rate of 1.5 per cent over the past few years. Cattle, buffalo, sheep, goats, pigs, and ponies are the important types of animals reared for food, ploughing, transportation, and wool. Kulu produces a sizeable amount of different varieties of fruits. About 14.5 per cent of the total land in the district is devoted to horticulture. The district has some small-scale industries dealing in shawl-making, carpet-weaving, and knitting.

Transportation and Communications

The road system is the most important form of transportation in the district. The road network serves about half of the villages. However, most of these villages are linked by fair weather roads and accessibility is limited during rainy and winter seasons.

Social Infrastructure

All villages in the district have one or more sources of drinking water supply. More than 80 per cent of villages have more than one source of water supply. Almost all villages have primary schools, 45 per cent have lower secondary schools, and 14 per cent have higher secondary schools. However, only 54 per cent of the villages have access to primary medical facilities. Only the district headquarters has a hospital and very few private medical practitioners, maternity homes, and child welfare centers are available in the district.

In 1981, roughly 70 per cent of the total villages with nearly 79 per cent of the total population had access to electricity supply. In most villages with power supply, electricity is used for domestic, industrial, and commercial purposes. Very few villages (about 8%) use electricity for agricultural purposes. About 60 per cent of the villages have postage and telegraphic facilities in the district.

Major Findings of the Survey

The major findings of the survey of the 10 selected villages are summarised in Tables 1 to 3. The smallest unit of settlement is a hamlet. Each village consists of a number of hamlets. Villages cover an area of 3 to 4 sq km and hamlets within a village are usually scattered. As a result, they may depend on the same forest to meet their biomass needs but they rarely depend on the same water source for domestic purposes. Natural springs are the major source of drinking water and most villages have access to tap water. Few villages depend upon streams for their water supplies. Distribution centres serving a number of hamlets have a catchment of approximately 6 km radius and are generally located along the highways.

Agriculture is the main economic activity during the summer months in all the surveyed villages. In roughly half of these villages there are other sources of income, including livestock, during the winter months, whereas in the remaining villages the people do not have any source of income during this period. The size of landholdings per household was observed to vary from 0.40 ha to 4.91 ha among the villages. Villages with gentler slopes have larger sized holdings compared to those with steeper slopes. Corresponding to the variation in size of landholdings, the volume of agricultural produce consumed and sold per household also varied across villages. The number of animals and the production of livestock products per household also showed a wide variation among these villages.

The survey indicated that villages with an average altitude of 1,800 m consumed 15 kg of fuelwood per household in summer and 30 kg in winter, whereas the corresponding figures for villages with an average

Table 1: Household Characteristics Occupation, and Income and Expenditure Patterns in the Sample Villages of Kulu District

Village	Hamlet	Altitude (in meters)	Average Household Size	Average No. Of Working Members (Per Household)	Occupational Pattern Per Household		Income and Expenditure Pattern (Per Household in Rupees)							
					Summer (months)	Winter (months)	Average Monthly Income	Average Monthly Expenses	Food	Animals	Education	Health	Household Maintenance	Others
Tarangali	Tarangali	1280 m	9	8	Agri (9)	Others (3)	2271.25	504.50	162.50	56.25	177.00	27.5	18.75	62.50
	Bagan	1240 m	6	3	Agri (9)	Others (3)	725.00	410.00	200.00	137.50	35.00	37.5	0.00	0.00
Kalwari	Kalwari	1720 m	10	7	Agri (7)	Others/Nothing (5)	146.00	123.00	49.00	0.00	35.00	3.0	6.00	25.00
	Mujhalli	1760 m	10	3	Agri (8)	Nothing (4)	33.30							
	Nannaut	1800 m	10	3	Agri (7)	Others/Nothing (5)	1100.00							
Chanon	Tilru	2240 m	9	4	Agri (8)	Animal husbandary (4)	472.22	460.78	288.78	65.56	12.00	15.56	78.89	000
Ghiagh	Shoja	2700 m	7	5	Agri (8)	Others/Nothing (4)	1241.25	1286.50	849.25	25.00	384.75	15.00	12.5	000
Sharchi	Jutli	1960	9	5	Agri (8)	Nothing (4)	1700.00	337.00	240.00	2.00	16.00	12.00	0.00	67.00
	Bundal	1800	5	2	Agri (7)	Other Nothing (5)	350.00	263.00	226.67	25.00	5.00	4.00	2.33	0.00
	Sulgad	2360	10	6	Agri (7)	Others (5)	990.00	512.33	433.33	0.00	20.00	60.00	0.00	0.00
Pekhri	Farrari	1800	9	5	Agri (9)	Nothing (3)	459.09	710.36	645.36	16.82	13.64	1.82	32.73	0.00
Lajheri	Kanda	2360	7	4	Agri (8)	Animal husb/others (4)	303.00	262.60	200.00	22.60	9.00	11.00	20.00	0.00
	Joan	2200	11	5	Agri (8)	Nothing (4)	811.75	943.00	824.25	0.00	87.50	31.25	0.00	0.00
	Bhargol	2400	7	3	Agri (8)	Nothing (4)	1350.00	862.25	400.00	262.25	100.00	37.5	62.50	0.00
	Ghai	2480	10	6	Agri (8)	Nothing (4)	1537.00	972.00	649.5	0.00	240.00	82.5	0.00	0.00
Bachher	Jaun	2200	8	5	Agri (7)	Nothing (5)	218.00	336.00	299.8	0.20	25.00	1.00	00.00	10.00
	Lafalli	2340	6	2	Agri (8)	Others (4)	2250.00	2099.00	999.00	0.00	400.00	200.00	00.00	500.00
Manjhadesh	Shamsher	1350	6	2	Agri (8)	Others (4)	359.50	727.80	460.00	141.00	54.00	40.0	32.80	0.00
Franali	Tilona	1300	8	4	Agri (8)	Others (4)	341.67	593.33	316.67	1.67	166.67	108.33	0.00	0.00
	Nishani	1600	4	3	Agri (6)	Others (6)	170.00	2015.67	999.00	100.00	0.00	666.67	250.00	0.00

Source: Primary Survey

Table 2: Agricultural and Livestock Charastristics, Fuel Consumption Patterns, Water Sources, and Type of Building Materials Used in the Sample Village of Kulu District

VILLAGE	HAMLET	AGRICULTURAL PATTERN PER HOUSEHOLD				LIVESTOCK PER HOUSEHOLD					FUEL CONSUMPTION PER HOUSEHOLD					WATER SOURCE		BUILDING MATERIAL		
		Land Holdings	Cropped Land	Produce Consumed	Produce Sold	No. of Animal	Milk	Meat	SkinWool	Fooder cons-umed	Wood	Agri. Waste	Coal	Kero-sene	Electr-icity	Man	Animal	Wall	Floor	Roof
		(in ha.)		(in kgs. per year)			in litre	in kg.	in kg.	in kg./ month	in kg.	in kg.	in kg.	in litres	in units					
Tarangali	Tarangali	4.91	2.84	2,619.5	4,979.0	10	10.4	-	0.4	10,120	163.44	103.86	0.31	0.41	45.83	Tap	Tap	Stone	Wood	Slate
	Began	1.08	0.88	1,469.0	-	5	3.5	-	-	7,580	128.75	112.5		1.0	28.33	Tap	Stream	Wood	Wood	Slate
Kalwari	Kalwari	2.72	1.34	2,173.6	416.0	10	4.6	-	0.8	6,780	113.20	-	14.4	1.1	50.22	Tap	Tap	Stone	Wood	Slate
	Mujhalli.	1.33	0.93	814.7	--	4	1.0	-	-	5,150	49.5	-	-	-	16.30	Tap	Tap	Stone	Wood	Slate
	Nannaut	2.36	2.04	2,730.0	2,990.0	6	13.0	-	-	6,500	45.0	-	-	0.06	22.22	Tap	Stream	Stone	Wood	Slate
Chanon	Tilru	1.05	0.90	1,808.4	2,004.9	11	3.0	-	1.2	17,500	63.0	-	-	0.65	24.20	Tap\	Tap	Stone	Wood	Slate
																Stream	Stream	Stone	Mud/	Slate
																			Wood	Slate
Ghiagh	Shoja	0.76	0.76	1,690.0	1,378.0	17	2.5	-	5.0	8,200	62.0	-	-	0.24	22.78	Tap	Tap	Stone	Mud/	Slate
																			Wood	Slate
Sharchi	Jutli Bundal	1.15	0.56	2,898.0	5,200.0	10	3.2	-	3.0	14,200	61.0	-	-	0.2	6.22	Tap	Tap	Stone	Wood	Slate
	Sulgad	0.88	0.83	936.0	34.7	3	1.0	-	-	1,400	40.0	-	-	0.02	30.37	Tap	Tap	Stone	Wood	Slate
		0.67	0.67	2,773.3	173.3	5	1.0	-	-	9,150	106.0	-	-	0.13	-	Stream	Stream	Stone	Wood	Slate
Pekhri	Farrari	0.81	0.75	1,474.9	-	9	1.5	-	0.2	12,750	60.0	-	0.45	-	13.94	Tap	Tap	Stone	Wood	Slate
Lajheri	Kanda	0.89	0.84	208.0	728.0	9	4.4	-	-	12,000	61.0	-	-	0.6	26.67	Tap	Tap	Stone	Wood	Slate
	Joan	1.00	0.86	1,820.0	1,755.0	11	2.3	-	2.0	6,000	71.9	-	-	0.04	36.11	Tap	Tap	Stone	Wood	Slate
	Bhargol	0.96	0.84	1,118.0	3,120.0	9	3.25	-	2.5	13,999	66.9	-	-	0.08	27.78	Tap	Well	Stone	Stone	Slate
	Ghai	0.66	0.64	1,976.0	1,625.0	16	2.0	-	1.5	10,500	69.4	-	-	0.03	23.33	Tap	Tap	Stone	Wood	Slate
Bachher	Jaun	1.95	1.45	1,726.4	759.2	11	3.8	-	0.6	9,550	48.5	-	-	0.02	22.22	Stream	Tap	Stone	Wood	Slate
	Lafalli	4.80	3.2	2,080.0	3,120.0	5	4.0	-	-	4,500	60.0	-	-	-	-	Stream	Stream	Stone	Wood	Slate
Manjhadesh	Shamsher	1.27	1.12	842.4	1,305.2	4	4.5	-	0.1	16,350	24.35	-	1.0	0.03	27.11	Tap	Stream	Stone	Wood	Slate
Franali	Tilona	0.85	0.85	2,340.0	173.3	7	1.67	-	-	1,000	151.9	-	-	1.5	81.48	Tap	Tap	Stone	Wood	Slate
	Nishani	0.40	0.40	450.7	-	4	-	-	-		2.15	-	-	-	22.22	Stream	Stream	Stone	Wood	Slate

Source: Primary Survey

Table 3: Aailability of Educational and Medical Facilities in the Surveyed Villages of Kulu District

Village	Hamlet	Distribution Centre	Altitude (in metres)	EDUCATIONAL AMENITIES				MEDICAL AMENITIES				
				Primary	Middle	Higher Secondary	College	Dispensary	Private Doctor	Primary Health Centre	Veterinary Hospital	Hospital
				1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Tarangali	Tarangali Bagan	Tarangali	1240									
Kalwari	Kalwari Mujhalli Nannaut	Dhed	1360									
Chanon	Tilru	Ghatgad	1800									
Ghtagh	Shoja	Ghtagh	2100									
Sharchi	Jutli Bundal Sulgad	Gosaini	1600									
Pekhri	Farrari	Gosaini	1600									
Lajheri	Kanda Joan Bhargol Ghai	Khanag	2400									
Bachhel	Jaun Lafalli	Gogri	1600									
Manjhadesh	Shamsher	Ani	1200									
Pranah	Tilona Nishani	Ulwa	1800									

Source: Primary Survey

NOTE: The number 1.5 denotes the time taken to reach the amenities.

1. Less than 1/2 hour
2. 1/2 - 1 hour
3. 1 - 2 hour
4. 2, 3 hour
5. more than 3 hour

Table 4: Estimation of Biomass Requirements (by Litterfall Method) in the Surveyed Villages of Kulu District

Village	Hamlet	Hamlet Popul-ation	Fuel Consumption (in kg/yr)	PER CAPITA FUEL CONSUMPTION/REQUIREMENT (in kg/yr)		Population 1981 Village Level	Total Litterfall (in kg/yr)	Area of Forest (in HQ)	Population 1991 Village Level	Total Litter Requirement (in kg/yr)	Area of Forest (in ha)	% Increase in Forest Area	Population 2001 Village Level	Total Litterfall Required (in kg/yr.)	Area of Forest (in ha)	% Increase in Forest Area
				Hamlet Level	Village Level											
1. Tarangali	Tarangali Bagan	68 23	97,564.50 88,056.25	1,434.77 3,828.25	2,631.65	682	17,94,785.30	1,929.87	768	20,21,107.20	2,173.23	12.61	830	21,84,269.50	2,348.67	21.7
2. Kalwari	Kulawari Mujhali Nannaut	31 29 20	41,318.00 18,067.50 16,425.00	1,332.83 623.02 821.25	925.70	978	9,05,334.60	973.48	1,209	11,14,335.30	1,198.21	23.08	1,447	13,39,487.90	1,440.31	47.95
3. Chanon	Tilru	80	22,995.00	287.44	287.44	1,218	3,50,101.92	376.45	1,589	4,56,742.16	491.12	30.46	2,006	5,76,604.64	620.0	64.69
4. Ghiagh	Shoja	28	22,812.50	814.73	814.73	316	2,57,454.68	276.83	364	2,96,561.72	313.50	13.25	404	3,29,150.90	353.92	27.85
5. Sharchi	Jutli Bundal Sulgar	45 15 29	22,265.00 14,600.00 38,872.50	494.78 973.33 1,340.43	936.18	1,381	12,92,864.60	1,390.18	1,649	15,43,760.80	1,659.95	19.4	1,969	18,43,338.40	1,982.08	42.58
6. Pekhri	Farrari	95	21,900.00	230.53	230.53	841	1,93,875.53	208.47	1,023	2,35,832.19	253.58	21.64	1,203	2,77,327.59	298.20	43.04
7. Lajheri	Kanda Joan Bhatgol Ghai	34 45 30 41	22,265.00 26,243.50 24,418.50 25,331.00	654.85 583.19 813.95 617.83	533.96	1,991	10,63,114.40	1,143.13	2,311	12,33,981.60	1,326.86	16.07	2,579	13,77,082.81	1,480.73	29.54
8. Bachher	Jaun Lafalli	42 6	17,702.50 21,900.00	421.49 3,650.00	2,035.74	1,623	33,04,006.00	3,552.69	1,794	36,52,117.60	3,927.01	10.54	1,891	38,49,584.30	4,139.34	16.57
9.Manjha desh	Shamsher	72	8,887.75	123.44	123.44	4,106	5,06,844.64	544.99	5,030	6,20,903.20	667.64	22.5	5,940	7,33,233.60	788.42	44.66
10. Franali	Tilona Nishani	46 11	55,443.50 784.75	1,205.28 71.34	638.31	2,326	14,84,709.10	1,596.46	2,984	18,83,829.00	2,025.62	26.88	3,709	23,67,491.80	2,545.69	59.46

altitude of 2,300 m were 30 kg in summer and 100 kg in winter. However, these villages did not show any significant variation in the consumption of forest biomass among different sizes of landholding. Since the biomass available from agricultural produce is generally used as fodder during the winter months, the size of landholdings determines the capacity of households to support milch cattle.
The building construction techniques and materials used are uniform across the study villages. All tension members used are invariably wood. Since each household is permitted to fell only two trees per year, the wood is shared on a community basis for building new houses or for repair. The timber is not usually seasoned and its lifespan is short and requires frequent maintenance. The sections used are much heavier than they actually need be for the dimensions covered, resulting in wastage of timber. The doors and windows are poorly constructed and are not well insulated. As a result, the energy consumption for space heating is very high, particularly in the winter. Since the kitchen is invariably located on the top floor, the rest of the building does not get the benefit of the heat generated during cooking.

Although wood is the major source of energy, those who can afford to and who have access to other forms of energy, such as coal, kerosene, and electricity use them. Electricity is the second-most widely used source of energy, however it is mostly used for lighting purposes and its use as fuel is limited. The kinetic energy of water is widely used to run water mills and sporadically, to run saw-mills.

Estimation of Biomass Requirements

All surveyed villages are almost totally dependent on biomass for cooking and heating. This section attempts to estimate the biomass requirements assuming that the present trend of consumption will continue in the future. There are various methods of estimating biomass requirements. This study uses the 'litterfall' method which is appropriate for the kind of data available.

Litter is mostly used in the study area for fuel. Litter includes both leaf litter and branches/twigs. Since branches and twigs are more important for meeting the fuel requirements of households, the estimation of biomass requirements takes into consideration only branches and twigs.

The annual volume of litterfall in the study area is assumed to be 3,100 kg per ha. Branches and twigs account for only 30 per cent of the total litterfall or about 930 kg per ha per year. Fodder consumption is not included in estimating the biomass requirements. The cattle graze mostly in the forests, except during the winter months. Fodder collected from the agricultural waste is used to feed the cattle during winter.

First, the total and per capita fuel consumption per year were estimated for each hamlet. Assuming that the fuel consumption is equal to the fuel requirement, per capita and total fuel requirements at the village level were estimated by taking the population data for 1981. The forest area requirement for 1991 and 2001 was estimated on the basis of population projections for these years. These population projections were made by assuming that the growth rate trend during the past two decades (1961 to 1981) would continue in the future. In addition, the decline in the death rate, resulting from various State policies such as family planning, was also considered in making these projections.

Apart from population a number of climatic factors affect the energy demand. These factors include temperature, rainfall, and sunshine hours. The effects of these factors were also considered in estimating the fuel requirement for this study. Data relating to temperature and rainfall are available from the two meteorological observations carried out in the district. A detailed study was undertaken in three sample villages to estimate sunshine hours in different seasons. Table 4 shows population projections, total litterfall, and forest area required to meet the fuel requirements for selected villages in 1991 and 2001.

The increase in forest area needed to meet the fuel requirements for these villages in 1991 varies from a low of 10.5 per cent to a high of 30.5 per cent. In order to meet the requirements in 2001, the forest area would have to increase from 16.6 per cent to 64.7 per cent. Thus, substantial increases in the forest area would be needed if the biomass demand is to be met through forests only.

Formation of Stress Matrix

A stress matrix was formed for the surveyed villages by aggregating the various stress factors relating to such facilities as location, education, health, food, fodder, and fuel. The comparative status of these villages was then tabulated and mapped in order to identify areas for improvement. The higher the total score, the greater is the stress of the village with respect to the factor under consideration. The gradings used in the formation of the stress matrix were modified on the basis of the survey findings. The weightages given to denote various levels of stress relating to different factors are shown in Tables 5 to 8.

Table 5: Gradings Used in Denoting Locational Stress

Distance	Pucca Road (All Weather Tarmacadam)	Kutchha Road (Seasonal Road)	Foothpaths (Tracks and Paths)
On the bus routes	0	2	4
Within 5 kms from bus route	1	3	5
5-10 kms from bus route	2	4	6
More than 10 kms from bus route	3	5	7

Table 6: Gradings Used in Denoting Stress relating to Access to Medical Facilities

Facility	Within the Village or 1/2 hr Travel Distance	Travel Time 1/2 hr - 1 hr	1 hr - 2 hrs	2 hrs - 3 hrs	3 hrs or more
Hospital	0	1	2	3	4
Primary Health Centre	0	2	4	5	6
Dispensary	0	3	5	6	7
Private Doctor	1	4	6	7	8

Table 7: Gradings Used in Denoting Stress Relating to Access to Educational Facilities

Facility	Within the Village or 1/2 hr Travel distance	1/2 hr 1 hr	Travel Time 1 hr - 2 hrs	2 hrs - 3 hrs	3 hrs or more
Primary	0	1	2	3	4
Middle	0	0	1	2	3
Higher Secondary	0	0	0	1	2

Table 8: Gradings Used in Denoting Stress Relating to Access to Fuel

Travel Time	Natural Fuel 25% Agricultural Produce 75% From Forest	Commercial Fuel 25% Commercial
Less than 1/2 hour	3	3
1/2 - 1 hr	4	4
1 - 1 1/2 hr	5	5
1 1/2 hr - 2 hrs	6	6
More than 2 hrs	7	7

Table 9 shows scores of the surveyed villages with respect to various stress factors and the total stress. The total stress scores ranged from a low of 25 to a high of 40 among these villages. These villages can be grouped into two categories based on the total scores. The first group, consisting of five villages, had a score between 25 and 31, whereas the score of the second group of five villages ranged from 34 to 40. The surveyed villages did not show any variation in food, fodder, and natural fuel stress. The variation in stress relating to location, medical facility, and educational facility was significant among these villages, but the stress level did not vary much with respect to the commercial fuel.

Table 9: Stress Matrix of Surveyed Villages in Kulu District

Village	Locational Stress	Medical Facility Stress	Education Facility Stress	Food Stress	Fodder Stress	Fuel Stress N	Fuel Stress C	Total Stress
Tarangali	0	9	1	0	3	8	4	25
Kalwari	2	10	0	0	3	8	5	28
Chanon	1	21	1	0	3	8	5	39
Ghiagh	2	22	2	0	3	8	3	40
Sharchi	2	17	1	0	3	8	6	37
Pekhri	4	13	1	0	3	8	5	34
Lajheri	2	10	3	0	3	8	5	31
Bachher	5	10	0	0	3	8	5	31
Manjhadesh	6	10	0	0	3	8	4	31
Franali	2	15	6	0	3	8	5	39

Note: N - Natural Fuel

C - Commercial Fuel

Summary and Conclusions

Fuelwood is the major source of energy in the study area. It is considered a free source of energy by villagers, although they spend an average of 4 to 6 hours each day to collect it from the forest. The estimation of biomass requirements for the surveyed villages indicated that a substantial increase in the forest area would be required if the biomass demand is to be met through the forests alone. Under these circumstances, efforts are needed to develop innovations to reduce the consumption of fuelwood and to promote the use of alternative sources of fuel for cooking and space heating. Electricity is widely used for lighting. Villagers do not consider electricity to be an important energy source for space heating and cooking but view it as a convenient energy source for industrial use and for lifting water. Considering the vast hydroelectric potential of the State and the expansion of transmission lines, electricity holds the promise of playing an important role in meeting the energy demand. It is worthwhile considering that the fuelwood consumption rate is directly correlated with altitude. Therefore, the saving in biomass would be greater if villages in the higher altitude range are made targets of alternative fuel technology on a priority basis.

The survey of selected villages showed that cooking and space heating shared the bulk of energy consumption. All buildings in the area are very poorly insulated. As a result, they are unable to retain heat. The *'chullas'* (cooking stoves) and *'tandoors'* (furnace to heat the room) currently in use are fuel inefficient. This calls for improvements in the design of buildings and the promotion of improved and energy-efficient stoves.

Sunshine hours vary across villages depending upon the location of the settlement and the surrounding topography. Due to atmospheric factors, effective sunshine hours are approximately 60 per cent of the total possible incidence. Hence, solar-powered equipment such as water heaters, cookers, and photo-voltaic cells may not be very popular in the area. In addition, the incidence of hailstorm is quite high and can adversely affect solar-powered equipment.

The kinetic energy of water is used in the area to run water and sawmills. The local technology for harnessing water power can be improved through technological innovations.

Biogas plants are unlikely to be popular in the district because the biological waste of cattle is not significant and is difficult to collect. So far, a total of 404 biogas plants of varying sizes ($2m^2$ to $5m^3$) have been installed in the district in villages below the altitude of 1,500 m. Since the majority of villages lie above this range of altitude, biogas plants do not seem to be a feasible alternative in the district.

Although there are significant potentials for saving energy and materials through improvements in the designs of residential buildings and community facilities, this is an area which requires a sustained effort over a long period of time to motivate and change the attitude of the people. It was observed that the people were responsive to the adoption of energy-efficient building construction techniques. There is a great need to popularise such techniques that use indigenous materials.

ICIMOD is the first international centre in the field of mountain development. Founded out of widespread recognition of environmental degradation of mountain habitats and the increasing poverty of mountain communities, ICIMOD is concerned with the search for more effective development responses to promote the sustained well being of mountain people.

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Mountain Infrastructure and Technology constitutes one of the four thematic research and development programmes at ICIMOD. The programme aims at achieving environmentally sound infrastructural development practices as well as the use of innovative technologies for alleviating drudgery and improving the living conditions of mountain inhabitants. This is carried out through state-of-the-art reviews, field studies, pilot training, and applied research. Currently, the main focus of the programme is on mountain risk engineering with special reference to hill road construction, decentralised district energy planning and management, as well as appropriate mountain technologies.

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