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ASSESSMENT OF BIOMASS AVAILABILITY FOR POWER GENERATION IN SELECTED TALUKAS OF UTTRANCHAL STATE

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INTRODUCTION

Biomass is a natural product of solar energy (Grover, 1996). World wide, energy stored in the form of biomass through photosynthesis is nearly 10 times the world's annual energy use (Hall and Overend, 1987). The growth and the economic utilization of biomass, for power generation, as an alternative to fossil fuels has been on the rise and is being considered seriously (Dua and Rao, 1996). Assessments indicate that even if a small percentage of this vast potential were tapped, it would be possible to meet the total energy requirements of the country for years to come (Rajan, 1995).

Being the forest rich state, Uttranchal has a potential to contribute significantly to power needs of the state through biomass gasification technology. Gasification is the thermo-chemical conversion of biomass into a gaseous fuel by means of partial oxidation at elevated temperature and pressures (Rao, 1996). This gas can be burnt directly for thermal applications or used for replacing diesel oil in dual fuel engines for mechanical and electrical applications (Singh, 1996). Therefore, the recommendations of bringing all kinds of the degraded waste lands under the afforestation schemes, especially with the fast growing species, not only will help in the increasing the forest cover, but would also minimize the effects of global warming through carbon sequestration, reduce air pollution, and check soil erosion and land sliding, which are the serious environmental problems (Ravindranath and Hall 1995; Johansson et al., 1993).

STUDY AREA AND METHODOLOGY

This study was conducted in four talukas (tahsils) of Uttranchal state: Rishikesh, Purola, Champawat and Almora, as a part of the country wide National Biomass Resource Assessment Program (NBRAP) launched by the Ministry of Non-Conventional Energy Sources (MNES), Government of India in 2002-03. The major objective of the study was to estimate the availability of surplus biomass based on the generation and consumption pattern and assess the potential for power generation from this surplus biomass.

The Uttranchal State is located between 28°45' and 31°30' N latitude and 77°30' and 81°5' E longitude covering an area of 53,485 km^2. The state shares international boundaries with Tibet in the north and Nepal in the east, while towards west is located another Himalayan state, Himachal Pradesh and towards northwest are Gangetic plains of Uttar Pradesh. The topology of the state is mountainous, constituting 88% hilly terrain, while the rest is the plains, continuing with Gangetic flood plains of Uttar Pradesh. Administratively, the state comprises of 2 divisions (Garhwal and Kumaon), 13 districts (Figure 1), 49 talukas, 95 developmental blocks, 71 towns and 15620 villages. The human population of state is 84,79,562, with a density of 159 person per km^2. Literacy rate (72.28%) is noticeably higher than the national average of 65.38% (Census of India, 2001).

The state has its own potentialities and resources, which need to be harnessed in the best possible way. Forests are one of the most important of these natural resources and cover 64.81% of the total geographical area of the state. The agriculture sector, though covers only about 13.21% of total geographical area of the state, engages about 71% of the total population (Dutta and Pant, 2003).

Figure 1: Map of State of Uttranchal showing the location of study taluks

Sample survey

The present study is based on the field surveys and secondary data collection from various sources. Of the total four, two talukas, Rishikesh and Purola were selected from Garhwal Division while Champawat and Almora were from Kumaon Division (Figure 1). The selection of talukas was based on variation in agro-ecological zonation, productivity status, socio-demography, altitude and the status of electrification. Within the selected talukas, villages were sampled for conducting primary field surveys, which were chosen randomly to represent the entire taluka. Since agriculture is one of the major sources of biomass production, intensive field surveys were carried out for both the cropping seasons. In each of the surveyed villages, all categories of farmers were interviewed, ranging from marginal to large landholders. Secondary data were collected from various government departments like Forest, Agriculture, Taluka, Block and Statistical offices, etc. Except Rishikesh, rest three talukas are located in the hilly terrain. Champawat is the largest in terms of geographical area as well as number of villages (696 villages), in which, only 411 (59.09%) villages are electrified. In the selected talukas, on an average 54% villages (n=458) were visited to collect the primary and secondary data on the production and consumption of biomass under different sectors.

Table 1: Baseline information on the study talukas

District	Taluka	Total geographical area (TGA) (ha) of taluka	No. of surveyed villages	% agriculture area of TGA	% forest area of TGA	% other land of TGA
Dehradun	Rishikesh	25,371	88 (100)	37.80	22.90	36.80
Uttarkashi	Purola	31,644	170 (88)	24.50	21.00	51.00
Champawat	Champawat	1,68,011	100 (15)	10.50	43.78	42.75
Almora	Almora	94,233	100 (11)	39.42	15.78	40.12

Values in parenthesis refer to the percentage of total villages in the respective taluka

Biomass generation and consumption

The biomass production and consumption was studied in two major sectors of the study talukas, *i.e,*. Forestry and agriculture sectors. The forestry sector comprises of forestlands, village commons and other wastelands and farm bunds. Following is the details of methodology adopted for each of the two major sectors:

Forestry sector

The forest includes the entire area under the administration of forest department of the study taluka. Other land use categories included the different categories of wasteland, such as tree crops and groves, culturable fallow, permanent pasture and grazing land, fallow land other than current fallow and barren unculturable land. The assessment of biomass production for these land use categories is essential in view of their productivity potential for developing tree crops for biomass generation (Sudha et al., 2003). For farm bunds, biomass assessment was done for the tree crop grown on the bunds of agriculture fields in the form of farm forestry or agro-forestry. Under this category, since the majority of the production, mainly tree trunks, are sold for commercial purpose, we accounted other parts such as twigs, dry branches and roots, those are used for domestic fuel wood purpose, for assessment of biomass production.

Regarding the productivity, it has been documented that from the forest land, on an average 2.25 t/ha/yr can be harvested on a sustainable basis, while from farm bund forestry, the average productivity comes to around 0.5t/ha/yr and from other wastelands it is around 1.5t/ha/yr (Ravindranath and Hall, 1995; Jagdish, 2003). These figures were further verified through the field visits in the study talukas and considered for calculating the biomass production from different land use typologies mentioned above.

To account for consumption patterns at household level in the selected villages, the families were selected randomly for questionnaire interview related to the quantity of fuel wood needed for cooking three meals in a day. The record of consumption of other fuel types such as LGP and Kerosene oil was also maintained during household interviews. Since dung cakes are not a popular source of fuel in this region, the villagers were not interviewed on this aspect.

Agricultural sector

Biomass from agriculture sector mainly included the residues of different crops. Based on the area under different crops and their per unit area productivity, the biomass production was calculated by using the standards of grain to residue ratios. The secondary data on the above aspects were collected from agriculture departments and agriculture research institute at Pantnagar. Further, the calculations of residue production from secondary data were verified through the sampled field surveys and interviews with farmers conducted for major crops in both the seasons in the selected villages.

Surplus biomass and power generation potential

The data on the production and consumption of biomass from both the sectors were used to calculate the surplus by subtracting the consumption from the generation. The data collected on per

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capita consumption of fuel wood at household level and the proportion of households dependent on this were extrapolated to calculate the consumption of biomass from forest lands and other wastelands. However, in agriculture sector, the produced biomass was mainly consumed in the form of fodder for animals and fuel for domestic purposes. Other forms of consumption were manuring agriculture fields by crop residues and sometimes thatching the kachcha houses. Information on this was generated through sample surveys with farmer and non-farmer households.

For calculating the annual power generation potential, formula worked out by Ministry of Non-conventional Energy Sources (MNES) was used as follows (MNES, 2001):

Annual power generation potential = (Total surplus biomass) X (collection efficiency)/(365 days X 24hrs X 1.5)

Where, it is assumed that 1.5 tons of biomass can produce 1 MW of electricity (Ravindranath et al., 1995) and the collection efficiency has been kept at 75% of total surplus on a conservative scale.

RESULTS

Biomass generation

Forest and other lands

Forests and other land resources, including farm bunds, wastelands, roadside areas, horticulture areas and village common lands are important source of biomass generation. The area under other land is significantly high at about 135163 ha, which contributes 42.3% of the total geographical area of all the four study talukas, followed by forest area (31.6%) and farm buds (22.6%). Due to less extent of agriculture areas, the biomass production from the farm bunds is significantly low. It has been estimated that annually about 465606 tons of biomass can be harvested from all these sources on a sustainable basis. The forestry sector alone contributed maximum (48.71%) to the total production, followed by other land categories (43.54%) and farm bunds (7.8%).

Table 2: Biomass production (tons) from forest and other land use categories

Talukas	Area under forest land (ha)	Area under other land (ha)	Farm bund area (ha)	Biomass from forest	Biomass from other lands	Biomass from farm bund	Total production
Rishikesh	5809	9335	9,588	13070	14003	4794	31867 (6.84)
Purola	6560	16182	7727	14760	24273	3864	42897 (9.21)
Champawat	73557	71833	17656	165503	107750	8828	282081 (60.58)
Almora	14873	37813	37154	33464	56720	18577	108761 (23.35)
Total	100799	135163	72125	226797	202746	36063	465606

Values in parentheses refer to the percentage of total biomass generated

Agricultural sector

In the agriculture sector, crop residues of paddy, wheat, maize, mustard, sugarcane, sawan, mandua and mixture of other crops cultivated on relatively smaller areas, such as pulses, oil seeds, barley, soyabeans and chilly was the major source of biomass in the study talukas. The total estimated annual biomass production from the study talukas was around 2,22,229 tons. The analysis indicated that wheat, paddy and mandua stalks were the major contributors, accounting to over 56%, while maize, mustard, sugarcane and sawan together contributed to 24% to the total production and the remaining biomass is from other crops, including oil seeds (til), pulses, barley, soyabean, vegetables and chilly, etc.

Table 3: Biomass production (tons/annum) from agriculture sector during 2002

Taluka	Wheat straw	Paddy straw	Maize straw and cobs	Mustard stalk	Sugar cane trash, leaves & tops	Sawan stalk	Mandua stalk	Others	Total production
Rishikesh	9882	22192	245	Nil	38908	1019	1738	1770	75754 (34)
Purola	5589	8583	77	5626	Nil	1817	Nil	1450	23142 (10.41)

Champawat	19994	16581	1820	172	Nil	1756	13307	8142	61772 (27.80)
Almora	6200	5188	1147	Nil	Nil	1204	15340	32482	61561 (27.70)
Total	41665	52544	3289	5798	38908	5796	30385	43844	222229

Values in parentheses refer to the percent of total biomass production.

Biomass consumption pattern

The per capita fuel wood consumption in the domestic sector of the study talukas was calculated as 2.11±0.65 kgs/day. It was found maximum (3.45±0.45 kgs/day) during the winters and minimum (1.34±0.48 kgs/day) during the summers. It was recorded that in the forestry sector, on an average about 62% of the total generated biomass is consumed. In case of agriculture residue about 63% of the total generated biomass from agriculture sector is consumed in the production sites itself, mainly in the form of fodder and fuel use, while the rest was assumed as surplus.

Table 4: Biomass consumption pattern in the study talukas

Talukas	Agriculture		Forest and other lands	
	Generation	Consumption	Generation	Consumption
Rishikesh	75754	40846 (53.91)	31867	25622 (80.40)
Purola	23142	10820 (46.75)	42897	17855 (41.62)
Champawat	61772	40407 (65.41)	282081	161223 (57.15)
Almora	61561	48184 (78.27)	108761	86187 (79.24)
Total	222229	140257 (63%)	465606	290887 (62%)

Values in parentheses refer to the percentage consumption of the biomass against generation

Power generation potential

It is estimated that from both the sectors, annually about 256691 tons of biomass remains as surplus, of which maximum comes from the forestry sector with over 68% in the form of twigs, dry branches, roots and wood chips etc. Due to limited area under agriculture, biomass production as well as surplus in this sector is very low, which accounts remaining 32% to the total surplus biomass, generated mainly in the form of stalks, husk, cobs, etc.

Using the formula worked out by MNES, it was calculated that at a collection efficiency of about 75%, annually about 14.65 MW of electricity could be generated from the overall surplus biomass on sustainable basis in the study talukas.

Table 5: Power generation potential from surplus biomass

Taluka	Surplus biomass (tons)		Total surplus (tons)	Annual power generation potential (MW)
	Agriculture	Forestry		
Rishikesh	34908 (42.58)	6245 (3.57)	41553	2.37 (16.18)
Purola	12322 (15.03)	25042 (14.34)	37364	2.13 (14.55)
Champawat	21365 (26.06)	120858 (69.17)	142223	8.11 (55.40)
Almora	13377 (16.32)	22574 (12.92)	35951	2.05 (14.00)
Total	81972	174719	256691	14.65

Values in parentheses refer percentage of the total generation

DISCUSSION

The situation of rural electrification in the country remains to be more challenging than ever since of about 80,000 villages in the country that are yet to be electrified, about 18,000 are in remote and inaccessible areas (IEA, 2002). These villages remain difficult to be electrified in the conventional manner by extending the grid because of difficult locations such as forests, islands, deserts and hilly areas. To provide electrify to such villages, Ministry of Non-conventional Energy Sources (MNES), in its Draft Renewable Energy Policy 2000 document (MNES, 2002) has decided to use renewable energy technologies as potential alternatives to meet the energy demand in the rural areas of the country. Accordingly, Tenth Five Year Plan (2002-2007) has set a target of electrifying about 5000, out of 18000 un-electrified villages in the country by the year 2012, using mainly Solar Photovoltaics (PV), Biomass and Small Hydro Power technologies (GoI, 2001).

Though, it is stated that Uttranchal is a power surplus state in the sense that even current levels of generation are in excess of demand, the fact remains that the rural electrification figures paint a grim picture since about 3287 villages in the state are yet to be electrified (http://powermin.nic.in/uttaranchal.htm). Irregular and insufficient power supply in the electrified villages worsens the situation of power in the state. Such a situation calls for promoting the renewable sources of energy in the rural areas, especially those, which are difficult to connect to the grid due to inaccessible terrain and lack of basic infrastructure. Viability of grid based village electrification decreases with increasing distance from the approach road and altitude. With its rich forest resources, Uttaranchal, therefore has huge opportunities for electrification through gasification, a comparatively cheaper, easily accessible and durable technology.

The present study has estimated a total production of about 14.65 MW of electricity from the surplus biomass in the study talukas. These results are indicative of the potential of electrifying the rural areas in the state, especially those, which are extremely tough to approach due to physical and other natural barriers. For example, the Champawat taluka in the present study has on one hand has maximum number of un-electrified villages, while on the other also has the highest potential of power generation, mainly because of relatively large extent of the forest land.

Such an attempt needs to be backed up by institutionalizing the whole process of collection of surplus biomass to the maximum extent possible and capacity building of the rural mass to use the technology to produce electricity at local level (TERI, 2003). We attempted to explore the implementation of the findings of the present, especially to setup the collection and power generation centers within the study talukas. Based on the field surveys, discussion with various stakeholders, including villagers, officials, technical experts and industrialist, the basic amenities, their networking, transport systems and accessibility were considered few important criteria to set up such centers.

Table 6: Suggested centers for biomass collection and power plants in the study talukas

Taluka	Location for biomass collection centers	Location for power plants setup
Rishikesh	Thano, Bhaniawala, Shyampur and Raiwala towns	Rani Pokhri town
Purola	Mori, Dhampur and Bhiyal towns	Purola town
Champawat	Lohaghat, Barakot, Pati towns	Champawat town
Almora	Chaumu, Kande, Dhatwal Gaon and Kotyura villages	Darimi village of Lamgarha block

Besides developing basic infrastructure, capacity building of local people and setting up of local institutions to meet the basic needs of power generation centers and distribution of powers to the villagers are other important factors, those need adequate attention in the planning phase. Capacity building on collection efficiency of biomasss, technical set up and maintenance of power plants and uninterrupted supply of electricity are few important areas for capacity building programme. Regarding distribution of generated power, it could be grid, interfaced with the state grid or could supply electricity directly to the local villages and industries, etc. Another option is to decentralize the power plants of smaller capacity, which could also be set up in individual villages or cluster of non-electrified villages.

The findings of the present study reveal that despite the fact that study talukas has less agriculture area, there is enough potential of surplus biomass to generate about 14.65 MW of electricity annually. The potential can be further increased by inputs in the form of capacity building, as mentioned above and also by expanding the afforestation programmes on the wastelands and village common lands, which contribute significantly to the total geographical areas (29.12%) of the state in general and study talukas (43%) in particular. Not only this, trends between 1974 and 1994 indicate that land under area not available for cultivation is increasing in almost all the districts (Rao and Nandy, 2001). Some of the districts, recording high growth in uncultivated area included Uttarkashi, Pithoragarh, Chamoli and Pauri. The out-migration of population for employment opportunities could be considered for such a significant land use changes in the state. Such large chunks of unutilized lands can be brought under plantation programmes for promoting biomass based energy generation, which will not only help in meeting power needs of the rural areas of the state, but at the same time would also generate employment for local communities.

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