ASSESSMENT OF SURPLUS AGRICULTURAL BIOMASS FOR POWER GENERATION USING GEO-INFORMATICS IN HARYANA STATE, INDIA

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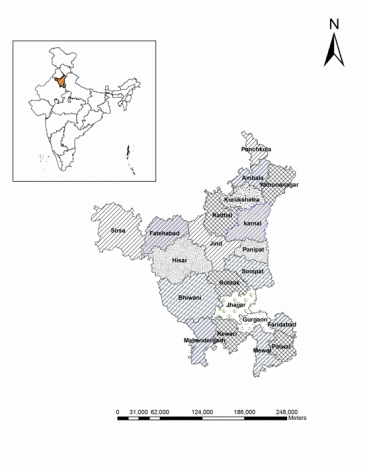
ABSTRACT: The present paper highlights the methodology and results of agricultural biomass estimation in Haryana using geo-informatics and conventional surveys for power generation. Multi-date and multi-season Indian Remote Sensing Satellite (IRS) LISS-3 digital data of 23.5 m spatial resolution along with various spatial and non-spatial collateral data have been used to generate total cropped area (Monsoon and Winter season). Harvest Indices (HI) values of various crops and average yield data were used to assess crop wise total agricultural biomass, total non-grain (NG)/non-economic (NE) agricultural biomass. Surplus agricultural biomass available for power generation was calculated using the field survey in about 200 village locations. The crop-wise biomass requirement for generation of 1 MW electrical power for 6500 hrs in a year was used as available in literature. In Haryana district-level power generation potential was computed using the availability of crop-wise surplus agricultural biomass. The net surplus biomass available after the domestic use and subtraction of crops biomass used as fodder and selling by the farmers is 8416.47 thousand tonnes. The total power generation potential from this biomass is 1018.95 MW. It is expected that the maps and data will help in selecting suitable sites for setting up of small power generation plants using surplus agricultural biomass.

1. INTRODUCTION

As conventional energy sources like coal and gas are depleting day by day, utilization of alternative energy sources is the only solution. India has huge prospects in developing energy through alternate sources. Various forms of alternative energy sources are solar, wind, biogas/biomass, tidal, geothermal, fuel cell, hydrogen energy, small hydropower etc. (Anice Alias, 2005). Biomass is a renewable energy resource derived from numerous sources, including the by-products from the timber industry, agricultural crops, raw material from the forest, major parts of household waste and wood. Assuming that there are about 140 million households in rural India, and assuming that each family uses annually about 3 tonnes of biomass as fuel, one comes to the figure of about 400 million tonnes of biomass utilized annually only for domestic cooking (Karve A D, 2005). Most of the crops constitute between 25 to 40% of grain or economic part of the total biomass and about 60 to 75% of the total agricultural biomass, or almost 600 million tonnes, is the waste /non-economic biomass produced annually. Every year, farmers in Maharashtra state alone are simply burning off millions of tons of sugarcane trash i.e. dried leaves of sugarcane left in the field after harvesting of the cane (Karve P, 2005). The study aimed to estimate district level total and non-grain (NG)/non-economic (NE) biomass of various crops and asses surplus biomass after consumption for domestic and other purposes in Haryana state. This may help in selecting suitable sites for setting up small biomass based power plants in the state.

2. MATERIALS & METHODS



Study Area

Haryana is a small agriculturally dominant northern state of India situated between 27°29' to 30°56' N latitudes and 74°27' to 77°36' E longitudes, covering an area of about 44,212 sq. km. It occupies 1.35% of the total area of the country having seventeenth position in area among 28 states. The state is divided into 04 Divisions, 21 Districts Figure 1 (Statistical Abstract, Haryana-2007-08). Haryana is an agriculturally dominant state with 82 per cent net sown area. The cropping intensity in the state is more then 180 percent, which indicates that the state has cropping intensity higher than the national average.

Figure 1. Location map of Haryana

Data Used

Remote sensing and Collateral data

Multidate IRS LISS-III data for the during December 2007 to March 2008 was acquired for winter season crop estimation and during August to October, 2007 for monsoon season crops. The average yield provided by Department of Agriculture and Harvest Index (HI) collected from literature were used for computation of total and non-grain (NG)/non-economic (NE) biomass of various crops. In-season ground truth data was collected during using Global Positioning System (GPS). The data of biomass requirement for generation of 1 MW electrical power for 6500 hrs in a year is used published by TERI (2003).

Methodology

Estimation Crop Acreage

Two to three dates LISS-III data of 23.5 m spatial resolution were co-registered and stacked for a particular district. The mask of non-agriculture classes such as forest, wasteland, water bodies, urban/settlement and permanent vegetation etc. and Normalised Difference Vegetation Index (NDVI) of each date data was generated and used during classification to improve the accuracy. Crop classification was carried out separately using July to October data for monsoon season crops, while December to March data was used for winter season crops. An unsupervised Isodata classification procedure was used (Panigrahy Sushma et. al., 2008). Using the ground truth information monsoon and winter crops were separated and area statistics of crops was computed at district-level.

Estimation of Crop Biomass

Average Harvest index values and average yield values of different crops were used for the computation of total biomass and Non-grain/Non-economic biomass for each crop using the below given formulae.

Biomass / ha. = (Grain Yield / Harvest Index)* 100
Non-Grain/Non-Economic (NG/NE) Biomass / ha. = (Biomass-Grain Yield)
Total Biomass = (Biomass * Crop Area)
Total NG / NE Biomass = (Crop Area*NG / NE Biomass)

Estimation of Surplus Crop Biomass

Assessment of surplus agricultural biomass is based on the field surveys in all the 119 blocks of 21 districts of Haryana using respondent's answer of three categories of the farmers viz large, medium and marginal, regarding the production and consumption of agricultural biomass based upon the pre-designed questioner. Within each district the sample villages were identified based on crop variation, agro-ecological zonation and productivity status for the crops of both the seasons i.e. monsoon and winter. 204 villages (Minimum 10 in each district) were selected as sample villages for field data collection with total 612 respondents (3 respondents per village). Using the survey data Domestic use, Basic Surplus and Net surplus was computed as follows:

Basic Surplus Biomass = (Total N.G. /N.E. Biomass) – (Domestic Use+ NG/NE of Sugarcane & Sorghum)
Net Surplus Biomass = (Total N.G./N.E. Biomass) – (Domestic Use+Selling as fodder)

Computation of Power Generation Potential

The crop-wise biomass requirement for generation of 1 MW electrical power for 6500 hrs in a year is used as published by TERI (2003) and available in literature. In Haryana at district-level power generation potential was computed using the availability of crop-wise surplus biomass for power generation.

3. RESULTS & DISCUSSIONS

Monsoon Crops Biomass

Analysis of remote sensing (RS) data indicated that Paddy, Pearl millet (Pennisatum) and Cotton (Gossypium) are the major crops followed by Sugarcane, Gwar and Sorghum, which could be identified using multi-date RS data. Other crops in the monsoon season include monsoon pulses, monsoon oilseeds, maize, vegetables, fodder crops etc. Paddy is mostly concentrated in northern and north-eastern part and in north-western districts, Bajra, Jowar, Guar and Cotton in southern & south-western districts while Sugarcane in northern, north eastern districts of the state. RS estimation showed that area of different crops and total cropped is closely matching with Dept. of Agriculture estimates for the same year 2007-08. Total cropped area, total biomass, non-grain biomass, net surplus biomass and power generation potential from net surplus biomass for monsoon season crops in each district has been depicted in Table 1.

Winter Crops Biomass

Wheat and Mustard are the major crops during winter season followed by Black gram which could be identified using multi-date RS data. Barley is a minor crop and not discriminable on satellite data from wheat due to its morphological similarity with wheat. Hence the area figures provided as by Department of Agriculture were used. The other crops grown in the state during winter season are winter Pulses, vegetables and fodder etc. Wheat crop is spread throughout the state except in southern, south-western and western sandy districts where concentration of mustard and black gram is more. Remote sensing based area estimation for different crops showed a close proximity with Dept. of Agriculture figures for the same year at district as well as state level. During winter season at district as well as state level total cropped area, total biomass, non-grain biomass, net surplus biomass & power generation potential from basic and net surplus biomass is depicted in Table 2.

Total Agricultural Biomass

District level as well as state level total cropped area, total biomass, non-grain biomass, net surplus biomass and power generation potential from basic and net surplus biomass is depicted

in Table No. 3 and Maps 02-05. The net surplus crop biomass available during both the seasons in the state is 8416.47 thousand tonnes and power generation potential from this biomass is 1018.95 MW. The top 9 districts comprising Karnal, Sirsa, Fatehabad, Kaithal, Sonipat, Kurukshetra, Jind, Bhiwani, and Hisar contribute nearly 68.49% of the total power generation potential in the state using net surplus biomass. Geographically, these are contiguous districts and therefore, offer scope for power plants (Table No. 3 & Map No.5). The power generation potential was significant in the group of above mentioned districts using as net surplus biomass.

4. CONCLUSIONS

Multi-date LISS-3 data is useful to estimate crop acreage at district-level for both the cropping season except minor crops like barley. Area of winter crops (3068.73 '000 ha.) is significantly higher as compared to Monsoon crops (2509.76 '000 ha.) but total available crop biomass is comparable i.e. (26604.28 '000 t) and (24795.83 '000 t) for winter and monsoon crops. It was due to higher harvest index of rabi crops. The surplus biomass was not available for Sugarcane and Sorghum crop as there NG/NE part is used as fodder. The basic and net surplus biomass available in the state is 14633.07 and 8416.47 thousand tonnes and power generation potential from this biomass is 1825.64 and 1018.95 MW. The top 9 districts comprising Karnal, Sirsa, Fatehabad, Kaithal, Sonipat, Kurukshetra, Jind, Bhiwani, and Hisar contribute nearly 68.49% of the total power generation potential in the state using net surplus biomass. Geographically, these are contiguous districts and therefore, offer scope for power plants. It is clear form the study that the basic and net surplus biomass is available for the power generation in the districts having area mainly under Paddy, Cotton and Mustard crops because of their low economic value and less usefulness for fuel, fodder and other purposes. The data base created in GIS may serve as a good decision support system in identifying suitable sites for setting up of crop biomass based small power generation plants.

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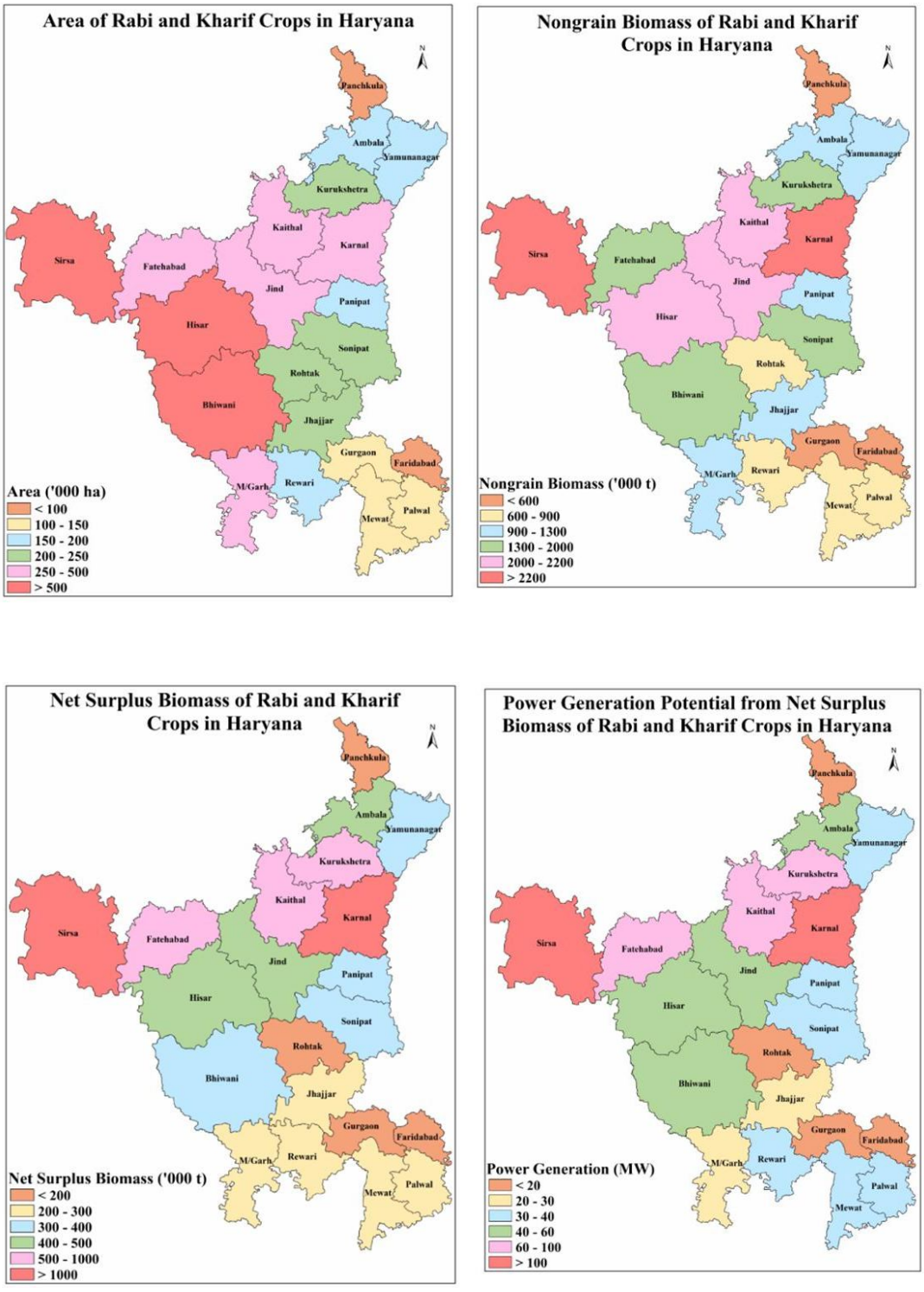

Figure 2 to 5. Crop Area, Non-grain Biomass, Net Surplus Biomass and Power Generation Potential from Net Surplus Biomass of Winter and Monsoon crops in different Districts of Haryana.

District/ Parameter	Area (000 h)	Total Biomass ('000 t)	N.G./N.E Biomass ('000 t)	Net Surplus Biomass ('000 t)	Pow. Gen. Potential from Net Surplus (MW)
Hisar	254.01	1281.18	762.47	278.48	34.49
F/Bad	168.71	1138.76	650.21	540.31	65.36
Sirsa	254.54	912.80	560.55	465.70	57.92
Bhiwani	260.11	1289.18	832.11	170.46	21.69
Rohtak	86.64	1263.53	383.27	136.20	16.73
Jhajjar	81.13	592.17	306.03	80.82	9.79
Sonipat	104.16	1591.47	526.81	303.88	36.13
Gurgaon	37.41	259.85	186.88	53.48	6.78
Mewat	43.81	239.40	170.96	113.02	14.41
Far/Bad	17.30	200.51	81.77	54.12	6.50
Palwal	49.19	622.31	238.16	150.92	18.04
Panipat	88.46	1237.84	432.74	287.59	33.76
Karnal	184.92	2643.38	1137.19	946.80	111.15
K/Shetra	117.08	2432.35	842.03	619.05	72.67
Kaithal	177.46	1813.02	1023.64	744.66	87.42
Ambala	93.76	1643.17	589.44	394.54	46.35
P/Kula	8.90	86.07	43.81	34.52	4.05
Y/Nagar	104.73	2943.18	731.18	299.67	35.22
Jind	192.77	1510.70	818.08	402.37	48.18
M/Garh	113.22	694.61	500.59	0.63	0.09
Rewari	71.45	400.38	290.63	32.21	4.15
State	**2509.76**	**24795.86**	**11108.56**	**6109.45**	**730.88**

(NG/NE – Non-grain/Non-economic)

Table 1. Area, Total Biomass, NG/NE Biomass, Net Surplus Biomass and Power Generation Potential from Net Surplus biomass of monsoon crops in different districts of Haryana

District/ Parameter	Area (000 h)	Total Biomass ('000 t)	N.G./N.E. Biomass ('000 t)	Net Surplus Biomass ('000 t)	Pow. Gen. Potential from Net Surplus (MW)
Hisar	288.37	2333.92	1379.26	174.57	21.83
F/Bad	199.26	2128.97	1240.97	104.70	13.41
Sirsa	329.36	2983.67	1757.16	569.92	73.39
Bhiwani	357.81	1866.23	1146.24	183.97	21.94
Rohtak	114.69	863.76	506.51	25.63	3.05
Jhajjar	138.16	1075.33	644.44	135.72	16.59
Sonipat	142.89	1444.47	839.24	22.54	2.85
Gurgaon	67.86	562.26	335.04	91.81	11.39
Mewat	102.28	752.18	453.07	154.85	19.10
Far/Bad	37.95	395.66	230.63	34.87	4.49
Palwal	96.51	1023.17	595.03	98.05	12.67
Panipat	84.13	867.58	503.53	13.46	1.73
Karnal	172.55	1900.67	1102.72	87.48	11.37
K/Shetra	110.59	1257.35	729.58	87.36	11.36
Kaithal	170.97	1820.58	1056.32	16.52	2.13
Ambala	82.23	747.32	433.68	11.88	1.54
P/Kula	16.62	120.18	70.26	2.72	0.33
Y/Nagar	76.75	687.55	399.55	4.36	0.52
Jind	219.31	2155.44	1252.63	42.16	5.35
M/Garh	143.58	766.42	484.84	211.48	25.20
Rewari	116.87	851.59	536.83	233.00	27.82
State	**3068.73**	**26604.28**	**15697.52**	**2307.04**	**288.07**

(NG/NE – Non-grain/Non-economic)

Table 2. Area, Total Biomass, NG/NE Biomass, Net Surplus Biomass and Power Generation Potential from Net Surplus biomass of Winter crops in different districts of Haryana

District/ Parameter	Area ('000 h)	Total Biomass ('000 t)	N.G./N.E. Biomass ('000 t)	Net Surplus Biomass ('000 t)	Pow. Gen. Potential from Net Surplus (MW)
Hisar	542.38	3615.10	2141.73	453.05	56.32
F/Bad	367.96	3267.73	1891.18	645.01	78.76
Sirsa	583.90	3896.47	2317.71	1035.62	131.31
Bhiwani	617.92	3155.41	1978.35	354.42	43.63
Rohtak	201.32	2127.29	889.78	161.83	19.78
Jhajjar	219.29	1667.50	950.47	216.55	26.38
Sonipat	247.04	3035.94	1366.06	326.42	38.99
Gurgaon	105.28	822.11	521.92	145.30	18.16
Mewat	146.09	991.58	624.03	267.87	33.51
Far/Bad	55.25	596.17	312.40	88.99	10.99
Palwal	145.70	1645.45	833.17	248.96	30.71
Panipat	172.59	2105.42	936.27	301.05	35.49
Karnal	357.47	4544.04	2239.91	1034.28	122.52
K/Shetra	227.67	3689.70	1571.60	706.41	84.03
Kaithal	348.43	3633.59	2079.96	761.17	89.55
Ambala	175.98	2390.48	1023.12	406.42	47.89
P/Kula	25.52	206.26	114.07	37.24	4.38
Y/Nagar	181.48	3630.73	1130.73	304.04	35.74
Jind	412.08	3666.14	2070.71	444.53	53.53
M/Garh	256.80	1461.03	985.43	212.11	25.29
Rewari	188.32	1251.97	827.46	265.21	31.97
State	**5578.48**	**51400.12**	**26806.06**	**8416.47**	**1018.95**

(NG/NE – Non-grain/Non-economic)

Table 3. Area, Total Biomass, NG/NE Biomass, Net Surplus Biomass and Power Generation Potential from Net Surplus biomass of Winter and Monsoon crops in different districts of Haryana

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