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A Study on Energy Consumption Pattern in Fatehpur Block of Western Himalayan State

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Abstract:

A study was carried out in Fatehpur block of Kangra district of Himachal Pradesh with the aim to find out the consumption of various types of fuels and to estimate the carbon emission in the study area. The energy consumption pattern indicated that the major fuels used were, fuelwood (88.90%), electricity (8.90%), LPG (1.0%), kerosene (1.0%) and dung cake (0.20%). The total estimated annual consumption in million tonnes of coal equivalent of households in the whole Fatehpur development block was fuelwood (98.13), LPG (1.11), kerosene (1.14), electricity (9.83) and dung cake (0.171). The per capita annual consumption of various energy sources in the Fatehpur development block was fuelwood (1.13tonnes), LPG (8.90kg), kerosene (1.81liter), electricity (133.9kWh) and dung cake (5.44kg). The annual CO_2 emission from energy consumption by the selected households was worked out to be 1,243.73 tonnes. The per capita CO_2 emission in household sector was estimated as1.24 tonnes annually.

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1. Introduction

India is predominantly an agricultural and rural country with majority of its people living in 640,867 villages with population of 1.21 billion [1] , of which the rural population stands at 833.1 million (68.8%) with an increase of 90.47 million during the last decade (2001-2011). The rural population depend largely on non-commercial sources of energy such as fuelwood, biomass, and agricultural residue for their energy requirements for cooking, heating and lighting. The average percentage of non-commercial sources of energy declined from 51 per cent in 2010 to 48 per cent in 2013. In recent time electricity has also been included for cooking and heating purposes [2].

Per capita consumption of energy in India is one of the lowest in the world, which was 800 kilogram of oil equivalent (kgoe) in 2013 as compared to 1,818 kgoe worldwide, 7,778 kgoe in USA, 4,745 kgoe in Russia and 1,700 kgoe in China.

The sector-wise energy consumption in India during 2005-06 was 6.9 per cent in agricultural, 44.4 per cent in industries, 16.8 per cent in transport, 15.1 per cent in residential & commercial, and other energy uses was 8.6 per cent. However, in 2010 - 11 sector-wise energy consumption was 7.32 per cent in agriculture, 43.63 per cent in industry, 17.5 per cent in transport, 13.73 per cent in residential & commercial and 9.56 per cent in other energy uses [3].

In recent time, there is a shift from non-renewable to renewable sources of energy in India. According to the India's Renewable Energy Status Report, 2014 [4] released at the Green Summit 2014, the total renewable energy potential from various sources in India was 249,188 MW. The Ministry of New & Renewable Energy (MNRE), Government of India has set a target of achieving overall renewable energy installed capacity of 41,400 MW by 2017.

According to Ministry of New and Renewable Energy, 2015 [5], Government of India, the total cumulative installed capacity of renewable energy in the country as on April 2015 was 35,503 MW. This included wind power 22,645 MW, small hydro power 4,025.35 MW, biomass power and gasification 1,365.2 MW, bagasse cogeneration 2,818.88 MW, waste to power 115.08 MW and solar power 3,382.78 MW.

The consumption of fossil fuels results in emission of greenhouse gasses which was mainly responsible for global warming. Presently, India contributes approximately 5.7 per cent, China 23.43 per cent and United States emits 14.96 per cent of total emission of global greenhouse gasses. India has committed to reduce the emission intensity from 25 per cent to 20 per cent below 2005 levels by 2020 and that per capita greenhouse gases emissions will not exceed those of industrialized nations.

Carbon dioxide concentration in the atmosphere has been rising alarmingly in the post-industrial era and the current level is about 400 parts per million (ppm) compared to 274 ppm earlier pre-industrialization [6]. The International Energy Agency (IEA) estimated that global CO_2 emissions totalled 32.3 billion tonnes in 2014, unchanged from the previous year [7].

The National Action Plan on Climate Change (NAPCC), which was released in June 2008 with the aim of promoting development goals while addressing greenhouse gases (GHG's) mitigation and climate change adaptations. To accelerate development and deployment of renewable energy in the country, the Government is taking a number of initiatives like up-scaling of targets for renewable energy capacity addition from 30GW by 2016-17 to 175 GW by 2021-22.The renewable power target of 175 GW by 2022 will result in abatement of 326.22 million tons of CO2 eq. /year. The ambitious solar expansion programme seeks to enhance the capacity to 100 GW by 2022, which is expected to be scaled up further thereafter. Efforts will include scaling up efforts to increase the share of non-fossil fuel based energy resources in total electricity mix including wind power, solar, hydropower, biomass, waste to energy and nuclear power.

In India, fire clay bricks are produced in about 42,000 small and medium scale brick kilns which operated normally using 4 to 5 million metric tonnes of coal each year [8]. On an average, 160 kg coal was required for firing 1,000 bricks [9].

Himachal Pradesh is a hilly state of India having a geographical area of 55,673 km^2 with population of 6,856,509 [10] comprises of 12 districts. It lies in the range of 32 ^{o}22'40" to 33 ^{o}12 ' 40 " North and in the range of 75 ^{o}

74′ 55″ to 79 ^{0} 04′ 22” East. Fatehpur Development Block is one of the blocks of Kangra District of Himachal Pradesh, located in Western Himalayas at 32^{0} 6′ 0” North, 75^{0} 56′ 0” East and has elevation of 470 meter from (amsl). The average summer temperature is 32^{0}C and average winter temperature is 20^{0}C. Block has 54 Panchayats and has total households of 17,372 out of which 3,257 are schedule caste, 377 are schedule tribe and rest 13,738 are in general category. The study on energy consumption pattern of this block has not been carried out previously. This necessitated carrying out a study on energy consumption pattern of conventional and non-conventional energy resources and to estimate the carbon emission in study area.

2. Methodology

Multistage random sampling procedure was adopted for the selection of respondents from the study area as sampling on contiguous basis may not be best way to adopt. In the first stage, list of panchayats falling in this block was collected from Fatehpur development block. Around 11 per cent of the total panchayats, aggregating to six panchayats were purposely selected so as to represent the whole block Figure 1. In the second stage, list of village falling under the selected Panchayats was prepared from office of Fatehpur development block. Twenty per cent of the villages from the selected Panchayats (aggregating to 14 villages) were randomly selected for the study. In the final stage of sampling, a complete list of households was prepared from the selected village in Fatehpur development block and 10 per cent of total households were selected randomly. In total 165 respondents were selected from the whole development block for the present study. Thereafter, the respondents were classified into five categories, viz. Above Poverty Line (APL) and Below Poverty Line (BPL) wise, land holding wise, monthly family income wise, family size and caste wise.

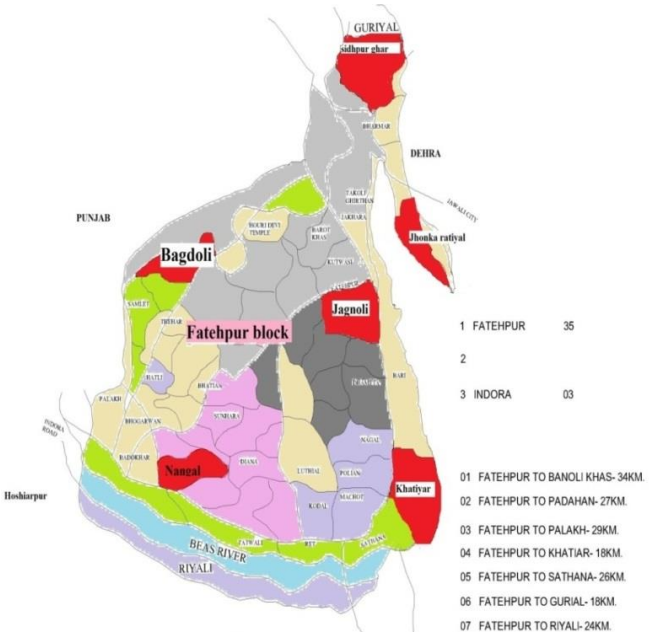

Figure 1: Map of Fatehpur development block

There were about five brick kilns in the Fatehpur development block and they all were selected for the study. Classification of industries is in accordance with the provision of Micro, Small & Medium Enterprises Development (MSMED) Act, 2006.

Primary data were collected on well designed, pre-tested survey schedule (In Hindi) through personal interview method. Participatory techniques were also utilized for the collections of the relevant information on socio-economic variables like household income, land holding, caste, and family size. The secondary data were collected from office of block development. The list of households and land holding were collected from concerned department. Socio-economic and other related data were analysed through tabular analysis, average and percentage as and when required.

The carbon emission from the burning of conventional fuels was estimated by conversion factors (Table 1) used to translate various energy uses into CO_2emissions [11]. Various sources of energy viz. fuelwood, kerosene, LPG, dung cake and diesel were converted [12] into coal equivalent and their conversion factors have been presented in Table 2. For hydroelectricity, the emission factor is 0.5-151 kg CO_2 per MWh [13].

Table 1: Conversion factors used to translate various energy sources into CO_2 emissions

Fuel category	kg CO_2 emitted per unit
Electricity (kWh)	0.87
Kerosene (liter)	2.41
Diesel (liter)	2.46
LPG (kg)	2.78
Fuelwood (kg)	1.07
Dung cake (kg)	1.07

Table 2: Various sources of energy in terms coal equivalent

Fuel	Coal replacement ratio (kg per unit)
Fuelwood	0.83
Kerosene	6.00
LPG	1.19
Dung cake	0.30
Diesel	0.20

3. Results and Discussion

3.1. Energy Consumption for Cooking in Selected Households (%)

Table 3 revealed that on the basis of the status of households the fuelwood consumption was (100%) for both APL and BPL families, but as the income increases the consumption of fuelwood decreases (100% to 93.93%). On the basis of land holding of the households, the highest (100%) consumption was in medium and semi medium land holding families and lowest (97.45%) in marginal land holdings families. It also indicated that larger the family size higher the consumption of fuelwood. On the basis of caste, the consumption of the fuelwood was highest in general category families followed by SC families (98.20%) and (95.83%) in OBC families.

The LPG consumption for cooking was higher (78.57%) in APL families as compared to (13%) in BPL families. However, kerosene consumption only for ignition of fuelwood was higher for BPL families (82.05%) as compared to (61.11%) in APL families. Electricity consumption for cooking was very less (1.58%) in APL only. The dung cake consumption was higher in BPL families (10.25%) as compared to (5.55%) in APL families.

3.2. Energy Consumption for Heating in Selected Households (%)

Table 3 indicated that fuelwood was the main source for heating. The APL families consumed (96.82%) and BPL families had (100%) consumption of fuelwood for heating. It was indicated that the consumption of the fuelwood increases with the increase in the land holding and number of family members whereas, it decreases with the increase in income of the family. On the basis of caste, consumption of fuelwood was highest (98.80%) in SC families followed by general category families (96.49%) and (95.53%) in OBC families.

The consumption of kerosene for heating was highest in APL families (61.11%) as compared to (17.94%) in BPL families whereas, the consumption of dung cake was highest (10.25%) in BPL families as compared to (5.55%) in APL families. On the basis of monthly income, the consumption kerosene was highest (73.33%) in low income families whereas the consumption of dung cake was highest (7.14%) in low middle income families. The consumption of kerosene was increased with increase in land holding of the households. On the basis of family size, the consumption of kerosene (81.81%) and dung cake (90.9%) was highest in big size families. The consumption of kerosene on the basis of caste, it was higher in SC families (76.19%) followed by OBC families (70.83%) and (49.12%) by the general category families whereas, consumption of dung cake was higher in SC families (7.14%) followed by general category families (5.26%) and (4.16%) in OBC families.

3.3. Energy Consumption for Lighting in Selected Households (%)

Table 3 indicated that the electricity consumption for lighting by all the categories was (100%), the same was found by Sood [14] in their study in Mid Himalayan Region of Himachal Pradesh, whereas, for kerosene, BPL families consumed more (82.05%) as compared to (60.31%) in APL families. On the basis of monthly income of the households, the kerosene

consumption was highest (73.33%) in low income families and lowest (51.51%) in high income families.

On the basis of land holding of the households, the consumption of kerosene increased with increase in land holding lowest (64.33%) in marginal land holding. On the basis of family size, the consumption of kerosene was highest (50%) in big size families. On the basis of caste, the kerosene consumption was highest (76.19%) in SC families followed by OBC families (70.83%) and (47.36%) in general category families.

Table 3: Energy consumption for cooking, heating and lighting in selected households in Fatehpur development block (%)

Particulars	Energy sources									
	Cooking					Heating			Lighting	
	Fuelwood	LPG	Kerosene	Electricity	Dung cake	Fuelwood	Kerosene	Dung cake	Kerosene	Electricity
APL	100.00	78.57	61.11	1.58	5.55	96.82	61.11	5.55	60.31	100
BPL	100.00	13.00	82.05	0	10.25	100.00	17.94	10.25	82.05	100
Overall	100	67.87	66.05	1.21	6.66	97.57	50.9	6.66	65.44	100
Monthly income (Rs.)										
<5000	98.33	30.00	73.33	0	6.66	98.33	73.33	6.66	73.33	100
5000-10000	97.61	88.09	61.90	0	4.76	97.61	38.09	7.14	61.9	100
10001-15000	100.00	87.50	68.75	0	6.25	100.00	68.75	6.25	68.75	100
15001-20000	100.00	92.85	71.42	0	7.14	100.00	71.42	6.25	71.42	100
>20000	93.93	90.90	54.54	6.06	6.06	93.93	54.54	6.06	51.51	100
Overall	97.57	67.87	66.05	1.21	6.66	97.57	59.99	6.58	65.44	100
Land holding (ha)										
<1	97.45	67.51	64.96	0.63	7.00	97.45	64.96	7.00	64.33	100
1 to 2	100.00	71.42	85.71	0	0	100.00	85.71	0	85.71	100
2 to 4	100.00	100.00	100.00	0	0	100.00	100.00	0	100.00	100
Overall	97.57	67.87	66.05	0.59	6.66	97.57	66.05	6.66	65.44	100
Family size										
<4	90.00	53.33	53.33	3.33	6.66	90.00	53.33	6.66	50.00	100
4 to 6	99.17	71.90	67.76	0.82	6.61	99.17	67.76	4.95	67.76	100
7 to 8	100.00	54.54	81.81	0	9.09	100.00	81.81	9.09	81.81	100
>8	100.00	100.00	66.66	0	0	100.00	66.66	0	66.66	100
Overall	97.57	67.87	66.05	1.21	6.66	97.57	66.05	6.66	65.44	100
Caste										
SC	98.80	71.42	76.19	1.19	7.14	98.80	76.19	7.14	76.19	100
OBC	95.83	37.50	70.83	0	8.33	95.53	70.83	4.16	70.83	100
General	96.49	75.43	49.12	1.75	5.26	96.49	49.12	5.26	47.36	100
Overall	97.57	67.87	66.05	1.21	6.66	97.52	66.05	6.66	65.44	100

3.4. Total Energy Consumption for Cooking, Heating and Lighting in Selected Households (%)

The energy consumption pattern indicated that the major fuels used were, fuelwood (88.90%), electricity (8.90%), LPG (1.0%), kerosene (1.0%) and dung cake (0.20%) Figure 2. Aggarwal [15] in his study conducted in Himachal Pradesh indicated that fuelwood consumption by households was 95.2%.

The annual total energy consumption in tonnes of coal equivalent by the selected households in the Fatehpur development block was fuelwood consumption (932.09), electricity (93.41), LPG (10.55), kerosene (10.84) and dung cake was 1.62 tonnes Fig 2.The per capita annual consumption of various energy sources in households in the Fatehpur development block was fuelwood (1.13tonnes), LPG (8.90kg), kerosene (1.81liter), electricity (133.9kWh) and dung cake (5.44kg). The per capita annual consumption of fuelwood was 1.559 as reported by Guleria, [16] in his study covering 136 households in Bharmaur block of district Chamba.

Sharma [17] conducted a survey in three Panchayats in which it was estimated that the per capita annual fuelwood consumption of Himachal Pradesh was 0.815 tonnes and found that consumption was higher in mid hills (0.908 tonnes) than the low hills (0.795 tonnes). Chhoerup [18] studied cooking energy consumption pattern in Lahaul and Spiti district of Himachal Pradesh, which showed that total energy consumed by 300 sample households was coming from fuelwood (55.46%), electricity (90.07%), dung cake (26.5%), kerosene (9.33%) and LPG (8.64%). The high consumption of fuelwood is due to requirement of heating in addition to cooking as severe winters prevails in the study area as such, fuelwood cannot be replaced by agro and forest wastes.

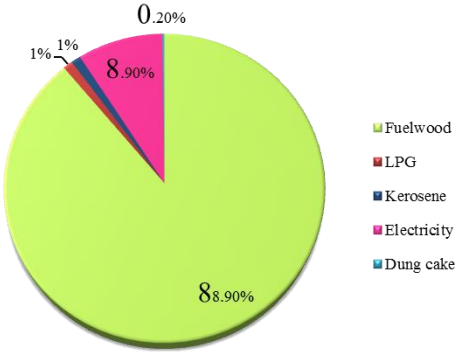

Figure 2: Total energy consumption in selected households in tonnes of coal equivalent (%)

3.5. Energy Consumption in Selected Brick Kilns for a Single Lot in kg of Coal Equivalent

The energy consumption of brick kilns to prepare a single lot of bricks in kg of coal equivalent was coal (40,000), fuelwood (16,500) and diesel (22.0) for transportation purpose, and electricity (9,800) for lighting. The annual energy consumption in kg of coal equivalent of the selected brick kilns for eight lots per year was worked out to be coal (320,000), fuelwood (132,000), diesel (176), and electricity (84,000).

3.6. Annual CO_2 Emission (tonnes) from the Selected Household and Sampled Brick Kilns in Study Area

The highest CO_2 emission in tonnes was from fuelwood (1,208.88) which is 97.19% of the total CO_2 emitted followed by LPG (24.65), kerosene (4.35), electricity (0.06) and dung cake (5.79) annually from all the sources of energy.

4. Conclusions

The study revealed that the consumption of fuelwood was highest among the various energy sources in the study area. The daily household consumption in kg of coal equivalent of various energy sources was highest in fuelwood, followed by electricity, LPG, kerosene and dung cake. In case of brick kilns highest consumption was for coal, followed by fuelwood, electricity and diesel. The per capita total energy consumption was 2.8 kgce per day Study indicated that renewable energy technologies were not found functional in the study area.

Investigation revealed that the annual CO_2 emission from different energy sources in the study area was highest in fuelwood, followed by kerosene, LPG, electricity and dung cake. The per capita CO_2 emission in the households sector was 1.24 tonnes annually. Therefore, remedial measures listed below are urgently required prior to situation may get worse.

Remedial Measures:

- Improvement in efficiency of energy systems for cooking, heating and lighting
- Change of fuel from conventional to non-conventional
- Use of renewable energy technologies for cooking (solar cooker, biomass based improved cookstove, biogas plant), for heating (solar water heating system, solar passive housing technologies), for lighting (solar photovoltaic light, LED), solar water pump, briquettes of agro waste and forest waste.
- Incentives in the form of rebate in taxes for using renewable energy technologies
- Establishment of research and development centre at local level to meet out the energy needs of the local people

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