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Status of Fuelwood Collection and Utilization Pattern in India

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ABSTRACT

Globally, more than three billion people are dependent on fuelwood as a primary source of household energy and one-third of them use it for cooking purposes. In India, approximately 77% of fuelwood is consumed at the household level. 49% of the households are dependent on fuelwood as a primary source of energy. Dependency on fuelwood is higher in rural areas as compared to urban. A major portion of the fuelwood is collected from non-forest areas whereas forest contributes about 20%-30% in the total collection. High fuelwood dependency has several hazardous effects on the environment as well as on human health. The major causes of concern are unsustainable harvesting of fuelwood and inefficient energy conversion technologies at the domestic level. One of the major barriers in fuelwood management is the lack of reliable information on its collection and utilization in the country. Therefore, there is an urgent need to develop an information repository at various levels on the fuelwood collection and utilization pattern.

INTRODUCTION

Our understanding of the fuelwood collection and utilization pattern in rural and urban areas is limited due to the lack of reliable information. As a larger part of fuelwood collection and utilization is by poor households in remotely located rural areas. Due to this, the valuation of the real extent of fuelwood use, and its impacts on forests and rural livelihoods, has consequently been difficult to determine and has been a subject of major discussion among the scientist and policymakers.

Around 3 billion people (40% of the population) across the world are dependent on fuelwood [1] and the majority of them use fuelwood as the major source for cooking fuel [2]. In developing countries, about 2.5 billion people (52% of the population) are reported to rely on biomass, such as fuelwood, charcoal, agricultural waste, and animal dung to meet their household energy needs for cooking and heating, etc. purpose and majority of the users are from rural areas. These resources account for over 90% of household energy consumption in many countries. Around 10 percent of world primary energy demand (~1090M.toe) of fuelwood is used in households in developing countries [2]. In Southeast Asia, 267 million people (45% of the population) still rely on solid fuels mainly fuelwood as a primary source of household energy [3].

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In India, out of 1.21 billion population [4], 853.88 million people (70.57%) are dependent on fuelwood for cooking or heating purposes [5]. In rural areas, the percentage of households depending on fuelwood is 67.3% while in urban areas, dependence on fuelwood is 14% as most of the households (68.4%) used LPG as the primary source of energy for cooking all over India [6]. The cooking gas (LPG) is majorly utilized in the close vicinity of the road. The LPG users in remote locations are negligible.

Fuelwood is generally being extracted from the forest areas, but in recent years this trend has decreased. In 2011, only 27% of the total fuelwood was extracted from the forest [5]. Other sources of fuelwood collection are roadside plantation, social forestry, private farms, and community lands [7]. In rural areas mostly females and children are involved in fuelwood collection mainly for household chores etc. [8].

Fuelwood is not only consumed by the household sector but also at a commercial level like in manufacturing, cottage, and construction industries; and in another sector like hotels and cremations, etc. [9,10]. **Figure 1** shows the general pattern of production, collection, and consumption in India.

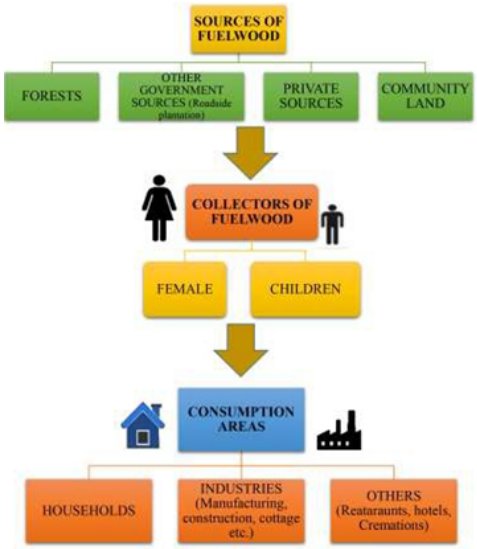

Figure 1. Fuelwood production, collection, and consumption pattern in India.

The sale and trading of fuelwood provide an income generation for a huge number of rural people. It has been estimated that almost 2 to 3 million people are engaged in fuelwood collection in India, making it the largest source of employment [11]. With the ease of access both to the resource and markets, a very large number of the landless and very poor people gather fuelwood from the nearby forest and sell in the market or to nearby people. Large numbers of farmers also harvest the fuelwood and sell it as well. Much of fuelwood retailing is small scale and access to the urban poor too. It is a major source of income for the poor and can be one of the main sources of forest product activities [12].

The major cause of concern is awareness, unsustainable harvesting, and lack of technologies for energy conversion. It harms the environment, health, and economic development of the country. Each year around 4.3 million people die prematurely worldwide due to indoor air pollution resulting from the traditional use of solid fuels [13]. Land degradation and regional air pollution are some of the environmental damage results [6].

There are few cited publications providing information on fuelwood, and is mostly government-generated data, to name some forest survey of India reports reporting the annual fuelwood consumption and, national sample survey office reports on energy sources of Indian households for cooking and lightning, etc. This paper attempts to overcome the limitation in information on the fuelwood collection and utilization pattern in rural and urban areas. The paper also highlights its impacts on the environment and human health.

This paper has tried to compile the statistics existing in the government reports, research papers, and other international reports and further have laid a conclusive outcome.

DATA SOURCES

The data/information was extracted from secondary sources including government published reports, publications by international agencies such as FAO, IEA; publications in peer-reviewed journals, and government portals. The collected data was thoroughly analyzed before finalization.

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RESULT AND DISCUSSION

Fuelwood Production and Consumption Pattern

According to the UNSD Energy Statistics database [10], there was an increase in fuelwood production in India from 2003 to 2013. In the year 2003, the amount of fuelwood production in India was 357.70 million cu.m which has increased to 386.33 million cu.m in the year 2013. In contrast, the consumption pattern of fuelwood decreased from 277.09 million cu.m to 292.47 million cu.m during 2003 to 2013 respectively. Out of the total fuelwood production from 2003-13, 444.54 million cu.m (~77%) was consumed by the household sector and only 17% of the fuelwood was consumed by the manufacturing, construction and non-fuel industry [10] (Table 1). The rest of the production goes to the sector like cremation, hotels and restaurants, etc. [10].

Table 1. Annual fuelwood consumption by different sectors and its production in India, 2003-2013 (in million cu. m.).

Year	Fuelwood consumption			Fuelwood total consumption	Fuelwood production
	Household	Manufacturing, construction and non-fuel industry	Others		
2003	277.1	60.95	19.65	357.7	379.23
2004	281.36	61.74	25.12	368.24	383.76
2005	285.55	64.32	24.82	374.67	391.27
2006	289.64	63.44	25.93	379.02	396.66
2007	293.64	64.32	22.3	380.26	397.55
2008	297.59	65.18	22.83	385.6	402.88
2009	301.51	66.04	23.36	390.91	408.19
2010	305.43	66.9	23.89	396.22	413.5
2011	309.36	67.76	24.42	401.55	418.83
2012	313.3	68.62	24.95	406.88	424.16
2013	292.47	68.84	25.01	386.33	429.46

It can be seen from Table 1 that the fuelwood consumption in industrial sector has increased by 12.96% during 2013 as compared to its 2003 value. However, the fuelwood consumption pattern in household sector showed overall 3% decrease as compared to 2003 regardless of initial increase in consumption.

Comparative analysis of fuelwood production and consumption trend in India showed that the fuelwood production had increase by 13.24% from 2003 to 2013 and consumption had increase by 7.41% for the same period (Figure 2). The production and consumption goes parallel to each other from 2003 to 2012 and after 2012 there is a decrease in consumption of around 5.05% irrespective of growth in production.

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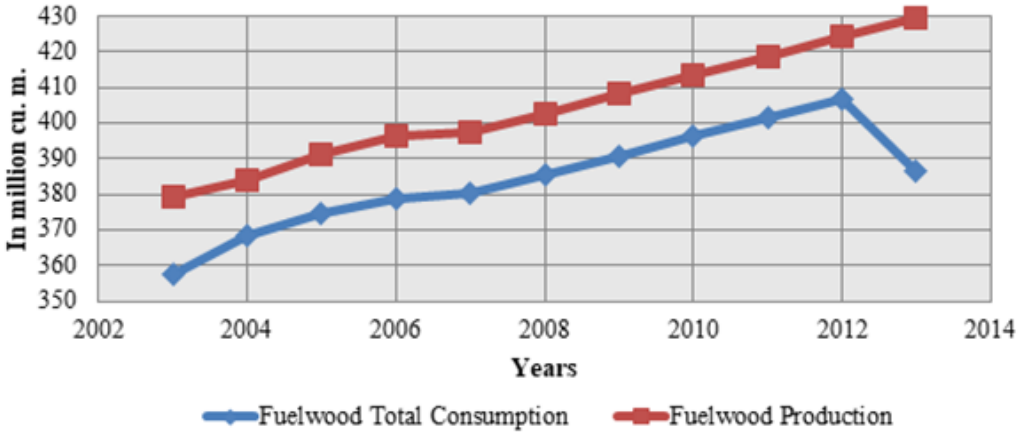

Figure 2. Fuelwood production and consumption from 2004 to 2013 in India (UNSD Koema, 2016) [10].

In India, a large portion of wood removed from the forests is used as wood fuel (fuelwood and wood charcoal, chips, etc.). The trend of wood removal from natural forest and its utilization as wood fuel is shown in **Figure 3**. It indicates the wood removed had increased from 255.981 million cu.m in 1992 to 434.48 million cu.m in 2012. Around 85% of the wood resource from the forest was used for the wood fuel [10].

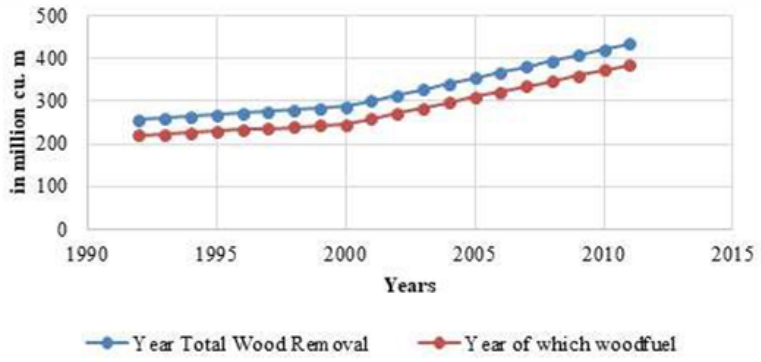

Figure 3. Annual total wood and wood fuel removal in India from 1992-2011.

In India, annually 216.47 million tons of fuelwood is consumed, in which forest (public land) contributes only 27.13%. At present, the major contributor of fuelwood in India is reported to be the non-government land, which contributes around more than 60% [7]. It includes road side land, canals, farm lands, village lands, community lands, etc. Several government schemes/programs on fuelwood plantation such as afforestation, farm forestry, agroforestry, community forestry, etc. contributed significantly in reducing people's dependencies on forest lands and has gradually shifted their collection areas to non-forestlands [7].

United nation statistic division in its study reported that the fuelwood production in Indian has increased during 2003 to 2013. Though the household sector was reducing the fuelwood consumption it can be observed that there was an increase in the consumption pattern due to manufacturing, construction and non-fuel industry and other sectors like cremation, hotels and restaurants, etc. [10] **(Table 1)**.

Households sector is the major consumer of fuelwood and approximately 77% of the fuelwood produced goes to household sector. About 49% of the households are found to be dependent on fuelwood as a primary source of energy. However, there is a decrease in the household fuelwood consumption as a primary source of energy for cooking by approximately 14% from 1993 to 2011. Nevertheless, with government initiatives on fuelwood plantation and raising people awareness on forest conservation, a significant change in the fuelwood extraction from the forest was reported from 1991 to 2011. It could be due to the new policies developed by the government in improving the access to clean household energy in addition to increase in number of LPG users, restrictions on fuelwood extraction from forestlands, innovations in energy efficiency using smokeless chulas, etc. This initiative by government of India would help in minimizing fuelwood demand and production gap which is more than 100 million tone still 2009 [14]. The decrease in fuelwood consumption against the increase in production from 2012 could be due to positive outcomes of government initiatives of distributing LPG to rural peoples in order to reduce their dependencies on fuelwood [6]. Consumption of LPG in rural areas has increased during the last two decades. But, its distribution in rural areas is very low and in the last one decade (1999-2012) its consumption has increased only by 9.6%. In urban India, number of LPG users increased by 54.8% from 44.2% to 68.4% over the same

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period [6]. Appropriate measures should be adopted by government for maximizing LPG distribution especially in rural India in order to minimize the gap.

Though there is a decrease in per capita fuelwood consumption due to increasing scenario of urbanization and Indian government schemes like National Programme on Improved Chulha (NPIC) in 1984-1985, and national biomass cook stoves initiative launched in 2009. In the coming years, an increase in number of brickkilns, hotels and restaurants in the growing sub urban areas will contribute toward increase in fuelwood consumption. Sharma, has projected an increase of 26.77% from 2011 to 2021 in overall fuelwood consumption for energy future scenario [15]. This increase in consumption would tend to show a decline in the coming future which would be decreasing to 6.48% in 2041 and 0.89% in 2051 respectively [15].

State Wise Fuelwood Consumption In India

The total annual fuelwood consumption in India during 2010-2011 was estimated to be 216.421 million tonnes of which 58.747 million tons (27.14%) was sourced from forest sector **(Table 2)**. The total fuelwood form TOF was estimated to be 19.25 million tones. Fuelwood extraction from forest decreased from 40.87% in 1991 to 27.15% in 2011 [7,16].

Table 2. Annual fuelwood consumption in different state of India in the year 2011 (to convert ton into cubic meter 1.39 conversion factor was used at 15% moisture content).

State/UT	No. of persons using fuelwood (millions)	No. of persons using fuelwood from forest (millions)	Quantity of fuelwood used (million tonnes)	Quantity of fuelwood used (cu. m)	Quantity of fuelwood used from forest (million tonnes	Quantity of fuelwood used from forest (cu. m)	Percapita consumption (tonnes)
Andhra Pradesh	64.992	7.573	24.293	33767.27	2.966	4122.74	0.37
Arunachal Pradesh	0.882	0.698	0.402	558.78	0.325	451.75	0.45
Assam	23.373	5.812	11.421	15875.19	2.494	346.66	0.49
Bihar	65.816	3.115	11.475	15950.25	0.465	646.35	0.17
Chhattisgarh	20.078	7.818	4.366	6068.74	1.378	1915.42	0.21
Gujarat	40.092	7.497	9.731	13526.09	2.225	3092.75	0.24
Haryana	8.092	0.012	1.494	2076.66	0.003	4.17	0.18
Himachal Pradesh	5.912	5.646	1.214	1687.46	1.163	1616.57	0.21
Jammu and Kashmir	8.375	4.54	1.394	1937.66	1.015	1410.85	0.17
Jharkhand	21.733	9.984	4.844	6733.16	2.849	3960.11	0.22
Karnataka	44.681	9.584	20.967	29144.13	5.776	8028.64	0.47
Kerala	29.504	4.429	14.543	20214.77	2.183	3043.37	0.49
Madhya Pradesh	51.007	24.839	13.665	18994.35	7.191	9995.49	0.27
Maharashtra	68.904	31.845	9.508	13216.12	4.527	6292.53	0.14
Orissa	33.029	11.11	8.894	12362.66	2.971	4129.69	0.27
Punjab	13.628	0.136	3.348	4653.72	0.029	40.31	0.24
Rajasthan	57.992	11.414	18.782	26106.98	3.698	5140.22	0.32

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Tamil Nadu	42.405	7.429	12.387	17217.93	2.601	3615.39	0.29
Uttar Pradesh	175.096	10.495	19.063	26497.57	1.294	1798.66	0.11
Uttarakhand	7.289	6.06	2.566	3566.74	2.139	2973.21	0.35
West Bengal	51.202	18.574	14.158	19679.62	6.361	8841.79	0.28
North Eastern States	9.383	6.588	5.274	7330.86	3.822	5312.58	0.56
UTs	10.412	4.432	2.633	3659.87	1.272	1768.08	0.25
Grand Total	853.879	199.63	216.421	300825.2	58.747	81658.33	0.25

Maximum dependency of population on fuelwood consumption was recorded in the state of Uttar Pradesh where 175.096 million people were dependent on fuelwood, followed by Maharashtra with 68.904 million people and Bihar with 65.816 million people. Whereas, in Arunachal Pradesh only 0.882 million people were dependent on fuelwood which is the lowest dependency amongst all states. Studies have found a solid association between the forest area of the district, distance from forest and per capita fuelwood consumption. Studies performed by forest survey of India in the forested areas of the country gave high consumption rates in North-east states and Madhya Pradesh [17].

In terms of fuelwood consumed, Andhra Pradesh recorded highest quantity of fuelwood consumption with 24.293 million tones fuelwood annually followed by Karnataka with 20.967 million tones and Uttar Pradesh with 19.063 million tones. Arunachal Pradesh had lowest access to fuelwood i.e. 0.402 million tones followed by Himachal Pradesh (1.214 million tons) and Jammu and Kashmir (1.394 million tons) **(Table 2)**.

More than 853 million people use fuelwood in India. From the total persons dependent on fuelwood, only 23.379 percent are dependent on forest for its consumption. In terms of per-capita consumption, North Eastern states was having highest consumption per year with 0.56 ton followed by Assam and Kerala with 0.49 ton of per-capita consumption, Karnataka with 0.47 tons and Arunachal Pradesh with 0.45 tons **(Table 2)**.

The dependence on fuelwood from forest area has decreased in the certain states. For example, Haryana and Punjab are least dependent on fuelwood **(Figure 4)**. The implementation on programs emphasizing on the importance of forests, implementation of large scale afforestation, farm, social forestry and joint forest management, and the fuelwood production area has shifted gradually to the non-forest area. A proportional percent of fuelwood is being produced from trees planted outside forest i.e. from farm lands, roads, agroforestry and wastelands. Further, the government has increased there stricted areas for removal of fuelwood to conserve the existing forest resources [9].

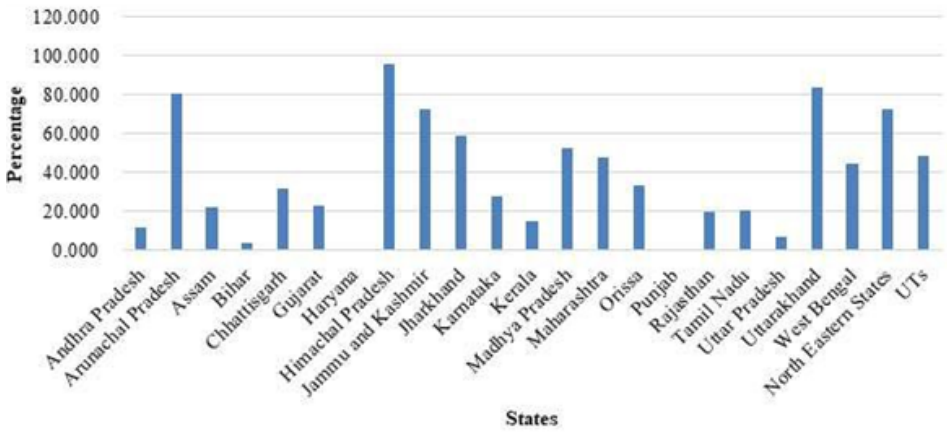

Figure 4. State wise percentage of fuelwood used from forest in the year 2011.

Though having a smaller amount of population dependent on fuelwood, Himachal Pradesh was the major consumer amongst all depending on its forest resources with 95.8 percent of its population followed by Uttarakhand with 83.4 percent

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and Arunachal Pradesh by 80.930 percent (Figure 4). It can be due to the hilly areas, the cold weather conditions and least LPG supply over the hilly areas due to topographic conditions.

State wise fuelwood consumption analysis showed that dependency on fuelwood is directly linked with the socio-economic status of rural population. In Madhya Pradesh, 78.6 percent of the rural households and 33.5% of urban households use fuelwood as a primary domestic energy [18]. In the state with higher fuelwood consumption like Andhra Pradesh, Karnataka, Uttar Pradesh and Bihar, more than 70% of the population is living in rural areas out of which maximum are economically weak. Similar kind of study carried out in Indian Himalaya reported that a negative correlation (-0.882) exists between income and fuelwood consumption in the region due to poor economic conditions leading to dependency of poor on forest for fuelwood as a primary source [19].

Fuelwood Consumption in Rural and Urban Areas of India

Fuelwood dependency in rural and urban areas of India has dropped by 10.9% and 15.9% respectively in the year 2011-12 as compared to its dependency during 1993-1994. In 1993, 78.2% of rural households and 29.9% of urban households were dependent on fuelwood as a primary source of cooking; however in the year 2011 only 67.3% rural households and 14% of urban households were reported to utilize fuelwood as a primary source of energy for cooking [6] (Figure 5). As in urban areas, LPG was used by 68.4% of the households as a [10]primary source of cooking and only 15% of rural households were dependent on it. Approximately 40% of the urban households used LPG in all major states. It is highest in Haryana (86.5% households), followed by Andhra Pradesh (77.3%) and Punjab (75.4%).

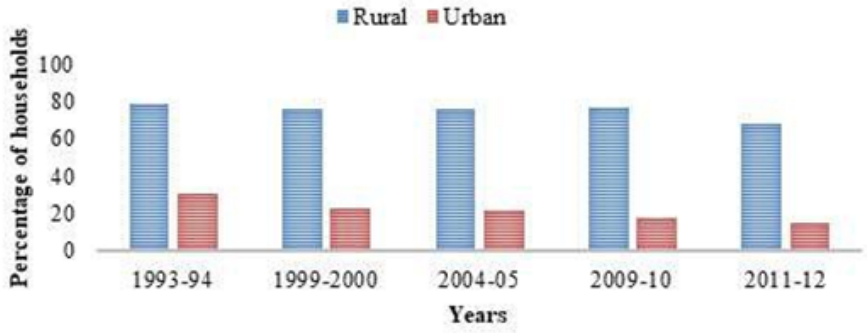

Figure 5. Percentage of households using fuelwood as a primary source of energy in rural and urban areas of India, 1993-1994 to 2011-2012.

The states like Chattisgarh, Rajasthan and Odisha has maximum rural population dependent on fuelwood as compared to other states. Chhattisgarh is highest among the states with 93.2% of the household followed by Rajasthan 89.3% and Odisha 87.0% (Figure 6). However, in urban area, Odisha with 36.5% households depending on fuelwood is highest followed by Kerala (36.3%) and Chattisgarh (34.7%) [6]. One common reason for low uptake of LPG in rural areas is income. Rural households are often notable to afford the upfront cost of LPG and if biomass is available at nor lowcost, there is a financial advantage to purchase the economical cooking fuels [20].

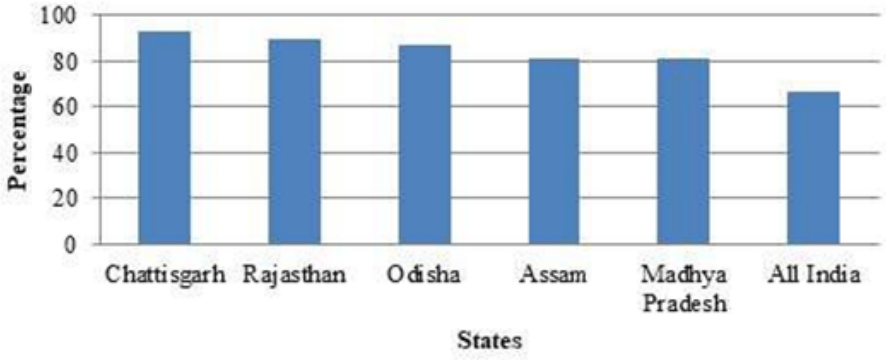

Figure 6. A comparison of the top five states with high fuelwood consumption with those of all India consumption.

Punjab is the lowest consumer of fuelwood where only 30.5% of the rural people and 6% of urban people are dependent on fuelwood as a primary source of household energy. Similarly, in Haryana only 41.7% of rural and 6.7% of urban people is dependent on fuelwood [6]. This is due to the increasing use of LPG, making Punjab and Haryana the only states exempting the excess use of fuelwood for household chores [6].

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Energy consumption in different parts of countries has a variable relationship with socio economic factors. Remote locality and poor socio-economic conditions are the major factors for dependency on forest areas. In the tough mountain terrain, the consumption pattern depends on the availability of the resources as well as socio-economic conditions of the people [21].

Forest dependent rural and tribal communities were reported to collect fuelwood from forest land as well as from private land. People of hilly regions are more dependent on forest land for fuelwood collection as compared to people living in plains which could be due to easy and free accessibility of fuelwood and unavailability of sufficient areas of private and community lands [19]. In Meghalaya, 90% of the tribal population use biomass as an important source of energy. Fuelwood consumption is linked with the area and availability of alternative energy sources. It is reported that fuelwood consumption is maximum at higher altitudes and lowest in the lower altitude in al zone [19].

Women and children are mostly involved in fire wood collection and consumption at household level. Fuelwood collection time also has a significant opportunity cost, limiting women and children to improve their conditions, educational status and engage in some income generating activity [8].

The collection of fuelwood is an exhausting and time consuming task and, mainly demands women and children's time and limits their opportunities for productive income generation activities and to obtain education. It forces girl child to dropout schools and help their mothers in household chores. Because of its regular needs in cooking food and heating water, women have to suffer long term physical damage due to this tireless work without having any recovery. It also risk them from any serious injury be it bites from venomous snakes, spider or any insect. Due to in efficient combustion in traditional cook stoves with low thermal efficiency produces smoke which causes serious health problems like acute respiratory disease, conjunctivitis, etc. [8]. A study of Himachal Pradesh revealed that women walk around 30 km each month for fuelwood collection having a trip of 2.7 hr per trip (i.e. 40.8 hr per month) over hilly high altitude terrains which causes a loss of 4-7 work days in a month resulting in a significant economic loss to the family [22].

In one of the study by UNin, estimated 84% of rural women aged 10-59 years are affected by fuelwood scarcity in India. Increasing scarcity causes women to walk many miles to get ahead load of fuelwood every day. In some villages, women walk 12 km or more spending whole day in search of fuelwood. This also risk the min stealing fuelwood from private forest they did not have access to which causes the min breaking their legs while running, financial penalties, etc. This all affects the min participating in important activities like family planning and nutrition programs. It also impact their cooking habits, they tend to cook food with low nutritional value that requires less time in cooking [4].

Fuelwood is not only used for cooking and heating water, it is also burnt for space heating in cold regions, lightening and livestock rearing, etc. [23]. A study of van gujjars in Uttrakhand region showed that 100% of population uses wood as a main source of energy for cooking and heating purposes. The average per capita fuelwood consumption is approximately 2.77 kg per day and a family consumes on an average of 20.09 ± 0.7 kg per day. Around 443 individuals collect fuelwood per day. This leads to a total annual consumption of fuelwood to be 2493.169 tonnes. This came as an outcome of deforested total wood as 1312.19 m^3 causing deforestation and Greenhouse Gas (GHG) emissions [21]. Excessive use of fuelwood at household sector is leading to severe deforestation in the northeastern Himalayas. Illegal and unsustainable harvesting of fuelwood from forest lands is causing degradation of forests in several states of the country [24].

Implication on Health

In developing countries, in terms of exposure, the number of people, time spent and the intensity is far greater than the developed countries that approximately 76% of the total particulate matter air pollution occurs in it. Fuelwood combustion produces a large amount of carbon dioxide and the emissions are considered carbon neutral if fuelwood is harvested sustainably. But in complete or in efficient combustion are not carbon neutral as carbon releases in other form which have high Global Warming Potential the carbon dioxide like methane, nitrous oxide, carbon monoxide and non-methane hydrocarbons [21]. Incomplete burning of biomass fuels produces large amounts of particulate matter as well as hydrocarbons, free radicals, carbon monoxide, oxygenated organics and chlorinated organic. According to WHO guidelines, the 24 hr mean particulate matter levels for air quality are 50 $\mu g/m^3$ for PM10, but it often exceeds 2000 $\mu g/m^3$ in many developing countries [25].

About 100 million households out of 240 million household of India are still depends on of fuelwood, cowdung, coal, etc. and are deprived of LPG. The smoke from burning these fuels causes serious indoor pollution affecting health of women and children causing them many types of diseases. About 4.3 million people die prematurely because of air pollution resulting from traditional use of solid fuels [3]. In India, more than one lakh people die because of in haling smoke from fuelwood and biomass burning for cooking [15].

Fuelwood dependent households had Disability Adjusted Life Years (DALYs) lost and deaths that are much higher than the National status [26,27]. Children exposed to indoor air pollution are 2-3 times more likely to catch pneumonia one of the

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leading killer of young children around the globe. Evidences link indoor pollution to low birth weight, tuberculosis, cataract and asthma [2].

Studies quantify in an exposure of 24 hours in the indoor air, carbon monoxide levels, poly aromatic hydrocarbons, formaldehyde and particulate matter during cooking with fuelwood were 156 mg/m^3, 2.01 mg/m^3, 109 mg/m^3 and 500 mg/m^3 to 2,000 mg/m^3 respectively. A difference of 149 ± 70 mg/m^3 in average 24-hr exposure is observed for those using biomass fuels for cooking over the clean fuels. Use of fuel other than LPG are associated with acute low respiratory tract infection, chronic obstructive pulmonary disease, age dependent cataract, prevalence of asthma, tuberculosis, cancer of nasopharynx, larynx, lung, and leukemia, etc. Formaldehyde also has harmful health effects like causing bronchitis, acute irritant, reducing vital capacity, is a carcinogenic causing leukemia and lung cancer [27]. A study from Ladakh reveals that the inmate's exposure to high concentration of soot because of the low ventilation in severe cold results in morbidities resembling pneumoconiosis [28].

Studies reveal that biomass fuel users are at 50% excess risk of still births during their pregnancy. Mothers from household with high indoor pollution gave birth to low birth weight child that is approximately 73 g light eras compared to clean fuel users. Size of child at the time of birth is also affected with the same [29,30]. It has also showed significantly increased child mortality at 1-4 years of age. More number of girls is affected and dies from exposure to solid fuel than boys. Non fatal pneumonia is also associated with solid fuel exposure [31].

Effects of Fuelwood Extraction on Forest Resources

India accounts for highest wood removal globally with 434,766 thousand cubic meters of which 88.6% is fuelwood. Generally fuelwood is collected from forests, trees grown on farmlands, common land outside forests and home stead and around 27.14% of fuelwood has been collected from government owned forests. The annual fuelwood consumption by 854 million people in India is 216.4 million tons per year. As per FSI, this consumption rate is beyond sustainable limit due to which 61.17% crops in forest area are prone to girdling and illicit felling [32].

In addition to human health impact, fuelwood burning also contributes to global climate change. It is estimated that 87840.00 Gg CO_2 losses due to fuelwood use. About 8.7% of the fuelwood consumption is estimated to come from felling of trees leading to net CO_2 emissions [33]. Fuelwood being a primary source of energy for domestic and commercial use in rural and semi urban areas contribute to more than 93% of GHG emissions from forestry sector in India [15].

More than 30 million hectare of forest is under threat due to unsustainable harvest of fuelwood making it a major driver of forest degradation. Moreover the government of India has also cancelled the subsidies given on LPG has also increased the demand of fuelwood in rural and sub urban areas [15].

For a long period timber has been considered as a locked carbon but more than 90% of contribution towards emission is due to use of fuelwood for various purposes. Unsustainable harvest of forest produce has degraded the ground and middle flora of forest. Around 6.15% of forest area is prone to injuries from lopping [32].

Though industrial requirement (Construction, realstate, production of agricultural equipment, pulp wood) of timber are primarily fulfilled by various farm forestry or tree outside forest but the pressure on natural forest for fulfilling the domestic and industrial need for fuelwood, fodder, NTFP is a major cause of forest degradation in India.

Though India has addressed the problem of deforestation and improvement has been reported from 2003 to 2015 in terms of forest cover by 2.17% but the growth stock is reduced significantly by 12.26%. And this reduction indicates degradation in forest quality. As light increase has been observed in growing stock in 2015. Approximately 94.96% of forest is prone to crop injuries and 5.05% has no generation [32]. Forest degradation directly impacts sequestration of GHG and enhance emissions [15].

Key Government Initiatives

To address the local deforestation by reducing fuelwood consumption and further more improving indoor air quality the government of India initiated the National Programme on Improved Chulha (NPIC) in 1984-1985. It also aimed at easing the burden on women and girl child for gathering fuelwood and providing employment opportunities to rural people. The government subsidized 50% of the cost of the stoves and supplied energy-efficient cook stoves. Improved Chula's are designed for optimal regulation of heat flow having heat transfer efficiency of 20-35% and letter fuel utilization. As a result the NPIC supplied it in 32.77 million households. However, from April 2002, the ministry of non-conventional energy sources has discontinued its funding support to NPIC [34].

After a massive success of NPIC, government initiated process of consultation for a substantial improvement in the technology and this gave birth to the National Biomass Cook stove Initiative (NBCI). In 2009, NBCI was launched by MNRE primarily aimed at enhancing the use of improved biomass cook stoves in context to concern over health, climate change

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and energy security strengthening research and development for more efficient, cost effective, durable and easy to use device. A number of pilot projects were initiated in different states under the roof of NBCI (MNRE, GOI).

In 2009 a project entitled-a new initiative for improved cook stoves: preparatory activities for launch was taken up by MNRE at Indian Institute of Technology (IIT), New Delhi to evaluate the present status of various types of improved chulhas, and prepare action plan for the further development of cook stoves. Its demonstration indicated reduction in fuel consumption of 40-60%, emission reduction up to 70% and saved 10-30% cooking time. It was followed by another project named Unnat Chulha Abhiyan Programme in 2014 for development of improved cook stoves and to make available the clean cooking solution in the rural, semi-rural and urban areas (MNRE, GOI).

Limitations

It is revealed that despite of other fuels like LPG, Kerosene, etc. fuelwood is major source of energy for households (about 50%) in India. A huge gap is been observed in the data reported by various organizations and researchers. A significant difference was found in the data published by UNSD and ISFR on production of fuelwood. Source of data collection was not clear in some reports whereas in other reports sources of fuelwood production was missing [10]. In global forest resource assessment report, fuelwood data is reported with biomass and or wood fuel and data on fuelwood was not provided separately. Even there port on people's dependencies on forest land for fuelwood like ISFR, FRA, UNSD, varied among various government and non-government organizations. In congruities were also recorded in the NSSO reports (report no. 567 and 588) [6] on household fuelwood consumption in rural and urban India for the year 2011-12. There is no proper report on collection pattern of fuelwood from different sources. Some of the reports just mention the role of men, women and children role in fuelwood collection but provide no data on gender wise involvement. Fuelwood sector being unorganized sector is difficult to monitor and record in NSC [35]. Information on dependency of people on forests for fuelwood also varies.

Some Recommendations in Achieving the Progress towards Improving Conditions

Although government is trying to improve the conditions, through many new policies and interventions but still the results is not significant and output is much below the expected level. A few of the actions and interventions suggested below can help improve the conditions:

- Increasing the productivity-strong new policies are required, local management, check at local level of illegal harvesting, forestry institutions should be strengthened, etc. Unplanned use is the biggest negative factor which leads to degradation of the resources that should be balanced with respect to time.
- Creating new resources-activities like afforestation, agroforestry, farm-forestry should be implemented specially in the hilly areas where land is limited and consumption pattern is high. These activities can benefit in many ways also like it will control soil erosion, provides continuous source of income as well as providing alternate fuelwood for self-consumption and can reduce pressure on the adjacent forest land.
- Fast growing tree species-government should promote fast growing tree species (e.g., *Ailanthus excelsa, Albizia spp., Alnus nepalensis, Pinus spp., Acacia spp., Cassia siamea, Dalbergia sissoo, Duabanga grandiflora, Melia azedarach, Peltophorumpterocarpum, Populus euphratica, Robinia pueudoacacia, Samnea saman, Sesbania sesban,* etc.) suitable to grow in the community and private land in various climatic conditions in order to meet the local demands.
- Improving the technologies-promoting more efficient and sustainable use of traditional biomass, efficient wood stoves, improving the thermal efficiency of cook stoves, encouraging people to switch to modern cooking techniques, etc.
- Substitution of fuelwood -switching to sustainable technologies like biogas, solar cooker, etc. Use of multiple fuels provides a sense of energy security, since complete dependence on a single fuel or technology leaves households vulnerable to price variations and unreliable service[6].
- Dependency of people on fuelwood should be reduced which leads to the multiple benefits like protect natural forests, enhance ecosystem services and will reduce impact of fuelwood burning on human health as well as in climate change [36].
- Implementation of new energy saving schemes of Government of India.

CONCLUSION

A broader picture of fuelwood consumption and utilization pattern is being developed by laying together the existing information. According to the best available figures, a large part of fuelwood production was being used in household consumption but in the past few years this trend has changed. Due to the availability of LPG, other alternative energies and government initiated schemes, its consumption has decreased in both urban and rural area but the production is still unpretentiously rising. It is being predicted that its consumption is inclining towards due the growing industrial usage in industries like manufacturing, construction, hotel restaurants, etc.

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Though there is a proportional progress in reducing the dependency on fuelwood however a strong policy development with tough implementation is required form in imaluse as well as diminishing the aforesaid impacts on environment and human health. To safeguard the resources and policies regarding energy development and utilization, it should be incorporated in the sustainable development context.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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