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Effect of Various Interventions in Reducing Fuel-Wood from Forest in the Households of Different Watersheds of Sirsi Taluk

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Abstract: ***The study was conducted in two watersheds of Sirsi taluk, Uttar Kannada district, Karnataka, India during year 2016-2017 to assess the effect of various interventions in reducing fuel-wood from forest. The use of intervention was 82.28 in households of watershed 4D4F5 and 75.8% was in watershed 5B1A5. The average quantity of reduction of fuel-wood was 0.5 and 0.4 t/year/person in 4D4F5 and 5B1A5watershed respectively. The total fuel-wood replacement by interventions in 4D4F5 watershed was 1,291.9 t/year and in 5B1A5 watershed was 274.2 t/year. The more number of households use LPG (65.1%), Gobargas (28.5%), Kerosene stove (10%) and electric stove (16%) in watershed 5B1A5 than watershed 4D4F5 (63%, 20.1%, 6.9%, 3.1% and 1% respectively). LPG was found to be used in all 10 villages of both watersheds, whereas Gobar gaswas used in 8 villages, Improved chula in 7villages, electric stove and Kerosene stoves in 5 villages each and solar heaters in only one village. LPG, Gobargas, Electric stove, Improved chula and solar heater are the suitable interventions to reduce the fuel wood useage from forest which in-turn helps to conserve the forest.***

Keywords: Fuel-wood, watershed, interventions, household, forest

1. Introduction

Energy is a fundamental and strategic tool to attain the minimum quality of life. At present inefficient energy use in various sectors is mainly responsible for detrimental impacts on the environment. In meeting energy demands in India, particularly in rural areas, traditional fuels, e.g., fuel-wood, dung and crop residues play a key role. The absolute amount of energy from these fuels consumed annually in the country has been growing, although its share in total energy consumption has been declining. Globally, large numbers of households are primarily dependent on traditional fuels for cooking and heating purposes. Approximately, 50 per cent of the total households worldwide, out of which 90 per cent being rural households use solid fuels for cooking or heating purposes. In developing countries, 2.5 billion rural households are primarily based on traditional sources for cooking purposes and use solid fuels with a high preference for fuel-wood [5].

Fuel-wood is the dominant domestic fuel for most of the rural people in developing countries of the Asia region. Fuel-wood refers to any source that comes from woody biomass. Fuel-wood is consumed in India in several forms-logs, billets, twigs, wood shavings, saw dust, *etc.* and is derived from a variety of sources (forests, own farms, roadside trees, scattered trees in villages, *etc.*). The most important use of fuel-wood is for cooking and water heating in most of the households in rural areas. The main source of fuel-wood includes dead and fallen wood from the forest [6].

Most of the fuel-wood is being used in traditional cookstoves and other devices. The traditional cookstoves have low thermal efficiencies with fuel-wood (14%). Large-scale saving of wood can be realized through the use of improved chulas which have improved efficiency as compared to traditional stoves. Such stoves also have social (e.g. time-saving), ecological (e.g. tree-conserving) and economic (e.g. fuel-saving) benefits. In order to meet the demand of fuel-wood which is not fulfilled by the deadwood available in the forest, even green trees are being lopped by the community for the fire-wood. This is one of the most important factors responsible for degradation of the forests [7].

Access to clean, affordable and adequate energy is essential to attain a good quality of life and sustainable economic and social development. One of the main reasons for this lack of inter-fuel substitution is that household choice and the use of a given source of fuel, hinges on a host of socioeconomic (e.g. income, and wealth), demographic (e.g. family size, household composition, lifestyle and culture) and location attributes (e.g. proximity to sources of modern and traditional fuels) in addition to fuel-wood availability. Collection and use of biomass is largely influenced by socioeconomic and demographic factors of households. However, there exists a two-way relationship between fuel-wood collection and deforestation. Demand for fuel-wood from village is the prime cause of forest degradation. Fuel-wood scarcity is the result of the perpetuation of forest degradation as it is the main source of energy for local people and ultimately this puts pressure on the environment in the form of loss of biodiversity, climate change and so on.

People in Sirsi area of Uttar Kannada district, depend upon fuel-wood mainly for cooking, water heating, arecanut boiling and NTFP processing. The estimated annual harvest of fuel-wood here from these species along with the other species is around 4.2 tonnes per ha which is more than 8 times the level of production [9].

Nowadays, pressure on forest is increasing due to higher demand of fuel-wood for various activities. Forest is being depleting because of exploitation and unsustainable harvesting. However, some of the interventions have helped in reducing the use of fuel-wood. Improved chula can save fuel-wood up to 700 kg/family/year. A solar water heater with capacity of 100 litres/day can save 2,138 kg of wood and a 2 m^3 biogas plant could replace, in a month, 210kg of fuel-wood [1]. Thus, a study is necessary to understand the fuel-wood effect of interventions in reducing fuel-wood use in order to reduce pressure on forest.

2. Materials and methods

2.1 Study area

The study was carried out in the watershed area of Sirsi taluk, Uttar Kannada District during the year 2016-2017. District lies between 13°55` and 15°31` N latitude and 74°09` and 75°10`E longitude with an altitude of not more than 700 m. The total forest cover of the district is 8,271 sq. km (80 % of the geographical area) out of total geographical area of 10,291 sq. km. District has higher forest cover in Karnataka spread over 6,502 sq. km under dense and 1305 sq. km under open forests. Sirsi taluk lies between 14°21` and 14°51` Northern Latitude and 74°34` and 75°4` Eastern Longitude.

2.2 Household survey

An extensive investigation was under taken to collect the information regarding fuel-wood usage in the households of different sizes in the villages. The information was collected by using the questionnaires from different sized families across the selected villages of the two watershed areas. The questionnaire consisted of the questions regarding respondent details, details about fuel-wood quantity, various interventions used, quantity of replaced fuel-wood by the intervention, *etc.* The households of the selected villages were surveyed of about 10% of the total households of the village which included the equal proportion of the households with the different family sizes *i.e.* small, medium and large families.

In the present study, family size of the respondents was operationally defined as a total number of members residing under one roof [4]. The families were grouped into three categories as follows.
1. Small sized family: 1-4 members
2. Medium sized family: 5-7 members
3. Large sized family: >7 members

2.3 Statistical Analysis

The data collected for the study was statistically analyzed in the software AGRISTAT.

Table 1: Details of the study area selected

Watershed areas	*Villages selected*	*Population (No.)*	*Forest area (ha)*
Watershed area 1 (5B1A5)	Devnalli	28,051.000	600.370
	Jaddigadde	544.000	749.785
	Kadabala	598.000	144.692
	Muregar	183.000	330.396
	Vanalli	474.000	298.889
Watershed area 2 (4D4F5)	Bidralli	314.000	58.119
	Kabbe	532.000	27.072
	Kerekoppa	557.000	69.581
	Sugavi	936.000	436.381
	Narebail	455.000	164.392

Source: Population census, 2011

3. Results and Discussion

The results indicate that, among the two selected watersheds, the households of watershed 2 use more intervention than watershed 1 (82.28% and 75.8%, respectively). The average quantity of reduction of fuelwod is also more in watershed 2 than watershed 1 (0.5 and 0.4 t/year/person, respectively). But the total fuel-wood replacement in the villages of watershed by interventions is more in watershed 1 than watershed (1291.9 and 274.2 t/year, respectively). The scope for reduction with 100% intervention adaptation in villages was higher in watershed 1 than watershed 2 (2703 and 306.6 t/year, respectively) (Table 2).

In watershed 1, the highest number of households using the interventions and the highest quantity of fuel-wood replaced was found to be in Muregar village (100% and 0.7 t/year/person, respectively), followed by Kadabala (94.7% 0.6 /year/person, respectively) and Vanalli (82.4% and 0.4 /year/person, respectively). In watershed 2, it was more in Kerekoppa (100% and 1.5 t/year/person, respectively), followed by Narebail (96% and 0.3 t/year/person, respectively) and Sugavi (76.2% and 0.3/year/person, respectively) (Table 2).

The further scope of fuel-wood replacement with 100% adaptation of interventions in the villages was found to be highest in Devnalli, followed by Kadabala and Jaddigadde (12467.1, 368.6 and 319.9 t/year) in watershed 1. It was highest in Kerekoppa, followed by Sugavi and Kabbe (821.6, 306.4 and 146.4 t/year, respectively) (Table 2).

The result indicates that more number of households use LPG (65.1%), gobargas (28.5%), Kerosene stove (10%) and electric stove (16%) in watershed 1 than watershed 2 (63%, 20.1%, 6.9%, 3.1% and 1% respectively). Improved chulas and solar heaters were used in more number of households of watershed 2 (9.5% and 1%, respectively) than watershed 1 (4.5% and 0%, respectively). LPG was found to be used in all the villages *i.e.* 10 out of 10 villages, gobar gas in 8, Improved chula in 7, electric stove and Kerosene stoves in 5 villages and solar heaters in only 1 village (Table 3).

The results also indicated that the quantity of fuel-wood reduced was more by LPG, gobargas, electric stove, Improved chula and solar heater in watershed 2 (4.8, 1.7, 4, 3.2 and 0.1 q/year/person, respectively) than in watershed 1 (2.7, 0.9, 0.3, 1.5 and 0 q/year/person, respectively) (Table 4).

The result also indicates that potential of LPG to replace fuel-woodwas higher, followed by electric stove and gobar gas. Kerosene stove has least potential. Improved chula, though having less potential compared to LPG, electric stove and gobar gas, it was highly preferred intervention by the villagers as it was user friendly and requires low installation cost (Table 3 and 4).

The statistical analysis carried out for the quantity of fuel-wood (quintals/year/person) replaced by various interventions in the villages of the selected watersheds states that there was no significant difference found between two selected watersheds, between the interventions and between the interactions of watersheds and various interventions (Table 5).

4. Discussion

In small sized families, the energy utilization from fuel-wood was found higher in plain region followed by and Ghat region. This was due to easy availability of fuel-wood in plain region and the higher biogas production in Ghat and coastal regions. In large sized families, as their economic conditions are good they met their energy requirement up to greater extent from biogas in all the regions as compared to fuel-wood. In Plain region more quantity of dry wood is available due to presence of deciduous forest in plain region, hence the fuel-wood availability was also higher here as compare to evergreen and semi evergreen forests of Ghat and coastal region [2].

Wealthier households are found to be using cleaner energy sources, whereas poor households primarily use solid fuels such as fuel-wood, dung cake, *etc*[3]. Heating water involves large amount of energy and quantity of fuel and it is for prolonged period (Ranges from 2 to 13 hours). It is found that very less intervention adaptation undertaken by the households to replace wood used for heating water. This is mainly because of high investment and management costs of water heating devices like solar heaters, Electric water heaters, *etc.*

The results indicate that, among the two selected watersheds, the households of watershed 2 use more intervention than watershed 1 (82.28% and 75.8% respectively). The average quantity of reduction of fuel-wood is also more in watershed 2 than watershed 1 (0.5 and 0.4 t/year/person, respectively).

LPG was found to be used in all the villages *i.e.* 10 out of 10 villages, gobar gas in 8, Improved chula in 7, electric stove and Kerosene stoves in 5 villages and solar heaters in only 1 village (Table 24). The reason for this was, LPG was supplied by the village panchayat and VFCs in one or two villages and gobar gas used by family choice may be due to availability of cow dung. Kerosene stove use in villages is related to the availability of kerosene in subsidy to families by the government. Use of electric stove and solar water heaters in the families was found to be dependent on the economic status.

The result also indicates that potential of LPG to replace fuel-wood is higher, followed by electric stove and gobar gas. Kerosene stove has least potential. Some households of Bidralli village prefer and use gobar gas for cooking since many years and it is reducing the fuel-wood considerably. For gobar gas installation, there is a need of cow dung availability for which cattle population should be sufficient in the village and simultaneously fodder availability.

Least potential is of Kerosene stove and thus it is insufficient and also it release pollutants. Though as a device, electric stove and gobar gas have equal efficiency as LPG, due to their high cost of installation, unavailability or inconvenience in the use by households, it is not that preferable.

Improved chula, though having less potential compared to LPG, electric stove and gobar gas, it is highly preferred intervention by the villagers as it is user friendly and requires low installation cost. Improved chula is the being used in households even with low financial level, as it is cheap and can be easily installed. It is also very comfortable to use for those families who is using traditional chula since many years. Improved chula is capable of reducing the fuel-wood 50 per cent and more compared to traditional chula. Improved chula though having less potential compared to LPG, electric stove, and gobar gas, it is highly preferable as it is user-friendly in nature.

Fuel efficiency studies in Uttar Kannada district reveal that there is scope for saving 27.45 per cent to 42 per cent fuel-wood by switching to improved stoves. The availability of bioresources in the hilly region is the main reason for less consumption of kerosene for cooking compared to the coastal region. Higher income groups are also dependent on fuel-wood significantly. In rural areas, scarce income combined with freely available biomass fuels lead people to continue to depend on biomass fuel. When fire-wood is scarce, residents depend on crop residues and dung. Poor distribution of fuels, such as kerosene in rural areas and LPG in towns, is an important factor in switching to modern fuel[8].

Alternative sources of domestic energy like animal dung, crop residues, wood from farms, biogas, kerosene and the use of improved stoves, *etc.* do not cause forest degradation and reduce pressure on the protected areas[3].

Biogas is mainly used for cooking in Uttar Kannada. Biogas produced in the district can meet 50 per cent of the total gas demand. About 40 per cent of the villages of Uttar Kannada have adequate biogas production potential to meet the domestic cooking and heating needs (Ramachandra *et al.*, 2014).

5. Future Scope of work

a) Improvements

- Detailed usage of interventions needs to be studied to work out the reduction of pressure for fuel-wood on forest
- Based on calorific value of different species consumption and supply relationship needs to be studied in detail
- Long-term studies on delayed impacts of fuel-wood harvesting
- In farmlands and wastelands, energy plantions can be raised to meet the fuelwoood requirement and reduce the pressure on natural forest

- Allotment of one or two rows of VFC owned *Acacia* plantation per family and permitting in lopping of branches in certain intervals to meet the fuel-wood requirement of the household and thus reduce the pressure on natural forest

b) Limitation

- Quantification use of interventions and their efficiencies is difficult
- Interventions are not efficiently being used throughout the year in the households which may lead to the biasing of the data
- Since fuel-wood availability is free of cost, people are not efficiently using the interventions even if owned

c) Benefits

- Use of more interventions to reduce pressure on forest
- Only dead and fallen wood must be allowed to use for fuel-wood purpose to avoid ecological imbalance
- Alternate sources of wood other than from forest need to be adopted for fuel-wood consumption like agriculture residue, plantations, *etc.*
- By use of interventions biodiversity conservation of tree species
- Under climate change scenario, the interventions would be inevitable to reduce global warming

6. Conclusion

The study conducted to assess the effect of various interventions in reducing the fuel-wood from forest resulted that the households of watershed 2 use more intervention than watershed 1 (82.28% and 75.8% respectively). The average quantity of reduction of fuel-wood is 0.4 t/year/person watershed 1 and 0.5 t/year/person in watershed 2. The total fuel-wood replacement in the villages of watershed by interventions is 274.2 t/year in watershed 1 and 1,291.9 t/year in watershed 2. The scope for reduction with 100% intervention adaptation in villages of watershed 1was 2,703 t/year respectively and 306.6 t/year in watershed 2. The more number of households use LPG (65.1%), gobargas (28.5%), Kerosene stove (10%) and electric stove (16%) in watershed 1 than watershed 2 (63%, 20.1%, 6.9%, 3.1% and 1% respectively). Improved chulas and solar heaters were used in more number of households of watershed 2 (9.5% and 1% respectively) than watershed 1 (4.5% and 0% respectively). LPG was found to be used in all the villages. gobar gas in 8, Improved chula in 7, electric stove and Kerosene stoves in 5 villages and solar heaters in only 1 village. The quantity of fuel-wood reduced was more by LPG, gobargas, electric stove, Improved chula and solar heater in watershed 2 (4.8, 1.7, 4, 3.2 and 0.1 q/year/person respectively) than in watershed 1 (2.7, 0.9, 0.3 and 1.5 q/year/person respectively).

The use of efficient source of energy (Biogas, solar heaters, LPG, *etc.*) reduces the use of fuel-wood from forest. From the study, a recommendation could be introduction of interventions like solar, biogas and LPG in the villages at subsidy rates by government to replace fuel-wood to 100 per cent. These interventions not only reduces the quantity of fuel-wood, but also saves the time and energy invested in the collection process. They also improve the quality of living, conserve forest and thus lead to sustainable economic and social development.

Table 2: Use of interventions in the villages and reduction of fuel-wood by them

Watershed	*Villages*	*% of House-holds using interve-ntions*	*Avg. Per capita fuel-wood redu-ced (t)*	*Population*	*Avg. fuel-wood reduced (t)*	*Scope for fuel-wood reduction with 100% intervention (t)*
Watershed 1	Devnalli	45.0	0.2	28051	5610.2	12467.1
	Jaddigadde	57.1	0.3	544	182.8	319.9
	Kadabala	94.7	0.6	598	349.2	368.6
	Muregar	100.0	0.7	183	119.9	119.9
	Vanalli	82.4	0.4	474	197.2	239.4
	Average	**75.8**	**0.4**	**5970**	**1291.9**	**2703.0**
Watershed 2	Bidralli	70.0	0.3	314	90.5	129.2
	Kabbe	69.2	0.2	532	101.4	146.4
	Kerekoppa	100.0	1.5	557	821.6	821.6
	Sugavi	76.2	0.3	936	233.5	306.4
	Narebail	96.0	0.3	455	124.0	129.1
	Average	**82.28**	**0.5**	**558.8**	**274.2**	**306.6**

Table 3: Use of various interventions in the households of the villages

Watershed	Villages	Households using various interventions (%)					
		LPG	Gobar gas	Kerosene stove	Electric stove	Improved chulah	Solar
Watershed 1	Devnalli	35.0	25.0	0.0	0.0	10.0	0.0
	Jaddigadde	57.1	14.3	0.0	14.3	7.1	0.0
	Kadabala	68.4	47.4	0.5	0.0	5.3	e0.0
	Muregar	100.0	50.0	20.0	60.0	0.0	0.0
	Vanalli	64.7	5.9	29.4	5.9	0.0	0.0
	Average	65.1	28.5	10.0	16.0	4.5	0.0
Watershed 2	Bidralli	10.0	60.0	0.0	0.0	10.0	0.0
	Kabbe	61.5	0.0	15.4	7.7	7.7	0.0
	Kerekoppa	100.0	30.8	0.0	7.7	15.4	0.0

	Narebail	96.0	0.0	0.0	0.0	0.0	d0.0
	Sugavi	47.6	9.5	19.0	0.0	14.3	4.8
	Average	63.0	20.1	6.9	3.1	9.5	1.0

Table 4: Per capita reduction of fuel-wood by the various interventions

Watershed	*Villages*	*Reduction of fuel-wood by the various interventions (q/year/person)*					
		LPG	*Gobar gas*	*Kerosene stove*	*Electric stove*	*Improved chula*	*Solar*
Watershed 1	Devnalli	1.5	0.4	0.0	0.0	0.2	0.0
	Jaddigadde	2.5	0.5	0.0	0.2	**7.1**	0.0
	Kadabala	2.0	1.7	0.0	0.0	0.0	0.0
	Muregar	3.9	1.6	0.1	1.1	0.0	0.0
	Vanalli	3.6	0.1	0.4	0.1	0.0	0.0
	Average	**2.7**	**0.9**	**0.1**	**0.3**	**1.5**	**0.0**
Watershed 2	Bidralli	3.0	3.3	0.0	0.0	3.0	0.0
	Kabbe	2.9	0.0	0.1	0.0	1.5	0.0
	Kerekoppa	10.9	4.2	0.0	20.0	9.0	0.0
	Narebail	2.7	0.0	0.0	0.0	0.0	0.0
	Sugavi	4.3	1.1	0.1	0.0	2.3	0.4
	Average	**4.8**	**1.7**	**0.0**	**4.0**	**3.2**	**0.1**

Table 5: Per capita reduction of fuel-wood by the various interventions

Per capita reduction of fuel-wood by the various interventions (q/year)	
Factors	*Quintals/year*
Watershed (5B1A5): W_1	1.29
Watershed (4D4F5): W_2	1.99
C.D. at 5 %	NS
Intervention: LPG (i_1)	2.82
Gobar gas (i_2)	2.48
Electric stove (i_3)	0.07
Improved chulah (i_5)	2.13
Solar heater (i_6)	2.32
C.D. at 5 %	NS
W_1i_1	0.04
W_1i_2	3.24
W_1i_3	0.10
W_1i_4	0.26
W_1i_5	1.47
W_1i_6	0.00
W_2i_1	2.96
W_2i_2	1.72
W_2i_3	0.04
W_2i_4	4.00
W_2i_5	3.17
W_2i_6	0.08
C.D. at 5 %	NS

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