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Identification of key biophysical determinants influencing fuelwood consumption in rural households of North-Western Himalayas

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ABSTRACT

The present investigation was carried out during the year 2019-2021 to investigate the impact of biophysical characteristics on fuelwood consumption among the local people in Ganderbal district of Kashmir Himalayas, India. The sample of study area was drawn by multi-stage random sampling technique. The data were collected through personal interviews of respondents using well-structured pre-tested interview schedule and non-participant observations. The effect of altitude, distance of House from district headquarter, distance of house from nearest metalled road and distance of house from nearest state forest was studied on domestic fuelwood consumption in the study area. The study revealed that out of the all the biophysical variables of the households three variables namely, altitude, distance of house from district headquarter and distance of house from nearest state forest had important contribution in influencing the fuelwood consumption. The value (0.805) of the co-efficient of determination (R^2) indicated that 80.50% of the variations in the volume of fuelwood consumption by the households are jointly explained by the biophysical variables. The F value (145.59, $p<0.05$) indicated that the regression model as a whole is significant in predicting the fuelwood consumption. The regression analysis indicated that the altitude, distances of house from district headquarter and distance of house from nearest state forest was the potential predictors in explaining the variation in the fuelwood consumption. The altitude and distance of house from district headquarter has direct linkage with the quantity of fuelwood consumption whereas, the distance of house from nearest state forest has indirect linkage with fuelwood consumption.

1. Introduction

Forests are vital for existence of mankind on earth. Forests provide us both the tangible and intangible goods and services. Forests provide us direct benefits like timber, fuel wood fodder, NTFP's etc. and indirect benefits like control the water cycle, o_2, Co_2 balance in the atmosphere and temperature Fuelwood is one of the important sources of energy in the developing and under developed countries. Energy generated from fuelwood is the main component of the domestic energy systems of the world, mainly in the developing countries. Fuelwood is the primary energy sources for cooking and heating used by rural households (70%) in developing countries (Bailis and Drigo, 2011). Fuelwood is pre-eminently, a renewable source of energy whose decentralized nature is particularly suited to the scattered nature of rural habitation and usually makes it possible to obtain the fuel at a very low cost. Forests exemplify a vital component of accessible national and regional biomass supply in rural India. Exploitation of forest biomass is a universal way among forest fringe dwellers for fuelwood consumption.

Forests exemplify a vital component of accessible national and regional biomass supply in rural India. Exploitation of forest biomass is a universal way among forest fringe dwellers for fuelwood consumption (Khanduri*et al.,* 2002). Extensive removal of forest biomass is the main

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cause of forest degradation and environmental instability (Chandra *et al.,* 2008). The extreme withdrawal of forest biomass widens the gap between biomass increment and biomass removal resulting in localized scarcities and un-sustainability of forest resources (IPCC, 2003). Due to the easy availability of forest resources and inadequacy of cheap alternative sources of the supply creates a massive pressure on forests for meeting the fuel requirement. The current production of fuelwood from forests, traditional agroforestry, community forestry and homestead forestry in the study area is meagre and cannot combat the fuelwood demand of population in the on-going scenario. As the accessibility of forest biomass is inadequate, forest cover is restricted and forest productivity is declining, forest biomass developments through various intercessions need to be designed to contend with the future pressure and stop the further forest degradation (Alam and Imtiaj, 2019).

India has a total geographical area of 329 million hectares and a population of 1.2 billion-about 80 per cent of which lives in rural areas (Anonymous, 2004). Fuelwood has remained the principal component of rural domestic energy in India (Arnold, 2002). Cooking energy constitutes half of the India's total domestic energy consumption. More than 80 percent of the energy needs of the Indian rural people is still met from non-commercial fuels (fuelwood, animal waste and crop residues) as the majority of the population cannot afford commercial fuels and moreover, their availability is erratic (Pohekar and Kumar, 2005). The average annual household consumption of fuelwood in India is 836kg/year for an average household of 5.5 persons with annual per capita consumption of 152 kg (Jensen, 1995). The annual production of fuelwood from forests and the potential production of fuelwood from trees outside forests (TOF) are estimated to be 1.23 m tones and 19.25 m tones respectively in India. About 23 percent population of the total population using fuelwood in India is obtaining fuelwood from forests. Most of the fuelwood has been reported to be derived from state forests. Because of the increase in population, the area under agriculture has been expanded and forests have shrunk during last two decades (Anonymous, 2010). Inspite of rapid growth in the commercial energy sector, the demand for fuelwood has increased in India due to its easy availability and low cost.

A high dependency of large proportion of human population on forest biomass for running their livelihoods and meeting their household needs of fuelwood demand is age old practice in Kashmir (Baba *et al.,* 2015). The extent and quality of forest cover governs the perennial water supply including ground water recharge and health of soils in Kashmir. In addition, for meeting their fuelwood requirement, people of the Kashmir lean heavily on forests for heating during winter. Therefore, forests are intrinsic to the sustainability of primary sectors like agriculture, horticulture and animal husbandry, particularly in hilly regions. Sheikh Noor- ud-din Wali (1377-1440 CE), the famous sufi saint within this reference has stated, “annposhi teli, yeliwannposhi, i.e., food will last as long as forests last.” The major sources for fuelwood are forests, farm forestry, social forestry, homestead forestry and pastures and the main areas of consumption are cooking, heating, cottage industries, community functions and others in Kashmir (Islam, 2008).

As in other parts of India, fuelwood is a source of domestic energy for majority of households in Jammu and Kashmir. Ganderbal is one of the districts of Kashmir division of Indian union territory of Jammu and Kashmir where people have colossal dependence on fuelwood. Out of various biofuels, fuelwood is considered as major source of domestic energy in the district. A majority (84.18 %) of the population of the district is rural (www.ganderbal.gov.in/district/ganderbalestablish.asp) and depend on fuelwood for domestic consumption for space heating and cooking.

2. Material and methods

The present study was based on the primary survey and data collection through pre-tested questionnaire by approaching the villagers representing different age groups and gender also and also using secondry data sources. The survey has been conducted in 146 households on random basis to obtain the real pattern of information. House to house visit was followed by field survey as well. The study was based on the primary data collected from the respondents on different aspects viz. family size, family type, livestock holding, land holding, land use pattern, cropping pattern and biophysical factors like distance covered by farmers to collect fuelwood, altitude etc.

Study Area Description

The proposed study has been conducted in district Ganderbal of union territory of Jammu and Kashmir, India (Fig.1). The district is situated on the bank of river Sindh at a distance of 20 km from Srinagar. The district is located between 34°23`N latitude and 74$^{\circ}$78`E longitude at an altitude of 1619 metres above mean sea level in the undulated surface of Kashmir valley. The district is predominantly rainfed but some areas of the district are irrigated through Sind irrigation canal network. The climate of the district is temperate which remains hot and dry in summer and cold and snowy in winter. The summer season sets in from April and ends up to June. The rainy season starts from July and continues up to September. The winter season begins from October and continues up to March. The mean minimum and maximum temperatures are 5°C to 20°C respectively with average annual precipitation of 700mm. The district has total geographical area of 39304 ha, out of which area under forest, non-agricultural use, barren and uncultivable land, permanent pastures and other grazing land, cultivable waste land and net area sown are 10949 ha, 5758 ha,3161ha, 1790 ha, 973 ha and 16673 ha, respectively (Anon., 2011b). The total human population of the district is 297446 (158,720 males and 138,726 females, sex ratio of 874 females per 1000 males, mean family size of 6.62, population density of 1148 per km^2 and literacy rate of 59.98%) among which the urban population is 47,039 (15.81%) and the rural population is 250,407 (84.19%) according to census of India, 2011. A majority (84.19%) of the population of the district is rural and is dependent on agriculture for their livelihood. The district consists of six tehsils (Ganderbal, Kangan, Lar, Tullmulla, Wakura and Gund) and seven blocks (Ganderbal, Gund, Lar, Kangan, Wakoora, Safapora and Sherpathri) with 146 villages and 44831 households (www.ganderbal.gov.in/ganderbalestablish.asp).

Design of Research

The already existing independent variables (socio- economic and biophysical characteristics), dependent variables (extraction and domestic consumption of fuelwood) and regression between these variables were identified and analyzed using Ex-Post-Facto Research Design.

Sampling Procedure

A multi-stage, random sampling design was adapted to select the villages and respondents for the household survey. In the first stage, two sample blocks out of the total of seven blocks of the Ganderbal district were selected purposively The sample blocks selected were Ganderbal and Gund. In block Ganderbal there were 51 villages and in Gund block there were 41 villages. In the second stage, a complete list of villages was prepared in both the respective blocks in consultation with tehsil and block officials. The total number of eight sample villages was selected from sample blocks using simple random sampling with 15 percent sampling intensity. The sample villages selected were Babosipora, Sadrabagh, Hardomardabagh, Babadariyadin, Chappergund and Gotlibagh from Ganderbal block; Sonamarg and Nilgrar. From Gund block. In the selected villages, a complete list of households was prepared in consultation with panchayat secretaries and village elders. In the third stage, selection of sample households having sample size of 20 percent of the total number of households in each selected village using proportionate allocation and simple random sampling with replacement method. The final sample size has been 146 households.

Data Collection

The present research includes both qualitative and quantitative methods for achieving the study objectives (Ray and Mondol, 2004). The collection of data has been done by using both primary field survey and secondary sources.

Primary Data

Primary sources include structured interviews with selected respondents and non-participant observations (Mukherjee, 1993). The collection of primary data has been done at individual/household and village level whereas the collection of secondary data has been done for block, village and household/individual level.

Secondary Data

Secondary sources include data from various journals, research reports, forest department records, village records, internet, previous researches, annual reports and other related documents of different governmental and non-governmental agencies.

Structured Interview

Primary data have been collected through personal interviews of respondents (household heads or eldest members) by using well-structured pre-tested interview schedule. Before the data collection, the interview schedule has been pre-tested at both the village and household level and modifications were made accordingly. The interview questionnaire so prepared have been employed to collect

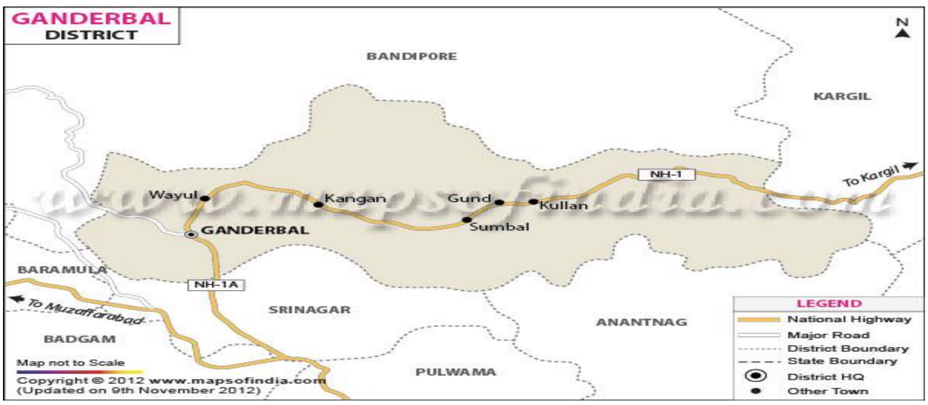

Figure 1. Location map of study area

information on demographic features, income, nature and size of landholding, land utilization pattern, inventory, yield of various crops and orchards, domestic fuelwood requirement and its sources, use of alternate fuels and preference of tree species for fuelwood.

Non-participant Observation

On the basis of personal observation and interaction with the respondents, the qualitative analysis has been done. This technique helped to have first hand on-the-scenes contact with the respondents, examine the behavior in natural situation and study the situation based features of conduct.

Variables and Their Measurement

In order to examine the consumption of domestic fuelwood, biophysical variables were selected after a comprehensive inspection of available admissible literatures, reconnaissance survey of the study area, thorough conversations with local household owners, forest officials, extension scientists and other experts and also valuable information collected by various organizations. The variables were measured by asking particular questions using the several scales or tests adopted previously by the social scientists with little modification (Singha*et al.,* 2006).

Consumption of Domestic Fuelwood

The fuelwood consumption has been taken to the annual quantity of fuelwood used by the households for cooking and heating. The weekly head loads used by each selected household have been ascertained through the interview schedule by asking the head of the respective household. The average quantities of fuelwood per head load per household have been ascertained by weighing five head loads in each selected village and taking their average. The summer and winter fuelwood consumption estimates have been made by assuming the summer and winter seasons of 32 and 20 weeks respectively. The weekly fuelwood consumption of the households in summer has been obtained by multiplying the number of head loads consumed per week with the average weight of head load in the respective village. The similar procedure has been followed to estimate weekly consumption of fuelwood by the household in the winter month. The weekly summer consumption of each household has been multiplied by 32 to obtain total fuelwood consumption of the household in the summer season. Similarly the weekly winter consumption of each household has been multiplied by 20 to obtain the total fuelwood consumption of the household in the winter season. The fuelwood used in the summer and winter months have been added to estimate the total annual fuelwood consumption of the households.

Data Analysis

The detected data have been interpreted on MS Excel and Statistical Package for Social Sciences (SPSS) software for consequential interpretation using following descriptive and analytical statistical devices as per Snedecor and Cochran (1967).

Frequency (f)

The frequency (f) is utilized to designate the number of times a response or character occurs in a class or category.

Percentage (%)

Percentages (%) are utilized in data demonstration to simplify and diminish the numbers in the standard form with base equal to 100.

The Univariate Procedure for Analysis of Normality of Fuelwood Consumption

The household level fuelwood consumption has been tested using the univariate test of normality through SAS-9.2 software. The normality of annual household level fuelwood consumption was also tested by drawing its histogram. To test the association between each of independent variables with fuelwood consumption the hypotheses tested were:

H_0 = There is no association between each independent variable with domestic fuelwood consumption of the households.

H_1 = There is a significant association between each independent variable with domestic fuelwood consumption of the households.

The significance of association has been tested at 0.05 levels.

Ordinary Least Squares Regression (OLS) Analysis/ Multiple Linear Regression Analysis

Regression analysis is an important multivariate statistical tool for predicting the dependent variable on the basis of the independent variables. The OLS regression analysis was applied for estimating the coefficients of linear regression equation which describe the relationship between independent variables and a dependent variable. The OLS regression statistics was utilized to find out the impact of alternate fuels and effect of socio-economic and biophysical characteristics on extraction and consumption of fuelwood in the study area.

The basic prediction equation was:

$$Y = ß_o + \sum_{i=1}^{n} ß_i X_i + E_n$$

Where, Y = Dependent variable

$ß_0$ = Constant or intercept

$X_1 – X_i$ = Value of independent variables

$ß_1$-$ß_i$ = Regression coefficients
n = Number of independent variables
E_n = Error term

3. Results and discussion

Biophysical Characteristics Influencing the Fuelwood Consumption

Most of the households was located at >2000m elevation with the average elevation of 2164.38m in the study area (Table 1). This might be due to the elevation of district that is 1650-3000mamsl. Majority of the households was 6-12km away from the district with the average distance of 29.06km in the sample villages (Table 1). The average distance of households from the nearest metalled road was 1.73km in the sample households (Table 2). The average distance of households from the nearest forest was 3.95km in the study area (Table 2). Similar findings were reported by Bijalwan*et al.* (2011) and Mushtaq*et al.* (2014).

Regression analysis of key biophysical determinants with fuelwood consumption

A perusal of data in Table 3 envisaged that the value of coefficient of determination (R^2) was recorded to be 0.805 which manifests that 80.5% of the total deviation in fuelwood consumption is being illustrated by these biophysical variables. Further, the interpretation of 't' values of regression coefficient demonstrate that out of the four independent variables of the respondents, altitude, distance of house from nearest state forest and distance of house from district headquarter had significant contribution in influencing the fuelwood consumption. The findings are in consistent with the reports of Silori (2004) who stated that the per capita daily and seasonal consumption of fuelwood was declined with declining altitude. Higher altitudes are characterised by longer winters, low temperatures resulting in high fuelwood consumption. The results are also in concurrence with the studies of Sanjay and Gupta (2005) who

Table 1. Altitude and distance of house from district headquarters in the sample villages (N=146)

S.No.	Altitude		Distance of house from district headquarters	
	Category	Households	Category	Households
1.	<1900 m	48 (32.87)	<6 km	26 (17.80)
2.	1900-2000 m	44 (30.13)	6-12 km	66 (45.20)
3.	>2000 m	54 (36.98)	>12 Km	54 (36.98)
	$\overline{X}$±S.E = 2164.38 ± 39.30		$\overline{X}$±S.E = 29.06 ± 2.22	

$\overline{X}$= Average, S.E. = Standard error, Figures in parentheses show percentage

Table 2. Distance of house from nearest metalled road and from nearest state forest in the sample villages (N=146)

S.No	Distance of house from nearest metalled road		Distance of house from nearest state forest	
	Category	Households	Category	Households
1.	<1 Km	54 (36.98)	<5 Km	98 (67.12)
2.	1-2 Km	48 (32.87)	5-10 Km	22 (15.06)
3.	>2 Km	44 (30.13)	>10 Km	26 (17.80)
	$\overline{X}$±S.E = 1.73 ± 0.12		$\overline{X}$±S.E = 3.95 ± 0.42	

$\overline{X}$=Average, S.E= Standard error, Figures in parentheses show percentage

Table 3. Regression analysis of biophysical characteristics with the domestic fuelwood consumption (N=146)

S.No	Household variables (code)	Coefficients (ß)	S.E.	t value	Sig	95% Confidence Interval for ß		Collinearity Statistics	
						Lower Bound	Upper Bound	Tolerance	VIF
1.	Altitude (X_1)	5.31	2.37	2.24*	0.002	-1.374	31.211	0.392	2.55
2.	Distance of house from nearest metalled road (X_2)	0.223	0.254	0.87	0.380	-0.278	0.726	0.11	8.48
3.	Distance of house from nearest state forest (X_3)	-0.1265	0.0424	2.98*	0.003	-0.380	0.126	0.36	2.74
4.	Distance of house from district headquarter (X_4)	0.198	0.056	3.53*	0.001	0.086	0.309	0.69	1.43

*=Significant at 5% level of probability

$ß_0$= 9.662 F= 145.59* R^2 = 0.805 Multiple R=0.897 Adjusted R^2=0.800

stated that the fuelwood consumption increased with increase in distance of house from the district headquarter. The regression equation fitted for the given set of data should be written as:

$Y = 9.662 + 5.31X_1 + 0.223X_2 – 0.1265X_3 + 0.198X_4$

4. Conclusion

The value (0.805) of co-efficient of determination (R^2) implies that 80.50% variation in fuelwood consumption is jointly explained by all the selected biophysical characteristics. The F value (145.59) demonstrated that all four biophysical traits had made a sizable difference in the fuelwood consumption deviation. The 't' values of the regression coefficients showed that, of the four biophysical variables, altitude, the distance from the nearest state forest, and the distance from the district headquarters all significantly influenced the amount of fuelwood consumed. The proximity of a home to the nearest state forest revealed a negative, significant correlation with fuelwood use among the biophysical characteristics of the population. Fuelwood use was found to have a positively significant association with altitude and distance from the district headquarters. While there is no correlation between the amount of fuelwood consumed and the distance of the house from the nearest metalled.

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