Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2019, Volume 32, Issue 2, Page 322-328

What influences farmers' choice of source of fuelwood collection from privately owned agroforestry systems vis-a-vis state owned forests: A study from Western Himalaya

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ARTICLE INFO

Article history:
Received 9 April 2019
Revision Received 21 August 2019
Accepted 13 September 2019

Key words:
agroforestry, state forests, regression models, social, economic, biophysical

ABSTRACT

Current study was carried out in district Samba of Western Himalayan province of Jammu and Kashmir of India. The data on various aspects of households (alternate fuel use, socio-economic, and biophysical) were collected in an interview schedule in personal interview with 180 household heads. In this way data on 26 factors related to households was collected. The primary choice of farmers for fuelwood collection was categorised into two categories: state owned forests and privately owned agroforestry systems. Logistic regression models of alternate fuel use, social, economic and biophysical factors were developed to identify key variables influencing the choice of the source of fuelwood collection. A composite model was also developed to identify key factors when all variables in all the pre-said categories were considered simultaneously. Out of five models (alternate fuel use, social, economic, biophysical and composite) only four (social, economic, biophysical and composite) were valid. The composite and biophysical models were similar and had the highest accuracy. The composite model implies that the physical factors primarily dominated the choice of primary source of fuelwood when all the factors were considered simultaneously. The study implies that increasing farmers' agriculture production would encourage to collect fuelwood from their own private farm rather than collecting the same from the state forests and consequently would reduce the pressure on state forests.

1. Introduction

There are many tangible and intangible benefits of the forests to human kind. Energy generated from fuelwood is the main component of the domestic rural energy systems in the developing countries as about 70 per cent of energy for domestic cooking and space heating is derived from fuelwood in these countries (FAO, 2010). Almost until 1980 a major portion of fuelwood was collected from the state forests either through existence of rights of the people on forests or illegally (Sood, 2003). The declining forests result in serious repercussions like the rural people have to devote an increasing proportion of limited time and money for obtaining the supply of fuelwood they need and switching to alternate non-commercial and commercial fuels (Sood, 2003). Further, switching from fuelwood to commercial fuels does not follow a linear displacement energy models (Barnes and Floor, 1996) but follows a stack model (Masera *et al.,* 2000). Besides, non-commercial fuels (animal waste and crop residues) are also used by the rural people owing to their socio-cultural affinity to these fuels, unavailability of fuelwood and erratic availability and higher cost of commercial fuels (Sood and Mitchell, 2011). Another strategy to reduce the pressure on declining availability of fuelwood from state forests is to collect from trees grown on private land.

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The quantities of domestic fuelwood used has been estimated in different regions and countries of the world like Asia (FAO, 1997), Bangladesh (Sarkar and Islam, 1998), India (Bhagwan *et al.,* 1995; Reddy and Chakravarty, 1999), Indian Himalayas (Gajendra *et al.,* 2009; Rawat *et al.,* 2009) and Kenya (Wamukonya, 1995). There are also some studies on factor influencing domestic fuelwood consumption (Tahir *et al.,* 2014) but comprehensive study to identify the key factors diverting the choice of fuelwood collection from state forests to privately owned own lands of the farmers, are still meagre. Keeping this in view, the present study was carried out to study the factors influencing farmers' choice of fuelwood collection from private land versus state forests. The current study was carried out in Samba district of Jammu and Kashmir province located in Western Indian Himalaya. 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 (FSI, 2004). About 80 per cent 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 836 kg/year for an average household of 5.5 persons. Samba is one of the districts of Western Indian Himalaya, where (97.0) per cent are dependent on fuelwood for domestic use (Tahir, 2013).

2. Material and Methods

The growing of trees on private land of farmers in various niches has been taken to mean agroforestry in the current study. Collection of fuelwood from agroforestry has been taken to mean collection of fuelwood by the household from trees growing on its privately owned land only. These privately owned lands are located nearer to the respective houses of the farmers than the state forests. The details of study area, sampling procedure, data collection, statistical and logistic regression analysis have been given below: Current investigation was carried in Samba district of Jammu and Kashmir province of India. The district is located at 32^{o} 33' N latitude and 75^{o} 7' E longitude. There are 382 villages in the district. The climate of the district is subtropical which remains hot and dry in summer and cold 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 begin from October and continues up to March. The average daily temperature in the study area ranges from 6-47^{0}C. The average annual rainfall in the district is 900mm. The total human population of the district is 2.87 lakh, which accounts for 2.75 per cent population of the province (www.samba.gov.in/ district /samba establish. asp). A majority (78.68 per cent) of the population of the district is rural and is dependent on agriculture for their livelihood. The district Samba consists of four developmental blocks, namely Vijaypur, Pumandal, Samba and Gaghwal.

A multi-stage, random sampling design was adopted to select the households. In the first stage, two blocks of the district were selected purposively to represent irrigated and rainfed locations, respectively. In the second stage, a complete list of villages was prepared in both the respective blocks with the help of government officials at block level. Six villages were selected using simple random sampling without replacement in each selected block. A complete list of households in the selected villages was prepared in consultation with key informants. The households in each selected village were selected using proportionate allocation and simple random sampling with replacement method. The final sample size comprised of 180 households. However, 49.4% of the total households collected fuelwood from state forests whereas 35.0% use their own agroforestry farm as source of fuelwood. The remaining 12.8% purchased the fuelwood and 2.8% did not collect any fuelwood at all. Overall of 180 households, only 152 collected fuelwood to various extent. The data were collected on a well-designed semi-structured interview schedule in personal interview with each of selected head of the household. Before the data collection the interview schedule was pre-tested in Khara Madana village located in the study area and a few modifications were made. The schedule contained information on alternate fuel use, social, economic and biophysical aspects of household and primary source of fuelwood collection of fuelwood.

For the current study the factors affecting choice of source of fuelwood collection (state forest *versus* own agroforestry system) were categorised into four categories: alternate domestic fuel use, social, economic and biophysical. Regression analysis is an important multivariate statistical tool for predicting the dependent variable on the basis of the independent variables, however, it cannot be applied when the response variable is binary. The assumptions of a linear regression model (linearity and normal distribution of residuals) are violated in such cases. A logistic regression provides a statistical approach for such an investigation (Tabachnick and Fidel 1996). Hence, the binary logistic regression analysis was used to identify key variables influencing the choice of the source of fuelwood collection (own private agroforestry systems *versus* state forests) which was a binary choice. The forward likelihood criterion was followed to select best predicting variables as the main aim was to select the best group of predictors. Forward selection starts with no variables in the model. At each step the predictor which contributes most to prediction is added.

3. Results

The details of variables, their abbreviations, codes/units and statistics are given in Table 1.

Table 1. Variables, their abbreviations, coding and statistics

S. No.	Variables (Abbreviations)	Code/Units	Range/Percentage
Primary Source of Fuelwood			
Primary Source of Fuelwood (PS)		State forests=0 Agroforestry system =1	State forest=58.5%* Agroforestry system =41.5%
Alternate Fuel Use			
1	Liquified petroleum gas (LPG)	kg/year	0-340.8
2	Cow dung cake (CD)	kg/year	0-1200
3	Agricultural residues (AR)	kg/year	0-1200
Social Factors			
4	Religion (REL) Hindu (H), Muslim (M) and Sikh (S)	Hindu=0, Muslim=1, Sikh=2	Hindu=68.0%, Muslim=5.15%, Sikh=26.85%
5	Caste (CASTE)	Upper caste=0, Lower caste=1	Upper caste=78.85%, Lower caste=21.15%
6	Occupation (OCCU)	Farming=0, Non-farming=1	Farming=49.15%, Non-farming=50.85%
7	Education level of head(ELHH)	Years	0-17
8	Household size (HS)	Numbers	3-15
9	Number of female members in the household (NFMH)	Numbers	1-6
10	Mobility index of household head (MI)	Number of trips/year	0-30
11	Annual food consumption (FCON)	kg/year	480-2160
12	Age of head of household (AGHH)	Years	26-90
13	Number of adult men in the household (NAM)	Numbers	1-6
14	Number of children (<18 years age) in the household (NCHD)	Numbers	0-7
Economic factors			
15	Size of land holding (LHD)	Hectare	0.05-12
16	Agricultural production (AP)	kg/year	0-16700
17	No. of family members having regular employment (NFMRE)	Numbers	0-4
18	No. of unemployed adult persons in the household (NUAP)	Numbers	0-4
19	On-farm income (ONFINC)	Rs/year	0-166000
20	Off-farm income (OFFINC)	Rs/year	0-852000
21	Total income (TINC)	Rs/year	8000-917000
22	Livestock holding (NAUH)	ACU	0-15.45
Biophysical Factors			
23	Distance of house from nearest metalled road (DHFNMR)	km	0.1-3
23	Distance of house from nearest state forest (DFNSF)	km	0.03-35
24	Distance of house from district headquarter (DFDH)	km	10-42
25	Altitude (ALT)	m	352-580

*% of those collected fuelwood

In the current study 58.5% of fuelwood collectors collected it from state forests where as 41.5% collected from own private land (Table 1).

Model of alternate fuel use: In this model the iteration terminated at second step (Table 2).

Step	Variable in:	Coefficient(β)	Exp β	df	p-value	Step Chi-square	Standardized coefficients
1	LPG	0.041	1.042	1	<0.0001	99.227	1.411
2	AR	0.004	1.004	1	0.075	3.167	0.038
	Constant	-5.558	0.004	1	<0.0001	-	-0.090

Table 2. Variables in the alternate fuel use model

For the entry of the predictors in the model the default value of 0.05 significance level was adopted.

Model specification

Logit is defined as natural log of odds and the model can be specified as:

Odds = P/1-P Logit = Ln (P/1-P) = $\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\text{------}+\beta_kX_k$ --------------------------- (1)

where, P is probability of outcome (probability of collecting fuelwood from own agroforestry system) 1-P = probability of outcome (probability of collecting fuelwood from state forests)

β_0 is the intercept term

β_1, β_2, β_3 and β_k are the coefficients associated with independent variables

X_1, X_2, X_3 and X_k are the predictors in the equation

The logistic regression analysis was carried out using binary logistic regression technique in SPSS 16.0 software. The importance of various factors (predictors) in the model was judged on the basis of standardised regression coefficients. For the validation of the model, model Chi-square, Hosmer and Lameshow goodness of fit and cases correctly classified were taken into account. The Nagelkerke's R^2 was used as measure of determination of variation caused by predictors.

The significance of model Chi-square indicates that all independent variables in model jointly cause significant variation in dependent variable. Non-significance of Hosmer and Lameshow goodness fit confirms that there is no significant difference between observed and predicted frequencies of respective categories of dependent variable (private agroforestry system *versus* state forest). The model was also significant in predicting the choice of primary source of fuelwood (Model Chi-square = 102.395, p<0.0001; Table 3). Not with standing this the model did not provide a good fit as Hosmer and Lameshow Chi-square value was significant (Table 3). Hence, model cannot be used in predicting the choice of primary source of fuelwood.

Table 3. Model summary

Item	Value	Df	p- value
Model Chi-square	102.395	2	<0.0001
Nagelkerke R^2	0.649		
Hosmer and Lameshow Chi-square	24.884	8	<0.001
N = 152			

The model was also significant in predicting the choice of the primary source of fuelwood (Model Chi-square = 77.338, p< 0.0001; Table 5). The model provided a good fit as Hosmer and Lameshow Chi-square was non-significant (Table 5).

Out of eleven variables tested for the model, only one appeared in the model. Religion was the only important social factor which influenced the choice of primary source of fuelwood (Table 4). The odds of fuelwood collection from own agroforestry system decreased by .0001 and 0.0002 for Hindu and Muslim households compared to Sikh households. This implies that both Hindu and Muslim households had lower choice of own agroforestry system as primary source of fuelwood than that of Sikh households (Table 4). The model predicted 80.3 per cent of the cases correctly (Table 6).

***Social model*:** The iteration terminated at second step (Table 4).

Table 4. Variables in the social model

Step	Variable in:	Coefficient(β)	Exp β	df	p-value	Step Chi-square	Standardized coefficients
1	REL(H)	-22.184	0.0001	1	< 0.0001	42.324	-2.823
	REL(M)	-42.406	0.0002	1	<0.0001	77.338	-4.382
	Constant	21.203	5.564	1	<0.0001	-	2.303

Table 5. Model summary

Item	Value	df	p- value
Model Chi-square	77.338	2	<0.0001
Nagelkerke R^2	0.537	-	-
Hosmer and Lameshow Chi-square	0.0001	1	<1.00
N = 152			

Table 6. Classification table for social model

Primary source	State forest	Agroforestry	Percentage correct
State forest	89 (100.0%)	0 (0.0 %)	100.0
Own farm	30 (47.6 %)	33 (52.4 %)	52.4
Overall percentage			80.3

Economic model: The iteration terminated at step four (Table 7). This model was also significant in depicting the choice of primary source of fuelwood (Model Chi-square = 185.778, p< 0.0001; Table 8).

The model provided a good fit as Hosmer and Lameshow Chi-square was non-significant (Table 8).

Each variable in the model contributed significantly in predicting choice of primary source of fuelwood (Table 8). The model predicted 96.7 per cent of the cases correctly (Table 9). Off-farm income number of adult un-employed members and agricultural production respectively, were the important economic variables, in order of their sequence, which influenced the choice of the primary source of fuelwood (Table 7). With unit increase in quantity of agriculture production, the odds of fuelwood collection from ownland increased by 1.003. The odds of choice of fuelwood collection from ownland decreased by 0.022 with unit increase in number of unemployed members in the household. With unit increase in off-farm income the odds of fuelwood collection from ownland decreased by 0.522 (Table 7).

Biophysical model: The iteration terminated only at single step (Table 10). This model as whole was also significant in predicting the choice of primary source of fuelwood (Model Chi-square = 200.247, p<0.0001; Table 11). The model provided a good fit as Hosmer and Lameshow Chi-square was non-significant (Table 11). A total of four variables were tested, out of which only one appeared in the model. Distance of village from nearest state forest was the only important factor which influenced the choice of primary source of fuelwood (forest v/s own-farm).

Table 7. Variables in the economic model

Step	Variable in:	Coefficient(β)	Exp β	df	p-value	Step Chi-square	Standardized coefficients
1	OFINC	-0.650	0.522	1	<0.0001	49.889	-4.984
3	NAUP	-3.795	0.022	1	<0.0001	42.168	-0.714
4	AP	0.003	1.003	1	<0.0001	74.938	0.278
	Constant	-2.385	0.092	1	<0.155		-0.223

Table 8. Model summary

Item	Value	df	p- value
Model Chi-square	185.778	3	<0.0001
Nagelkerke R^2	0.958	-	-
Hosmer and Lameshow Chi-square	1.221	8	<0.996
N = 152			

Table 9. Classification table for economic model

Primary source	State forest	Agroforestry	Percentage correct
State forest	87 (97.8 %)	2 (2.2 %)	97.8
Own farm	3 (4.9 %)	58 (95.1%)	95.1
Overall percentage			96.7

Table 10. Variables in the biophysical model

Step	Variable in:	Coefficient(β)	Exp β	df	p-value	Step Chi-square	Standardized coefficients
1	DFNSF	2.661	14.305	1	<0.0001	200.877	1.022
	Constant	-21.990	0.0001	1	<0.994		-0.082

Table 11. Model summary

Item	Value	df	p- value
Model Chi-square	200.247	1	<0.0001
Nagelkerke R^2	1.00	-	-
Hosmer and Lameshow Chi-square	0.0001	6	<1.00
N = 152			

It was quite surprising that the model predicted 100.0 per cent of the cases correctly (Table 12). The model implies that the fartherness of household from nearest state forest had positive influence on household choosing own-farm as primary source of fuelwood. The odds of fuelwood collection from ownland increased by 14.305 with unit increase in distance of state forest from the house (Table 11).

Table 12. Classification table for biophysical model

Primary source	State forest	Agroforestry	Percentage correct
State forest	89 (100.0 %)	0 (0.0 %)	100.0
Own farm	0 (0.0 %)	63 (100.0 %)	100.0
Overall percentage			100.0

Composite model**:** The iteration terminated at first step only (Table 13). The composite model was significant in predicting the choice of primary sources (state forest v/s privately owned agroforestry systems) of fuelwood (Model Chi-square = 200.877, p<0.0001; Table 14). The model provided a good fit as Hosmer and Lameshow Chi-square was non-significant (Table 14). A total of twenty-six variables were tested for the model, out of which only one appeared in the model (Table 13).

Distance of village from nearest state forest was the only factor which influenced the choice of fuelwood source. The model predicted 100.0 per cent of the cases correctly (Table 15).

4. Discussion

Out of five models (alternate fuel use, social, economic, biophysical and composite) tested only four models (social, economic, biophysical and composite) were valid in predicting the primary choice (state forest/ privately owned agroforestry systems) of fuelwood. Biophysical and composite models were similar and the most accurate models. Both these models included only one variable (distance of house from the nearest state forest). This implies that biophysical factors dominated the choice of primary source of fuelwood. In composite model, out of twenty six factors only one (distance of house from the nearest state forest) appeared in the model. This implies that the strategies to divert the choice of fuelwood consumption from state forests to privately owned agroforestry systems must take into account distance of house from the nearest state forest. Amongst social factors, the religion was the most important factor in the social model predicting the choice of source of fuelwood collection. Both Muslim and Hindu households were less likely to collect fuelwood from their own agroforestry systems. This could be attributed to larger family size in Muslim and Hindu households leading to availability of more labour to collect fuelwood from the state forests. Therefore, more efforts are required to devise strategies to encourage Muslim and Hindu households to collect fuelwood from ownland agroforestry to reduce deforestation. It is implicit from the present study that this could be achieved by making efforts to increase employment and off-farm income of the households which would increase the opportunity cost (decreasing the availability household labour to collect fuelwood) of collecting the fuelwood as "*giffen good*" from the state forests and hence would increase the chances of collecting it from ownland agroforestry systems. The later source of fuelwood is nearer to houses compared to the state forests.

From the economic model it is evident that higher agricultural production increased the chances of fuelwood collection from ownland agroforestry. This could due to fact the farmers with higher production be busy in production of agriculture commodity and would lack time to collect fuelwood from state forests than to collect from his own agroforestry land, the latter usually located nearer to his house. Moreover, unemployment in households means more time with household to collect fuelwood from forests which is free good than to use his own resources. The study implies that increasing farmers' agriculture production would encourage to collect fuelwood from their own private farm rather than collecting the same from the state forests and hence will reduce the burden on the state forests.

Table 13. Variables in the composite model

Step	Variable in:	Coefficient(β)	Exp β	df	p-value	Step Chi-square	Standardized coefficients
1	DFNSF	2.661	14.305	1	<0.0001	200.877	1.022
	Constant	-21.990	0.0001	1	<0.994		-0.082

Table 14. Model summary

Item	Value	df	p- value
Model Chi-square	200.877	1	<0.0001
Nagelkerke R^2	1.00	-	
Hosmer and Lameshow Chi-square	0.0001	6	<1.00
N = 152			

Table 15. Classification table for composite model

Primary source	State forest	Agroforestry	Percentage correct
State forest	89 (100.0 %)	0 (0.0 %)	100.0
Own farm	0 (0.0 %)	60 (100.0 %)	100.0
Overall percentage			100.0

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