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Original Research Article

The dependency of rural livelihood on forest resources in Northern Pakistan's Chaprote Valley

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ABSTRACT

Overexploitation of forest resources continues to pose a severe threat to the environment in Chaprote Valley, Northern Pakistan. Therefore, this study investigates the main determinants of household dependency on forest resources for livelihoods in Chaprote Valley. We collected data randomly from 193 household heads through semi-structured questionnaires. To investigate the dependence of rural households on forest resources, we employed a Logistic regression model. The findings reveal that household's education level, household size, livestock income and agriculture income significantly affect the dependency of households on forest resources, while other variables seem to be insignificant. The share of forest income to the total household income was 32%, while off-farm income, agriculture income and livestock income were 44%, 13% and 9% respectively. Among all forest products, firewood contributes more to forest income with a share of 47%. Moreover, the study found that an increase in household head's education, livestock income, agriculture income, off-farm income and own landholding will result in reducing forest dependency. The study concludes that alternate sources of energy, modern agricultural methods, access to higher education, and public awareness about biodiversity are essential for creating a balance between forest dependency and biodiversity conservation.

1. Introduction

Rural livelihoods are highly dependent on environmental sources in developing countries. Most notably, the ecological resources such as timber, firewood, food, and medicines play a vital role in the livelihood of rural people (Angelsen et al., 2014; Babulo et al., 2009; Fikir et al., 2016). The households of rural areas not only utilize forest resources to fulfill their subsistence needs but also generate a significant cash income by trading forest products (Mamo et al., 2007). According to an estimation, 20% of the global population is dependent on forest resources to meet their essential livelihood needs (Cheng et al., 2019). This nexus between forest dependency and biodiversity conservation demonstrates a considerable concern for researchers and academicians to understand the factors of household dependence on forest resources for the sustainability of forest resource management and biodiversity conservation.

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A vast body of literature highlighted the significance of the forest resource for the livelihood of rural people across the world, especially developing economies (Babulo et al., 2009; Prado Córdova et al., 2013; Neumann and Hirsch, 2000). The literature has empirically investigated the level of forest dependency from the entire household livelihood paradigm. There is a shared consensus among researchers about the rural livelihoods' reliance on forest resources, but there is a variation on the level of forest dependency for subsistence across different socio-economic groups geographically (Babulo et al., 2008; Bwalya, 2013). For instance, in rural areas of Zimbabwe, 40 percent of the total income is generated from forest resources (Cavendish, 2000). In rural Malawi, 30% of the total income of households is contributed by forest resources (FISHER, 2004). A study conducted by (Mamo et al., 2007) found that the income generated from forest resources makes a significant contribution of 39% to an average income of household income in a district of southwestern Ethiopia named Dendi (Vedeld et al., 2007). estimated the forest income of 17 developing countries with the help of 51 case studies that revealed 22 percent of the average household income was generated through forest resources (Godoy et al., 2002). analyzed the household income of four Amerindian villages that belong to Bolivian lowlands and East Honduras and came up with the estimation that up to 45 percent of the average income was generated from the forest. Forest income contributes 14–20% to the average income of households in the case of South America (Prado Córdova et al., 2013; Uberhuaga et al., 2012) whereas between 30 and 45% of the average income of households in Sub-Saharan Africa and 10–20% of the average income of households in Asia is derived from forest resources in Sub-Saharan African countries (Kalaba et al., 2013; Mamo et al., 2007).

Moreover, forest income makes a contribution of around 10–20% in the average household income in Asia (Ahmed et al., 2016). These research studies validated the substantial impact of forest resources on household income. Some households merely depend on forest resources as a sole subsistence source. In spite, the significant role of forests in livelihoods, human reliance on forest resources is a different facet. Forest resources are a vital source of livelihood, but its significance changes all over the world in different periods and across various socio-economic groups (Babulo et al., 2008; Beckley, 1998; Bwalya, 2013; McElwee and Bosworth, 2010). As the nature of communities across different regions is not homogeneous, so the difference in the reliance of households on the forest is something essential (Prado Córdova et al., 2013). Furthermore, the households of local communities, directly and indirectly, depending on the forest for subsistence needs (Tiwari and Joshi, 2015). For example, in the Himalayan region, India, approximately 80% of rural communities depend on agriculture and activities relevant to agriculture. Consequently, the forest plays a crucial role in agricultural activities through indirect contribution to the household livelihoods and it also makes a direct contribution to the livelihood in some cases (Sharma and Vetaas, 2015; Singh et al., 2015). Moreover, about 82.5% of households in Gujrat, India, depend on the forest for firewood which is a significant source of fuel energy for cooking purposes, whereas approximately 72.5% of people are dependent on the forest for timber. In Pakistan, forest covers only 5% of the total area of the country (Government of Pakistan, 2010) which is very low as compared to the global average coverage of forest, i.e. 30.3% in other countries of South Asia (FAO, 2007). Moreover, there is evidence of rapid deforestation in Pakistan, and between 1990 and 2010, 170,684 hectors of the forest have been cut down (Qamer et al., 2016). One of the most critical factors responsible for deforestation is the increasing population. There is only 0.03 hector of forest per capita in Pakistan compared to 1 hector of the global average, with a growing population of 2.6 percent annually. Consequently, forest resources in the whole country are under intense pressure, particularly Khyber-Pakhtunkhwa and Gilgit Baltistan are more affected (National Forest Policy, 2015). Therefore, investigating the factors influencing forest dependency is very crucial to formulate effective policies for biodiversity conservation (Gunatilake, 1998).

Based on the literature of forest, people's dependency on forest resources depends on various elements, among them socioeconomic and demographic factors are the most crucial (Bhavannarayana et al., 2012; Garekae et al., 2017). Contrary to the higher education, household size and forest dependency are positively linked to each other. Larger family size has higher needs for subsistence, and it results in more dependence of households on forest resources (Gunatilake, 1998; Mamo et al., 2007). There is a positive relationship between the household heads' age and forest resource dependency, even though with falling impact once reaching the top of physical power (Soe and Yeo-Chang, 2019). Older people, however, may have solid environmental knowledge of their surroundings, a phenomenon that may enhance their probability of becoming more forest dependent. In Pakistan, the majority of the inhabitants of the mountainous regions live far away from the industrial hubs, which have a considerable impact on their living style (Pham et al., 2015). Due to limited access to income creating opportunities, people are involved in low-income activities. However, the reliance of households on forest resources for their subsistence is a more productive activity for the rural community (Charlery and Walelign, 2015).

The above-highlighted complexities regarding forest resources emphasize comprehending the actual determinants of forest dependency for sustainable forest management and conservation of forest policies (Gunatilake, 1998). This is one of the crucial initiatives that lead to targeted involvements to reduce forest dependency, development of the plan, and sustainable planning and management strategies (Fikir et al., 2016; Hussain et al., 2019a). By knowing the trends of households' forest reliance, policymakers, researchers and professionals will be able to develop informed empirical strategies for diversification of portfolios of livelihood and encourage sustainable use of resources for bringing balance between forest dependency and biodiversity conservation (Mmbando and Baiyegunhi, 2016).

In the above context, the current study aims to analyze the socio-economic and demographic determinants of rural households' dependence on forest resources for livelihood in Chaprote Valley, Northern Pakistan. We developed the following main research questions to achieve the objectives of our study.

(i) What are the main determinants of household dependency in our study area?

(ii) What is the level of household dependency on forest resources?

2. Methodology

2.1. Study area and sampling

We conducted our study in two locations of Chaprote Valley, namely Chaprote Main and Rabat. Chaprote is believed to be one of the oldest villages of Gilgit-Baltistan, Northern Pakistan. As the map, shown in Fig. 1, the Chaprote Valley (36° North, 74° East) is located in the Himalayan Highlands of Karakoram Mountain ranges that is approximately 100 km away from the city of Gilgit. The area of Chaprote is scattered over 178 km, and the altitude of the area is 2200–3500 m (a.s.l). According to forest classification, Chaprote Valley is a dry temperate mountainous region in Pakistan.

Chaprote Valley consists of two villages Chaprote Main and Rabat. The tribes living in Chaprote Valley are called Sheen and Yashkoon. There are 435 households in Chaprote Main with a population of 3542 individuals, while 135 households in Rabat with a population of 1153 individuals. The residents of the valley highly depend on forest resources for their livelihood. For cattle, the locals rely on pastures and other resources of forest such as *Jrooch* (Spruce) and *Pinus wallichina* (*blue pine*) and *Pinus gerdiana* (*edible pine*). *Juniper* species are used to get timber and firewood while medicinal plants or herbs are used for medical purposes. The photographs of the study area are presented in Fig. 2. The climate of Chaprote Valley is dry temperature; generally, there is severe cold in winter and pleasant weather in summer. The participants of this study were taken from Chaprote Main and Rabat (Table 1). There were 570 households in the sampled villages of Chaprote. In our study, we used 193 households as our study sample through the technique of random sampling, approximately 33% of the total households (Djamba and Neuman, 2014).

2.2. Data collection

We collected primary data in Chaprote Valley, from April 2018 to August 2018. Interviews were taken through questionnaires following the procedures proposed by the "Poverty Environment Network" (CIFOR - Center for International Forestry Research, 2007). During the session of our dialogue with the household head, we orally interpreted all interview questions into the local dialect of Chaprote Valley. We followed all the required ethical procedures. All the respondents were informed in advance through official letters. The questionnaire was focused on the socioeconomic and demographic characteristics of the households. Qualitative data on rural analysis such as trends of forest resource utilization had been examined with the help of semi-structured group discussion, village meetings and key informant interviews. We organized focused group meetings (FGDs) with forest department staff and local community heads to determine the general trends of livelihood

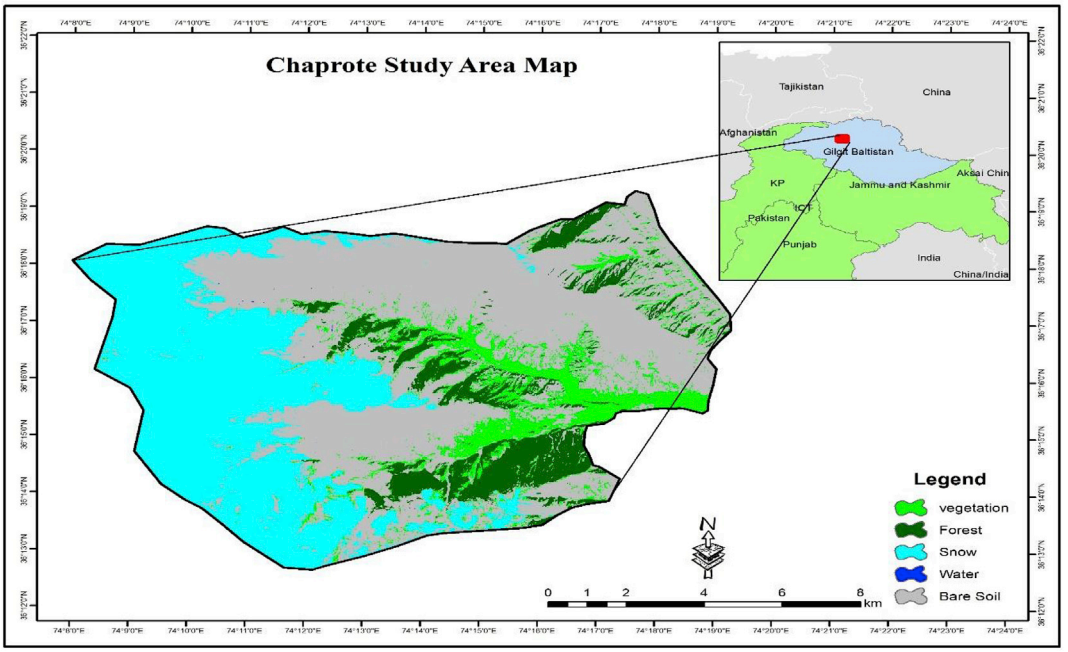

Fig. 1. Location map of the study area, Chaprote Valley.

Fig. 2. Photographs of the study area.

Table 1
Characteristics of the study area.

Study area	Total population	Total households	Sample households	Distance to forests (m)	No. of schools
Chaprote Main	3542	435	147	1000–6000	5
Chaprote Rabat	1153	135	46	1000–6000	3

Note: m = distance in meters.

and the linked livelihood resources. To fix any errors and inconsistencies, respondents were repeatedly asked for clarification. For proper recording of information, we used MS excel sheets, and for quality accuracy, PEN STANDARD procedures were followed.

2.3. Income computation

The total household annual income has been calculated as the combination of all incomes generated from the forest, livestock, agriculture, government services and daily wages. Income generated from all sources was computed based on income computation technique used by (Cavendish, 2000) We converted Pakistani currency (PKR) into US$ (1 US$ = 154 PKR) for valuation of the total annual income of households. The values of all products have been valued under the current market prices. Forest income, livestock income, agriculture income and off-farm income are the components of total annual household income as mention below.

Total household annual income = $\sum$ (Forest income + livestock income + agriculture income + off-farm income)

$$H_{Tincome} = \sum_{T=1}^{m} Y_j \quad (1)$$

Where $H_{Tincome}$ shows total household annual income and Y_j indicates income from source j.

Firewood, timber, fodder, fruits and nuts, mushrooms and herbs are ingredients of forest income. The forest income generated from forest products (firewood, honey, fruits and nuts, herbs, mushrooms, and honey per kg, fodder in per mound and timber is calculated as per log) has been calculated by multiplying the number of products with current market prices (Hussain et al., 2019b) Livestock income consists of goat income, sheep income, bull income, donkey income, yak income and horse income. The agricultural products such as potatoes, wheat, barley, fodder, poultry, maize, apricots, apples, walnuts,

almonds and cherries contribute to agriculture income. The values of all the products were at their market values during field visits (Mamo et al., 2007; Vedeld et al., 2007). The components of off-farm income are business income, daily wage income and government service income. Daily wage income in this study refers to salaries earned from private jobs or pensions of old aged people. The income generated from business and government services was investigated during the interview.

2.4. Model specification

To investigate household dependency in Chaprote Valley, we have used the logistic regression model. Logistic regression has been widely used in past studies to examine the dependence of rural livelihood on forest resources dependency (Adam et al., 2014; Jain and Sajjad, 2016; Lepetu et al., 2009; Masozera and Alavalapati, 2004; Tieguhong and Nkamgnia, 2012).

Nonetheless, the logistic regression model has included three elements: random, systematic, and link function. The random part specifies the dependent variable (Y = 0 or 1), the systematic element identifies the combination of explanatory variables (Z_i), while the link function defines a linear relationship between the explanatory variables and their probability function. The stepwise scheme for the logistic regression model is presented in Fig. 3.

2.5. The rationale for selecting variables

The variable we used in our study to develop an association with forest dependency on the theoretical basis is age, education, household size, distance to forest, own land holding, livestock income, and agriculture income. The justification behind the utilization of these variables in our study is given below.

Age: Generally, young people rely less on forest resources than their elders, as they have the interest to find career-oriented positions in cities to make their future bright (Jain and Sajjad, 2016). On the other hand, the studies by (Fonta and Ayuk, 2013; Thondhlana and Muchapondwa, 2014) depict that forest extraction activities are labor-intensive and require substantial physical strength. Due to this reason, older people reduce their dependency on forest resources. So the age factor of the household is assumed inversely proportional to forest dependency.

Education level: There is a positive relationship between education level and education level of the household. As education creates alternate sources of employment, so educated people are assumed to be less dependable on forest resources (Fonta and Ayuk, 2013; Masozera and Alavalapati, 2004). Various studies such as (Adhikari et al., 2004; Baiyegunhi et al., 2016; Soe and Yeo-Chang, 2019) show that higher education creates better sources of employment and other future opportunities, hence it diverts livelihoods to diverse fields from extracting forest resources(Godoy and Contreras, 2001). also found that there is an inverse relationship between education and forest dependency.

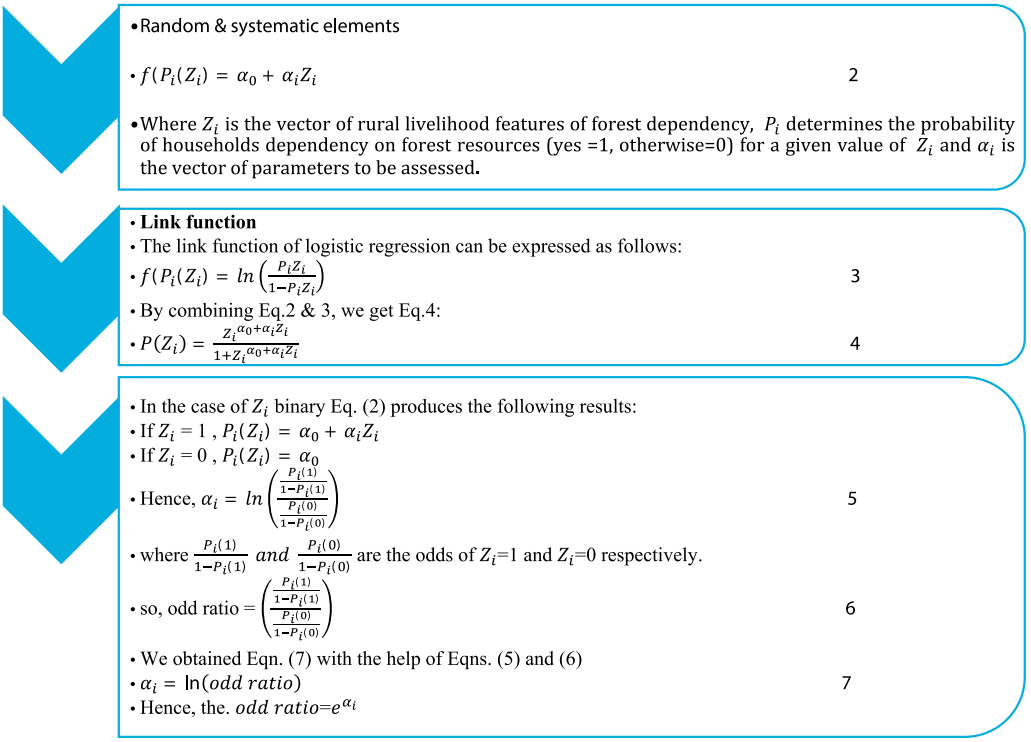

Fig. 3. The stepwise scheme for the logistic regression model.

Household size: Generally, household size is directly proportional to forest dependency because bigger families consume more forest resources. As forest activities are labour-intensive and require more workforce for the extraction of resources, so it is assumed that larger families are more dependent on forest (Fonta and Ayuk, 2013; Kabubo-Mariara, 2013; Prado Córdova et al., 2013). A study by (Adhikari et al., 2004) also shows that households with large families have a higher demand for forest resources, and they have more human resources to meet this demand.

Distance to the forest: The households who live nearer to the forest are assumed that they will be comparatively more reliant on forest resources than others (Ali and Rahut, 2018) shows that distance to the forest significantly affects forest resource reliance. It adversely affects household the forest dependency of households.

Agriculture income (Swinton and Quiroz, 2003) illustrates that the dependency on forest resources reduces when agricultural resources are available. People who have easy access to farmlands, they are usually expected to rely less on the forest (Adam et al., 2014; Gunatilake, 1998). also, suggest that households having higher agricultural income are less reliant on forest because they prefer to perform agrarian activities in fields than depending on forest resources. Hence, agriculture is assumed to have an inverse relationship with forest reliance.

Off-farm income (Angelsen and Kaimowitz, 1999) shows that off-farm income and forest dependency are inversely proportional to each other because increase off-farm opportunities reduce forest dependency of the households (Cavendish, 2000; Escobal and Aldana, 2003). also, specify that people with better off-farm activities depend less on forest resources due to their higher-income from other sources.

Livestock income: Livestock includes goats, sheep, cow, bull, donkeys, yaks, horses etc. Grazing and feeding livestock is dependent on forest resources, and it causes ecological pressure on the environment. Livestock income has a positive association with the forest dependency, in short increase in the population of livestock will lead to increased forest dependency (Jain and Sajjad, 2016).

Landholding: Generally, households having more land are expected to rely less on forests because of having alternative means of livelihood through agricultural resources (Gunatilake, 1998). So, it is presumed that there is an inverse relationship between landholding and forest dependency.

3. Results and discussion

3.1. Household profile

The description of the features of 193 respondents from Chaprote Valley is given in Table 2. According to our survey, the household average size is 9.4, and the standard deviation is 2.3 (Table 3). The mean of household head's education is 9.8 schooling years, while 45.6 was recorded as the mean age of the households. The mean value calculated for the distance required to arrive forest for extraction of forest resources is 3000 m. Regarding own landholding in our study area, 34.6 Kanal (1kanal = 0.05ha) was the average landholding.

3.2. Primary income sources of households

The significant sources of income, such as forest resources, livestock, agriculture and off-farm sources, are presented in Fig. 4. Forest resources contribute 32% in the total annual household income while the contribution of off-farm, agriculture and livestock income is 44%, 13%, and 9% respectively. 433858.8 PKR (1PKR = USD154) is the mean annual income per household from resources of the forest, as presented in Table 2. The average yearly income received from forest resources such as firewood, timber, fodder, fruits and nuts, herbs, mushrooms, and honey is 205310.11 PKR, 171241.71 PKR, 14577.2 PKR, 24500.52 PKR, 11264.25 PKR, 5401.81 PKR, and 1563.21 PKR respectively. According to our results, firewood makes more contribution to the households' livelihood among all other forest resources. The average annual income per household received from sources of agriculture is calculated as 184471 PKR. Among all agricultural products, the average annual income generated from potatoes is highest, i.e. 70611.4 PKR. The agriculture income's share in the total household income is 13%. On the other hand, the average annual values of the mean for livestock income is 126126.9 PKR, and its share in the total average yearly income of the household is 9%. Likewise, 587435.2 PKR is the mean annual income generated from off-farm resources. Off-farm resources include business income, daily wages income and government service income. Among all off-farm activities, government income contributes more to the livelihood of the household with the value of 237901.6 PKR. From the above figures, it is clear that forest income has a significant impact on the livelihood of households in Chaprote Valley, so the rural households have a considerable inclination towards forest resource extraction.

3.3. Share of forest products to total forest income

The households of Chaprote Valley depend on forest products such as firewood, timber, fodder, fruits and nuts, herbs, mushrooms, and honey. The degree of their reliance varies from product to product. Extraction of the forest resources causes harmful effects for the forest ecosystem. The share of forest income generated from forest products such as firewood, timber, fodder, fruits and nuts, herbs, mushrooms and honey is 47%, 39%, 3.3%%, 5%, 2%, 1%, and 0.3% respectively. Firewood income makes more contribution to the total forest income among all forest resources because households use it as a primary source of energy in Chaprote Valley. Firewood is mainly used for cooking throughout the year, and during winter it is a primary

Table 2
Households' demographic and socioeconomic characteristics.

Characteristics	Mean	S.D
Household head's age	45.64	7.74
Household size	9.49	2.35
Household head's education	9.86	2.38
Socio-economic variables		
Wealth		
Own land holdings	34.611	8.129
Forest products		
Firewood	205310.11	195309.3
Timber	171241.71	165808.2
Fodder	14577.2	14115.02
Fruits and Nuts	24500.52	18910.66
Herbs	11264.25	14017.55
Mushrooms	5401.81	4993.87
Honey	1563.21	2132.57
Livestock Products		
Goats	28911.92	14450.62
Sheeps	39238.34	27620.95
Cows	28240.93	17617.62
Bulls	10580.31	15552.5
Donkeys	2689.11	6333.33
Yalks	13735.75	30165.65
Horses	2730.57	6229.96
Agricultural Products		
Potatoes	70611.4	81215.63
Wheat	13798.45	17555.16
Barley	1357.51	2089.57
Fodder	19388.6	24247.62
Poultry	1590.67	2094.34
Maize	4601.036	6031.29
Apricots	11966.84	13705.3
Apples	9661.65	13941.1
Walnuts	33844.56	36530.84
Almonds	7569.94	10361.51
Cherries	10080.31	12994.59
Off-farm Income		
Business	139533.7	331697.5
Government Service	237901.6	302516.1
Daily Wages Labor	210000	314674.1
Accessibility		
Distance to Forest	3.17	1.52
Income Sources		
Total Forest Income	433858.8	399296.5
Total Livestock Income	126126.9	69770.39
Total Agriculture Income	184471	163295.5
Total Off-farm Income	587435.2	272899.7
Total Income	1331892	499155.1
Forest Resource Dependency	0.55	0.49

Note: Std. Dev. = Standard Deviation.

source of heating as well because of the severe cold weather of the valley. Timber contributes the second-largest share in the total average forest income. Timber is used for building houses and construct cattle sheds. The share of all significant sources of forest income is presented in Fig. 5.

3.4. Determinants of forest dependency

In this study, we used the binary regression model to examine the households' forest dependency for livelihood. The logistic regression model findings are presented in Table 3. The values for calculated average forest dependency was 0.55 with SD 0.49. This indicates a household dependency on forest resources, which is influenced by socioeconomic and demographic characteristics.

The results of the likelihood ratio in the logistic regression model show the significance of the model with 201.0 value of χ^2 -tests. Moreover, results also illustrate that the independent variables of the study have a significant association with forest dependency. Similarly, 0.75 Pseudo R^2 was formed by the model; moreover, 88% correct prediction percentage signifies the rationality of our study model's (logistic regression model) descriptive power. According to Table 3, the values of the household head's age and distance to the forest are found to be insignificant statistically while all other variables are

Table 3
Logistic regression results.

Forest resource dependency	Coef.	Odds. ratio	Std. Err	P>|z|	95% Conf.	Interval
Household head's age	0.183047	0.832728	0.122457	0.213	0.624208	1.110906
Household head's education	−0.17338	1.189329	0.449113	0.050	0.049319	2.868059
Household size	0.009747	0.907126	0.041642	0.052	0.401057	2.051772
Agriculture income	−0.00382	0.966962	0.000247	0.042	0.999986	1.000006
Livestock income	0.006702	1.000067	0.000019	0.001	1.000029	1.000105
Off-farm Income	−0.00104	0.999989	2.29E-06	0.000	0.999985	0.999994
Distance to the forest	−0.24354	0.783844	0.365882	0.602	0.313983	1.956828
Ownership of landholding	−0.14241	0.867259	0.070634	0.056	0.739302	1.017364
No. of Obs. = 193						
Pseudo R^2 = 0.7594						
LR χ^2 (8) = 201.08						
Prob > χ^2 = 0.0000						
Log likelihood = −31.862						

Note: Coef. = coefficient, Std. Err. = Standard error, Conf. = Confidence interval.

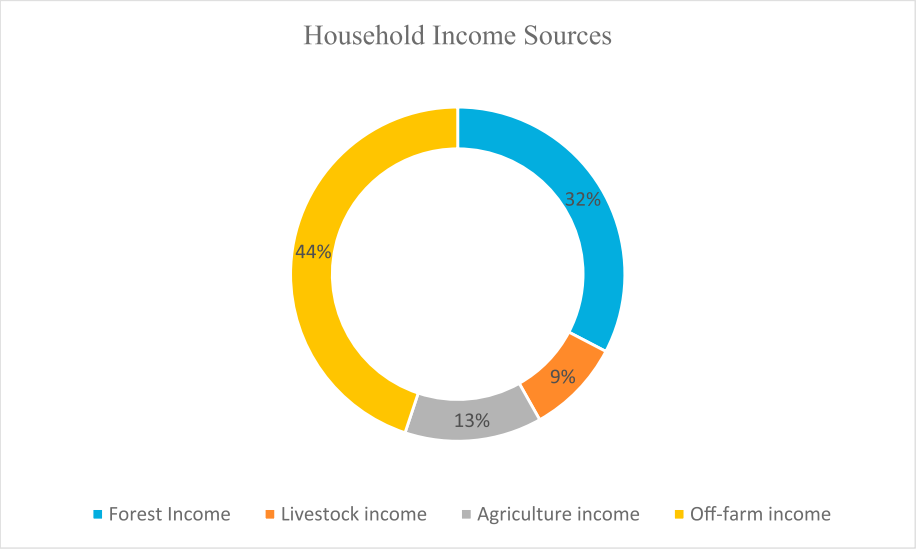

Fig. 4. Income sources of rural livelihood in Chaprote Valley.

significant for forecasting forest dependency of households. For instance, livestock income and off-farm income are statistically significant at 1% while the household head's education, household size and own landholding are significant at 5% significance level.

The results show that the coefficients for household size found to be positive and the value of the odds ratio (1.189) suggests that with the increase of 1 unit of households, the forest dependency will be around 1 times higher. It implies that large families depend more on forest resources because extraction of forest resources is a labor-intensive activity, so it needs an adequate human resource to collect forest resources (Adam et al., 2014; Fonta and Ayuk, 2013; Kabubo-Mariara, 2013). Large households need more firewood and other forest resources to meet their subsistence requirements, so usually, households with more family members have a high capacity for more extraction of forest resources (Gunatilake, 1998). Similarly, the coefficient of livestock had a positive value, and its odd value was 1.00007. It suggests that due to the increase of livestock, the probability forest dependency will be increased by an approximate portion of 1. The results are consistent with the study of (Jain and Sajjad, 2016). On the other hand, there was an inverse relationship between household heads' education and forest dependency. The odd value of the household's level of education is 1.189, signifying that rural household reliance on forest resources decreases by 1.189 for each unit of increase in education. These findings reveal that household head's education is negatively associated with forest dependency, implying that higher education lessens forest dependency by creating better and diversified employment opportunities. The same kind of findings has been found in various other studies such as (Baiyegunhi et al., 2016; Kabubo-Mariara, 2013; Lepetu et al., 2009; Masozera and Alavalapati, 2004). The agriculture income has a significantly inverse association with forest dependency having the odd value of 0.966. This indicates that households' dependency on the forest will be decreased by the portion of 0.966 with a specific increase in agricultural

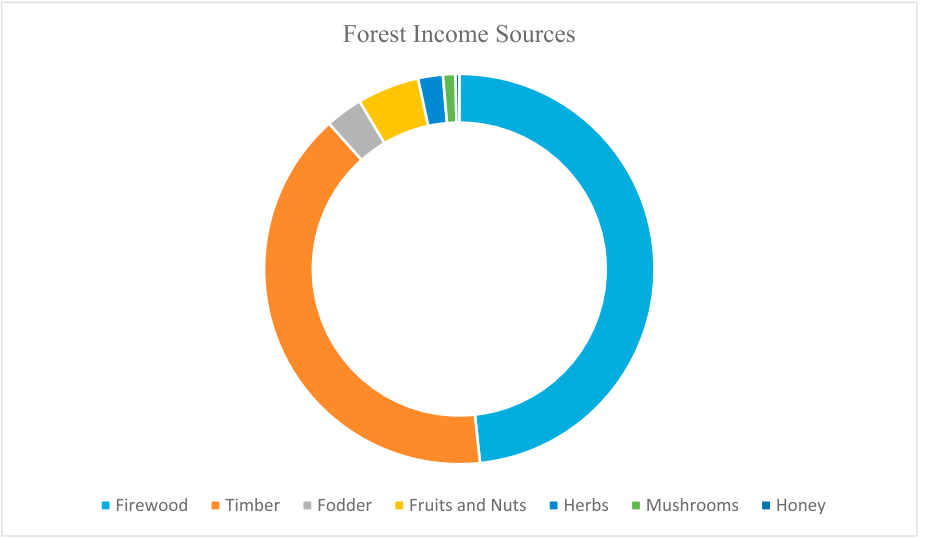

Fig. 5. Contribution of different forest products in forest income.

income. Forest reliance reduces when agricultural resources are available because people who have easy access to farmlands are usually less reliant on forest resources. The obtained results are consistent with the other various studies (Adam et al., 2014; Gunatilake, 1998; Swinton and Quiroz, 2003). Likewise, the study also found a negative association between off-farm income and forest dependency. With every unit increase of off-farm income, 0.999 units of forest dependency will be dropped down (Cavendish, 2000; Escobal and Aldana, 2003). specify that people with better off-farm activities are less dependent on forest resources due to their higher income from their other sources. So households with better off-farm opportunities are less inclined towards forest resources, and it will reduce their forest dependency. Hence, we can assume that by providing employment opportunities to the households in the study area, forest dependency can be reduced.

4. Conclusion and policy implications

Forest resources play a significant role in rural livelihood, but over-extraction of these resources causes environmental issues for biodiversity conservation and ecosystem. The study aimed to investigate the determinants affecting forest dependency in Chaprote Valley, Northern Pakistan. The primary sources of income in Chaprote Valley include forest income, livestock income, agriculture income, and off-farm income. The results of the study reveal that forest income contributes a significant share of 32% to the total annual household income while off-farm income, agriculture income and livestock income contributes 44%, 13% and 9% respectively. Forest income is the second-largest source of income among all others. Firewood makes a most substantial contribution in forest income with a share of 47%. Furthermore, the negative association of household head's education, agriculture income, off-farm income and own landholding offers helpful insight for researchers and policymakers. Hence, the results of our study endorse that an increase of off-farm income and agriculture income will result in a lessening of forest dependency in Chaprote Valley.

We suggest some necessary policy actions based on our findings. Alternate sources of energy are essential to reduce the consumption of firewood in Chaprote Valley. To boost agricultural output, advanced and modern ways of agriculture could be introduced in the valley. Policymakers could make higher education accessible to everyone so that people would be able to find diverse sources of income for their livelihood subsistence rather than depending on forest resources. Lastly, the government and non-government organizations could come forward to create awareness in the area about the significance and biodiversity conservation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

Adam, Y.O., Mirghani, A., Tayeb, E.L., 2014. Forest dependency and its effect on conservation in Sudan: a case of srf-saaid reserved forest. In: Gadarif State. Agric. For.

Adhikari, B., Di Falco, S., Lovett, J.C., 2004. Household characteristics and forest dependency: evidence from common property forest management in Nepal. Ecol. Econ. 48, 245–257. https://doi.org/10.1016/j.ecolecon.2003.08.008.

Ahmed, M.S., Manzoor, R.A.Z.M., Belal, U.M., Ahmed, K.N., 2016. Role of non-timber forest products in sustaining forest-based livelihoods and rural households' resilience capacity in and around protected area: a Bangladesh study. J. Environ. Plann. Manag.

Ali, A., Rahut, D.B., 2018. Forest-based livelihoods, income, and poverty: empirical evidence from the Himalayan region of rural Pakistan. J. Rural Stud. https://doi.org/10.1016/j.jrurstud.2017.10.001.

Angelsen, A., Kaimowitz, D., 1999. Rethinking the causes of deforestation: lessons from economic models. World Bank Res. Obs. https://doi.org/10.1093/wbro/14.1.73.

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N.J., Bauch, S., Börner, J., Smith-Hall, C., Wunder, S., 2014. Environmental Income and Rural Livelihoods: A Global-Comparative Analysis. World Dev. https://doi.org/10.1016/j.worlddev.2014.03.006.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J., Mathijs, E., 2008. Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. Agric. Syst. https://doi.org/10.1016/j.agsy.2008.06.001.

Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J., Mathijs, E., 2009. The economic contribution of forest resource use to rural livelihoods in Tigray, Northern Ethiopia. For. Policy Econ 11, 109–117. https://doi.org/10.1016/j.forpol.2008.10.007.

Baiyegunhi, L.J.S., Oppong, B.B., Senyolo, M.G., 2016. Socio-economic factors influencing mopane worm (Imbrasia belina) harvesting in Limpopo Province, South Africa. J. For. Res. https://doi.org/10.1007/s11676-015-0168-z.

Beckley, T.M., 1998. Moving toward consensus-based forest management: a comparison of industrial, co-managed, community and small private forests in Canada. For. Chron. https://doi.org/10.5558/tfc74736-5.

Bhavannarayana, C., Rao, P.B., Saritha, V., Sarala, K., 2012. A study on community managed degraded forest in Srikakulam and Vizaynagaram districts of Andhra Pradesh. Int. J. Life Sci. Pharma Res. 2, 40–50.

Bwalya, R., 2013. Transaction costs and smallholder household access to maize markets in Zambia. J. Dev. Agric. Econ. 8, 328–336. https://doi.org/10.5897/jdae12.134.

Cavendish, W., 2000. Empirical regularities in the poverty-environment relationship of rural households: evidence from Zimbabwe. World Dev. 28, 1979–2003. https://doi.org/10.1016/S0305-750X(00)00066-8.

Charlery, L., Walelign, S.Z., 2015. Assessing environmental dependence using asset and income measures: evidence from Nepal. Ecol. Econ. 7, 40–48. https://doi.org/10.1016/j.ecolecon.2015.07.004.

Cheng, S.H., MacLeod, K., Ahlroth, S., Onder, S., Perge, E., Shyamsundar, P., Rana, P., Garside, R., Kristjanson, P., McKinnon, M.C., Miller, D.C., 2019. A systematic map of evidence on the contribution of forests to poverty alleviation. Environ. Evid. 8, 2–22. https://doi.org/10.1186/s13750-019-0148-4.

CIFOR - Center for International Forestry Research, 2007. PEN Tech. Guidel. 4, 1–52.

Djamba, Y.K., Neuman, W.L., 2014. Social research methods: qualitative and quantitative approaches. Teach. Sociol. https://doi.org/10.2307/3211488.

Escobal, J., Aldana, U., 2003. Are nontimber forest products the antidote to rainforest degradation? Brazil nut extraction in Madre De Dios, Peru. World Dev. 31, 1873–1887. https://doi.org/10.1016/j.worlddev.2003.08.001.

FAO, 2007. The State of the Food and Agriculture. FAO Agricultur.

Fikir, D., Tadesse, W., Gure, A., 2016. Economic contribution to local livelihoods and households dependency on dry land forest products in hammer district, southeastern Ethiopia. Int. J. For. Res. 2016, 1–11. https://doi.org/10.1155/2016/5474680.

FISHER, M., 2004. Household welfare and forest dependence in Southern Malawi. Environ. Dev. Econ. 9, 135–154. https://doi.org/10.1017/s1355770x03001219.

Fonta, W.M., Ayuk, E.T., 2013. Measuring the role of forest income in mitigating poverty and inequality: evidence from south-eastern Nigeria. For. Trees Livelihoods 22, 86–105. https://doi.org/10.1080/14728028.2013.785783.

Garekae, H., Thakadu, O.T., Lepetu, J., 2017. Socio-economic factors influencing household forest dependency in Chobe enclave, Botswana. Ecol. Process 2017, 1–10. https://doi.org/10.1186/s13717-017-0107-3.

Godoy, R., Contreras, M., 2001. A comparative study of education and tropical deforestation among lowland Bolivian Amerindians: forest values, environmental externaltiy, and school subsidies. Econ. Dev. Cult. Change 49, 555–574. https://doi.org/10.1086/452515.

Godoy, R., Overman, H., Apaza, L., Byron, E., Huanca, T., Leonard, W., Pérez, E., Reyes-García, V., Vadez, V., Wilkie, D., Cubas, A., McSweeney, K., Brokaw, N., 2002. Local financial benefits of rain forests: comparative evidence from Amerindian societies in Bolivia and Honduras. Ecol. Econ. 40, 397–409. https://doi.org/10.1016/S0921-8009(02)00006-X.

Government of Pakistan, 2010. (Government of Pakistan, Economic Survey of Pakistan).

Gunatilake, H.M., 1998. The role of rural development in protecting tropical rainforests: evidence from Sri Lanka. J. Environ. Manag. 53, 273–292. https://doi.org/10.1006/jema.1998.0201.

Hussain, J., Akbar, M., Ali, S., Kui, Z., Raza, G., Khan, A., Zafar, M., Moazzam Syed, N., Hyder, S., Hussain, A., Hussian, F., 2019a. Assessing natural forest conservation using diameter size class distributions in Pakistan. Pol. J. Environ. Stud. 29, 629–640. https://doi.org/10.15244/pjoes/102785.

Hussain, J., Zhou, K., Akbar, M., Zafar khan, M., Raza, G., Ali, S., Hussain, A., Abbas, Q., Khan, G., Khan, M., Abbas, H., Iqbal, S., Ghulam, A., 2019b. Dependence of rural livelihoods on forest resources in Naltar Valley, a dry temperate mountainous region, Pakistan. Glob. Ecol. Conserv. 20 https://doi.org/10.1016/j.gecco.2019.e00765.

Jain, P., Sajjad, H., 2016. Household dependency on forest resources in the sariska tiger reserve (STR), India: implications for management. J. Sustain. For. 35, 70–74. https://doi.org/10.1080/10549811.2015.1099108.

Kabubo-Mariara, J., 2013. Forest-poverty nexus: exploring the contribution of forests to rural livelihoods in Kenya. Nat. Resour. Forum 37, 177–188. https://doi.org/10.1111/1477-8947.12003.

Kalaba, F.K., Quinn, C.H., Dougill, A.J., 2013. The role of forest provisioning ecosystem services in coping with household stresses and shocks in Miombo woodlands, Zambia. Ecosyst. Serv 5, 143–148. https://doi.org/10.1016/j.ecoser.2013.07.008.

Lepetu, J., Alavalapati, J., Nair, P.K., 2009. Forest dependency and its implication for protected areas management: a case study from Kasane forest reserve, Botswana. Int. J. Environ. Res. 3, 525–536. https://doi.org/10.22059/ijer.2010.68.

Mamo, G., Sjaastad, E., Vedeld, P., 2007. Economic dependence on forest resources: a case from Dendi District, Ethiopia. For. Policy Econ 9, 916–927. https://doi.org/10.1016/j.forpol.2006.08.001.

Masozera, M.K., Alavalapati, J.R.R., 2004. Forest dependency and its implications for protected areas management: a case study from the Nyungwe Forest Reserve, Rwanda. In: Scandinavian Journal of Forest Research, Supplement. https://doi.org/10.1080/14004080410034164.

McElwee, G., Bosworth, G., 2010. Exploring the strategic skills of farmers across a typology of farm diversification approaches. J. Farm Manag. 13, 819–838.

Mmbando, F.E., Baiyegunhi, L.J.S., 2016. Socio-economic and institutional factors influencing adoption of improved maize varieties in hai district, Tanzania. J. Hum. Ecol. 53, 49–56. https://doi.org/10.1080/09709274.2016.11906955.

National Forest Policy, 2015. Policy.

Neumann, R.P., Hirsch, E., 2000. Commercialisation of non-timber forest products: review and analysis of research. Commer. Non-Timber For. Prod: Rev. Analy.Res. https://doi.org/10.17528/cifor/000723.
Pham, T.P.T., Kaushik, R., Parshetti, G.K., Mahmood, R., Balasubramanian, R., 2015. Food waste-to-energy conversion technologies: current status and future directions. Waste Manag. 38, 399–408. https://doi.org/10.1016/j.wasman.2014.12.004.
Prado Córdova, J.P., Wunder, S., Smith-Hall, C., Börner, J., 2013. Rural income and forest reliance in highland Guatemala. Environ. Manag. 51, 1034–1043. https://doi.org/10.1007/s00267-013-0028-6.
Qamer, F.M., Shehzad, K., Abbas, S., Murthy, M.S.R., Xi, C., Gilani, H., Bajracharya, B., 2016. Mapping deforestation and forest degradation patterns in Western Himalaya, Pakistan. Rem. Sens. 8, 1–17. https://doi.org/10.3390/rs8050385.
Sharma, L.N., Vetaas, O.R., 2015. Does agroforestry conserve trees? A comparison of tree species diversity between farmland and forest in mid-hills of central Himalaya. Biodivers. Conserv. 24, 2047–2061. https://doi.org/10.1007/s10531-015-0927-3.
Singh, K.K., Davis, A.J., Meentemeyer, R.K., 2015. Detecting understory plant invasion in urban forests using LiDAR. Int. J. Appl. Earth Obs. Geoinf. 38, 267–279. https://doi.org/10.1016/j.jag.2015.01.012.
Soe, K.T., Yeo-Chang, Y.O.U.N., 2019. Perceptions of forest-dependent communities toward participation in forest conservation: a case study in Bago Yoma, South-Central Myanmar. For. Policy Econ 100, 129–141. https://doi.org/10.1016/j.forpol.2018.11.009.
Swinton, S.M., Quiroz, R., 2003. Is poverty to blame for soil, pasture and forest degradation in Peru's Altiplano? World Dev. 31, 1903–1919. https://doi.org/10.1016/j.worlddev.2003.06.004.
Thondhlana, G., Muchapondwa, E., 2014. Dependence on environmental resources and implications for household welfare: evidence from the Kalahari drylands, South Africa. Ecol. Econ. 108, 59–67. https://doi.org/10.1016/j.ecolecon.2014.10.003.
Tieguhong, J.C., Nkamgnia, E.M., 2012. Household dependence on forests around lobeke Nationa l Park, Cameroon. Int. For. Rev. 14, 196–212. https://doi.org/10.1505/146554812800923426.
Tiwari, P.C., Joshi, B., 2015. Local and regional institutions and environmental governance in Hindu Kush Himalaya. Environ. Sci. Pol. 49, 66–74. https://doi.org/10.1016/j.envsci.2014.09.008.
Uberhuaga, P., Smith-Hall, C., Helles, F., 2012. Forest income and dependency in lowland Bolivia. Environ. Dev. Sustain. 14, 3–23. https://doi.org/10.1007/s10668-011-9306-8.
Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., Kobugabe Berg, G., 2007. Forest environmental incomes and the rural poor. For. Pol. Econ. 9, 869–879. https://doi.org/10.1016/j.forpol.2006.05.008.