Global Environmental Change 59 (2019) 102004

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Forest conversion by the indigenous Kalasha of Pakistan: A household level analysis of socioeconomic drivers

Alam Zeb[a,b,*], Glen W. Armstrong[a], Andreas Hamann[a]

[a] Department of Renewable Resources, University of Alberta, 751 General, Services Building, Edmonton, AB, Canada T6G 2H1
[b] Shaheed Benazir Bhutto University Sheringal Dir (Upper), Pakistan

ARTICLE INFO

Keywords:
Forest conversion
Cropland expansion
Social drivers
Economic drivers
Logit-tobit models
Indigenous Kalasha
Pakistan

ABSTRACT

Indigenous groups in many parts of the world are often forest dependent societies, and thereby may also play a disproportionate role in protecting and managing threatened forest resources. Taking the Kalasha indigenous group of Pakistan as a test case, this study contributes a socio-economic analysis at the household level aimed at understanding factors that influence forest clearing decisions. The findings of the study may help to develop general policies that facilitate sustainable resource for indigenous and other marginalized forest-dependent communities. The analysis was based on a contrast of 74 households at the forest margin that cleared nearby forested land versus 49 households that did not clear. Survey results indicated that the prime motivation for conversion of forests was expansion for cropland (77%), livestock grazing (18%), and orchards (5%). We found that families with more members and fewer physical assets were more likely to clear forested land for agricultural expansion. Families with more members employed off-farm, and members of Joint Forest Management Committees were less likely to be involved in forest clearing. For poor households, fuel wood constituted the largest part of their total income and for households with off-farm income the smallest. Social factors, such as education, ethnicity, and forest ownership were not significantly associated with clearing of forests. We conclude that programs focusing on off-farm income generation opportunities targeted towards the poorest households would be the most effective policy intervention for lowering deforestation and forest conversion.

1. Introduction

Deforestation in developing countries has been a concern to policy makers and environmentalists due to its contribution to soil erosion, biodiversity loss, and climate change (Alix-Garcia et al., 2005). As with most environmental problems, deforestation is closely linked to human activities, especially agriculture (Chowdhury, 2010). In fact, agricultural expansion is widely identified as the main proximate driver of deforestation globally, accounting for 73% of global forest conversion (Carr et al., 2009; FAO, 2011; Chowdhury, 2010). Therefore, understanding the interactions between humans and the environment in the context of the socioeconomic drivers of forest clearing is important for the conservation of threatened forests.

Indigenous groups in many parts of the world are often particularly forest dependent societies, and thereby may also play a disproportionate role in protecting and managing threatened forest resources. Indigenous people number from 300 million to 400 million worldwide (Hall and Patrinos, 2012), and these groups manage or have ownership rights over at least 38 million km^2 (28%) of global land, including at least 13.3 million km^2 (23%) of ecologically intact forest land (Garnett et al., 2018). Preventing the degradation and clearance of intact forest ecosystems is an essential component of global efforts to mitigate climate change and indigenous peoples are making significant contributions to protecting these forests (Stevens et al., 2014; Schwartzman et al., 2000). For example, deforestation rates in the Amazon were five times less inside indigenous peoples' territories and conservation units than outside those areas (RAISG, 2015).

However, several studies (Nepstad et al., 2006; Porro et al., 2014; Vasco et al., 2018) showed that indigenous groups also involve in unsustainable practices, including commercial farming, mining, cattle ranching and timber logging when in contact with the market economy. Exposure of indigenous populations to the outside world has generated demands for new goods and services, and the subsequent extraction of more resources from the forest. In order to develop general policies that facilitate sustainable resource for indigenous and other marginalized forest-dependent communities, we require socio-economic analyses at the household level aimed at understanding factors that influence forest clearing decisions.

* Corresponding author.
E-mail address: zeb@ualberta.ca (A. Zeb).

https://doi.org/10.1016/j.gloenvcha.2019.102004
Received 8 January 2019; Received in revised form 10 October 2019; Accepted 24 October 2019

Expectations regarding the relationship between a household's socio-demographic characteristics and forest land clearing vary between studies. Some studies argue that most land is deforested by the poor (Fisher, 2004; Khan and Khan, 2009; Shively, 2004). Others show that wealthy people clear more forest (Babigumira et al., 2014; Adhikari et al., 2004; Reetz et al., 2011). Some studies indicate that secure tenure rights and formal titling of common property are associated with better forest management and a higher rate of success in controlling forest conversion (Robinson and Lokina, 2011; Vergara-Asenjo and Potvin, 2014). Understanding the effect of socio-economic factors on clearing decisions at a household-level basis could have important policy implications that might not be detected at a village or region level scale (Rindfuss et al., 2004; Chowdhury, 2010).

Most research on deforestation links regional level clearing with socio-economic data aggregated at a higher level (Duveiller et al., 2008; Lapola et al., 2010; Soares-Filho et al., 2006). The main limitation of regional deforestation models is the use of the overall deforestation rate as a top-down input. A bottom-up approach linking a household's land clearing decisions to its socioeconomic characteristics is preferable (Rosa et al., 2013). One of the practical problems in implementing this approach is that remotely sensed data for activities dating back decades is often not accurate enough to link forest conversion to an individual household's clearing activities (Rindfuss et al., 2004). The approach requires ground truthing, and ideally accurate self-reporting of historical forest conversion activities by residents. Research to date has mostly relied on household's self-reported clearing. For example, Babigumira et al. (2014) based his global comparative analysis on self-reported clearing of 7172 households from 24 developing countries. They state that the accuracy and reliability of self-reported data on land clearing for agriculture is probably low. When the activities under survey are either sensitive or illegal, the data may be strongly biased (Nuno and John, 2015). There is a high probability that respondents will choose not to report or to under-report forest clearing due to fear of penalty, which may lead to inaccurate results and misleading interpretations.

This paper contributes an analysis of forest clearing at the household level in the Kalasha valleys of Pakistan. Data on forest clearing (collected through remote sensing) is related to socio-economic data (collected through household surveys). The objective is to relate the household level land clearing decision to household level socio-economic variables and bio-physical characteristics of the farm plot. This information could help inform policies aimed at reducing deforestation and forest degradation. Specifically, this study tested some of the dominant hypotheses in the field: (a) larger households clear more forest because they have more workers and more family members to sustain; (b) households with more members employed off-farm are less likely involved in forest clearing; (c) asset-poor households clear less forest because they do not have means to clear land; (d) asset-poor households clear more forest as they need more land to grow food; (e) socially privileged households are more likely to clear forest as they have more access and control over natural resources as compare to socially underprivileged. Points (c) and (d) highlight the difference between “means vs. needs hypotheses” (Babigumira et al., 2014).

2. Profile of study site

The Kalasha valleys (Bumburet, Rumbur and Birir) are situated in the Chitral District of Pakistan. The Chitral District is approximately 250,300 km^2 in area. The Kalasha valleys occupy 456 km^2 (Fig. 1) (Rafiq, 2008). The valleys are diverse in climate, topography and vegetation. Summers are mild and winters are severe. There is more than six months of snow cover in the Chitral District. The area is mountainous and situated in the dry temperate zone with average annual rainfall of 250–400 mm. The altitude of the district ranges from 1070 m to 7700 m (Khan et al., 2013). Forests in the district occur between about 1500 and 3000 m altitude. This altitude range is divided into a lower and an upper zone based on the dominant tree species. In the lower zone, *Cedrus deodara, Pinus wallichiana, Abies pindrow, Picea smithiana* are the main conifer species with *Quercus incana* at lower altitudes and *Quercus dilitata* common above 2130 m. In the upper zone, *Abies pindrow* and *Quercus semicarpifolia* are the dominant tree species (Khan et al., 2013). The northern part of the district has little forest cover due to high elevation. The terrain is rugged and the area of cultivable land in Chitral is severely limited.

The Kalasha valleys are inhabited by the Kalasha people, an ethnic and religious minority of Pakistan (Ayub et al., 2015). About 3600 of the 17,994 people living in the three valleys are Kalasha. The Kalasha people depend heavily on forests for their livelihood as well as their ritual cultural practices. Otherwise, the livelihood of the Kalasha people is comparable to other ethnic groups living in the Hindu Kush mountain range. They practice a mixed mountain economy of small-scale agriculture combined with livestock husbandry (Nüsser and Dickore, 2002). Crops are cultivated in the Kalasha valleys on tiny irrigated and terraced fields between altitudes of about 1500 to 2000 m. The major crops grown in the valleys are wheat, maize, potatoes, red beans, and a variety of vegetables. Important fruits grown in the valleys include apples, apricots, walnuts, mulberries, pears, and grapes.

All Kalasha people are legal collective owners of forest lands in the Kalasha valleys under customary laws. Non-Kalasha residents of two villages, Shakhandeh (Rumbur) and Shakhandeh (Bumburet) claim ownership rights but the Kalasha people consider them non-local and non-owners (Taj and Ali, 2018). People of other ethnic groups are considered to be non-owners of the forest lands.

3. Data and methods

3.1. Sampling design

To be included in our sample for household surveys, we only considered farms on the forest margin with potential of expansion into forest. To determine the area of expansion for these farms, we used three sources of data: (1) Google Earth imagery was used to identify and digitize the boundaries of farms with potential for expansion; (2) Landsat scenes of 2003 and 2015 were used to identify farms which expanded into forest and those which did not; and (3) field surveys were used to measure the area of forest conversion. Landsat images were selected which contained the 3 Kalasha valleys. The scenes selected were acquired during the summer months (June, July, August, and September) of 2003 and 2015, during the daytime, and with cloud cover less than 10%. We used a supervised maximum likelihood classification technique to classify each pixel in these images into a specific land cover. As the focus of this study was on cropland expansion to forested land, the land cover classes identified were forest, cropland and other classes. To identify farms with expansion versus no expansion into forested land, we then compared the 2003 and 2015 landscape associated with the boundaries of each digitized property (Evans et al., 2008).

A total of 190 farm polygons were initially selected using Google Earth imagery. We used geographic coordinate information attached to the farms and local representatives from each village to identify the farm owners. We were only able to identify the owners of 123 farms polygons, 34 in Birir valley, 55 in Bumburet and 34 in Rumbur. Out of a sample of 123 households, 74 cleared forested land for agriculture between 2003 and 2015 and 49 did not. A schematic representation of the sampling design is shown in Fig. 2.

Our sampling design is a purposive selection method in order to ensure that both groups (households with and without clearing) are included in the analysis. A purposive sampling strategy allows for selection of a sampling frame that may be most relevant to a specific issue or study objective (Patron, 2002). By using a non-random sample, we narrow the inferences that may be drawn. For examples, our results do not apply to households not located near the forest edge without the

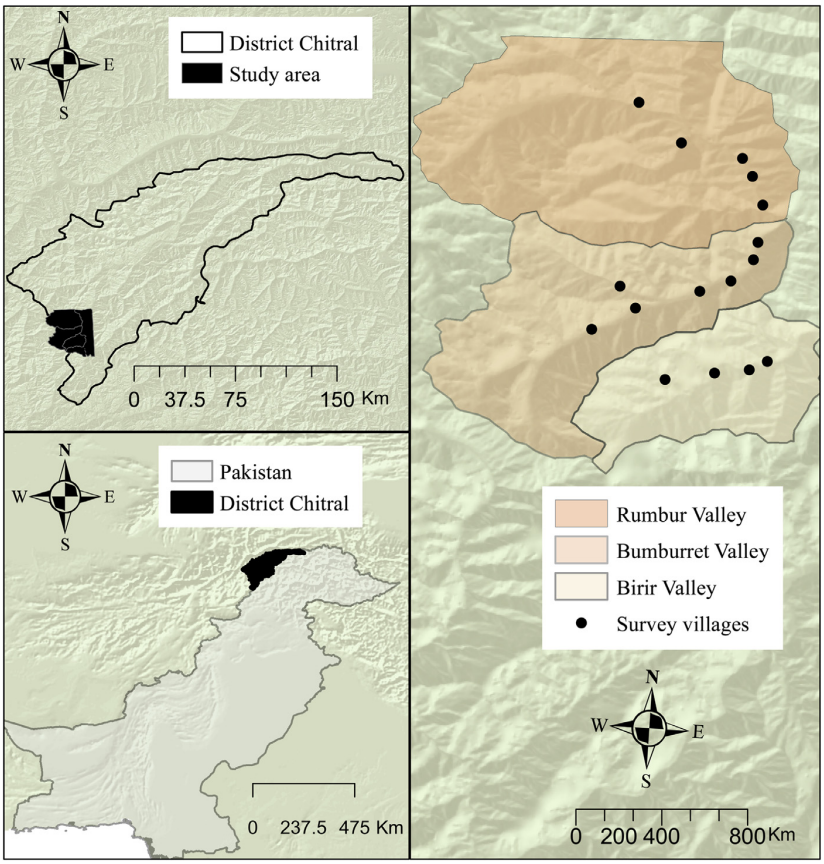

Fig. 1. Map of Pakistan showing the Chitral district (lower left panel) the location of the Kalasha valleys (upper left panel), and the Kalasha valleys (upper panel).

potential for agricultural expansion. Our sample includes non-Kalasha households and a wide spectrum of assets levels, ownership and membership with forest management associations. Though not a random sample, variability in these criteria ensures a good representation of communities.

3.2. Variables and expectations

Our statistical analysis relies on a binary response variable, indicating whether households cleared forest since 2003, as well as a continuous response variable of area cleared per household since 2003. Predictor variables comprise a set of attributes related to household's human, social, physical and financial characteristics that may be related to forest clearing. The predictor variables were selected based on a questionnaire developed by the Poverty Environment Network (PEN) of the Centre for International Forestry Research (CIFOR) (https://www.cifor.org/pen). The questionnaire is based on work by Cavendish (2000).

This study used the livelihood framework (LF) as an organizing approach to assess the effects of assets available to the households on forest clearing decision and area cleared. The framework provides a general method for thinking about the various factors and their interactions that influence land use decisions (Angelsen et al., 2012; Babigumira et al., 2014). The core idea of livelihood framework is that availability of, and access to, assets determines the strategies people adopt to attain the livelihood outcomes in a given policy and institutional context (Haan and Zoomers, 2005). The expected effects are summarized in Table 1.

Most of the variables identified in Table 2 are coded as continuous variables. Membership in a Joint Forest Management Committee (JFMC), forest ownership, and ethnicity were coded as categorical variables. The variable "Kalasha" was treated as 1 if the ethnicity of the household was recorded as Kalasha, 0 otherwise. The variable "JFMC" was treated as 1 if the household was a member of a JFMC, 0 otherwise. The variable "Owner" was treated as 1 if the household was considered a legal owner, 0 otherwise. The variable "Claimant" was treated as a 1 if the household was considered a "Claiming owner", 0 otherwise. Households considered non-owners had the values of both "Owner" and "Claimant" set to zero.

3.3. Household surveys

We used a survey instrument based on the PEN questionnaire mentioned above. The questionnaire is used to collect information on the household income, including income from forests, wages, business, crops, and livestock. The questionnaire also includes detailed sections on household assets, forest resource use, forest access, and aspects of forest governance.

The primary survey respondent was the head of the household. The survey was implemented through a semi-structured interview focused on recording household assets, including human, social, natural, physical and financial capital. It also included questions on topographic variables such as slope, aspect and elevation of the cleared land. Six non-local enumerators were trained to conduct the surveys, which were conducted over a 6-month period starting in June 2016.

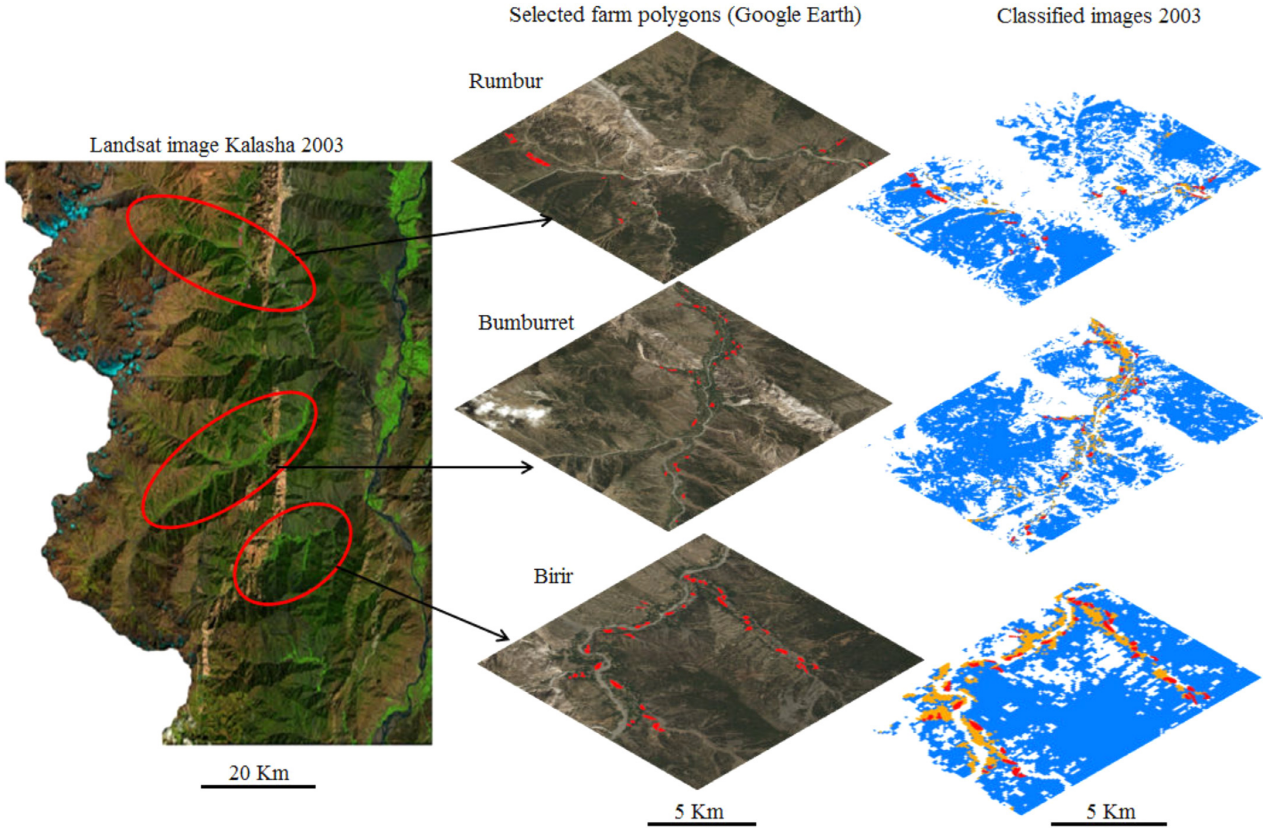

Fig. 2. Methodology schematic showing the selected farm polygons in red (center column) based on remotely sensed land cover changes since 2003 (right column), where brown indicates cropland land and blue indicates forest.

3.4. Statistical analysis

We used a regression modeling approach to examine the relationship between the land clearing decision in the period 2003–2015, and a set of explanatory variables related to household and farm characteristics (Table 1). Because 49 of the 123 sampled households cleared no land in the period, techniques which allow zero-inflated data were chosen: a logit model for a binary response variable (reflecting the binary decision to clear or not to clear land) and a tobit model for a zero-inflated response predicting area cleared, including zero area. We chose to analyze the data using both logit and tobit models as the logit model is useful for explaining the relationship between the probability of land-clearing and the explanatory variables, and the tobit model is useful for explaining the relationship between area cleared and the explanatory variables.

The logit model is represented by Eq. (1) (Gujarati 2003):

$$\text{logit}(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 x_{1,i} + \ldots + \beta_m x_{m,i} \quad (1)$$

where (p_i) represents the probability that farm associated with observation i was cleared in the time period, and $x_{m,i}$ represents the value of the mth independent variable for observation i.

Solution procedures for tobit models use the method of maximum likelihood. The estimated coefficient provides an equation for a latent variable, y_i^*, which is related to the observable dependent variable through the ramp function in Eq. (2):

$$y_i^* = \beta x_i + \in_i \quad (2)$$

$$y_i = \begin{cases} 0 \; if \; y_i^* \leq 0, \\ y_i^* \; if \; y_i^* \geq o, \end{cases}$$

where y_i is the observed dependent variable and $y_i^*$is the latent variable, which is greater than zero when households are involved in forest clearing.

4. Results

4.1. Household summary statistics

In our sample of 123 households, 60% of respondents expanded their farms into forested land since 2003. The median forested land cleared by households for the purpose of agriculture since 2003 was 0.22 ha. The motives for forest clearing were primarily expansion of cropland (77%) and, to a lesser degree, expansion of pasture (18%) and orchards (5%). The principal crops grown on the cleared land were wheat, maize and beans.

The household size in the study area is higher than the national average at 6.8 persons per household. The maximum household size recorded as 32 members. On average, households extract 13 tons/year of firewood from forests. Most of the heads of household were in their productive age and had established families. The median settlement time was 31 years. In the sample households, the years of schooling were low: most of the heads of household did not complete primary level education. Off-farm employment is the only source of winter income for majority of households. Off-farm employment opportunities in the Kalasha valleys are limited to teaching in school, shop keeping, and running small businesses. For men, collecting fuelwood and timber in

Table 1
List of predictor variables that may influence forest clearing decisions and area cleared. A plus and minus sign is assigned to indicate the anticipated direction of the relation between the predictors and response variables.

Variables	Definition & Unit of measurement	Expected sign
Human capital		
Household size	Total number of people in the household (people)	+
Age of head	Household age in years (years)	–
Education of head	Years of schooling (years)	–
Employed off-farm	Number working in off-farm sector (people)	–
Social capital		
JFMC (membership)	Membership of forest organization (0/1)	–
Forest ownership	Forest ownership (categorical)	
Kalash (ethnicity)	Membership of large ethnic group (0/1)	-
Time of settlement	Time of residence in the village years (years)	+
Physical & natural capital		
Physical assets	Value of household implements and other large items in Pakistan rupees (PKR)	-/+
Distance from forest	Distance of cleared land from forest	–
Distance to market	Distance of cleared land to market in Ayun (km)	–
Cropland area (2003)	Agriculture land owned by the household in 2003 (ha)	–
Financial capital		
Livestock value	Estimated value of livestock (PKR)	+
Saving	Total saving (PKR)	–
Debt	Total amount debt in (PKR)	+
Parcel characteristics		
Slope of land cleared	Slope of cleared land in	–
Elevation of land cleared	Elevation of cleared land (km)	–

the nearby forested land is an important source of off-farm cash income. Some families send members to other districts to work during winter. The median number family members working off-farm was two. Sixty-five percent of the sampled households were members of Joint Forest Management Committees (JFMCs), 50% of survey respondents were considered legal collective owners of the forest, and 51% belonged to the Kalasha ethnic group.

4.2. Factors influencing forest clearing

The box plots shown in Figs. 3 and 4 give an indication of the relationship between area cleared and the independent variables. The median of the area cleared by households with 10 or more members was twice that cleared by families with 4 or fewer members. The results of the logit model indicate that household size, number of members employed off-farm, the value of physical assets, membership in JFMCs, and distance to market show a significant relationship ($p < 0.1$) with the land clearing decision (Table 2). As expected, larger households are more likely to clear forest (Table 2). The distribution of the area cleared by household size class (Fig. 3) showed that families of ten or more members cleared two times more forest than families of four or fewer members. Larger households may have more labor available for land clearing and have a greater need for land to feed their members. Households with members employed off-farm were less likely to clear forest to expand their farm (Table 2). This may be because the households with members in off-farm sector are likely less dependent on subsistence agriculture and they may also less labor available for clearing.

Fig. 5

Richer households (as measured by the value of physical assets) were less likely to clear forest land (Table 2). Richer households are more involved in off-farm activities and less dependent on subsistence

Table 2
Results of regression analysis for factors influencing forest clearing for agriculture expansion between 2003 and 2015. Values in parentheses are standard error (SE). The variable JFMC has the value of 1 if the household is a member of a JFMC, 0 otherwise. The variable Kalasha has a value of 1 if the household belongs to the Kalasha ethnic group. The variable Owner has a value of 1 if the household is classified as an owner, 0 otherwise. The variable Claimant has a value of 1 if the household is classified as a claiming owner, 0 otherwise.

Predictor variable	Clearing decision (Logit model)	Area cleared (Tobit model)
Cropland area (2003)	−0.102 (0.193)	−0.002 (0.027)
Distance from forest	−0.040 (0.196)	−0.012 (0.027)
Household size	0.164**(0.088)	0.017* (0.012)
Employed off-farm	−0.359**(0.167)	−0.064***(0.025)
Physical Assets	−0.222**(0.098)	−0.031**(0.015)
Livestock	0.131 (0.110)	0.018 (0.014)
Savings	−0.485(0.300)	−0.067(0.047)
Debt	−0.296(0.391)	−0.028 (0.057)
JFMC	−1.25*(0.623)	−0.166 *(0.094)
Kalasha	0.983 (0.657)	0.151 (0.099)
Owner	0.104 (0.819)	−0.043 (0.114)
Claimant	0.519 (0.815)	0.084 (0.118)
Age of head	0.023 (0.031)	0.003 (0.005)
Settlement time	0.008 (0.022)	0.004 (0.003)
Education	−0.056 (0.051)	0.0003 (0.007)
Slope	−0.011 (0.057)	0.010 (0.007)
Elevation	−1.009 (1.183)	−0.058 (0.162)
Market Distance	−0.050*(0.027)	0.008**(0.004)
Fuelwood Extracted	0.052 (0.034)	0.006 (0.004)
Constant	2.553 (2.705)	0.034 (0.397)
Observations	123	123
Log Likelihood	−60.721	−48.186
Akaike inf.crit.	161.441	
Wald Test		34.091**

Notes:
* 10% level of significance.
** 5% level of significance.
*** 1% level of significance.

agriculture. Households with membership in JFMCs were less likely to clear land, perhaps because of greater engagement in and understanding of forest management. Distance from the market village of Ayun was negatively related to the clearing decision, as expected. None of the other predictor variables examined had significant coefficients ($p < 0.1$ levels).

Goodness-of-fit for the logit model was tested using the Hosmer-Lemeshow test with 10 groups. The X^2 value was 5.57 with a p value of 0.679. The null hypothesis that the fitted model is correct could not be rejected.

The results of the tobit model for area cleared indicates that off-farm employment, value of physical assets, membership in JFMCs, and distance to market were significantly related (at the $p < 0.1$ level) to area cleared (Table 2). The results are largely consistent with the expectations. Area cleared was negatively related to the number of household members working off-farm. We were unable to find any significant relationship of area cleared (and probability of clearing) with any of the other predictor variables. (Table 2). Overall, the performance of the tobit model was quite weak with only 14.8% of the variance (as measured by the square of the correlation between measured and predicted areas) accounted for by the model.

5. Discussion

5.1. Off-farm employment

Policies aimed at stimulating off-farm employment and revenue generating activities discourage deforestation in two ways; 1) by reducing dependence on subsistence agriculture thereby reducing the need to clear land; and 2) by labor competition, where time spent as a

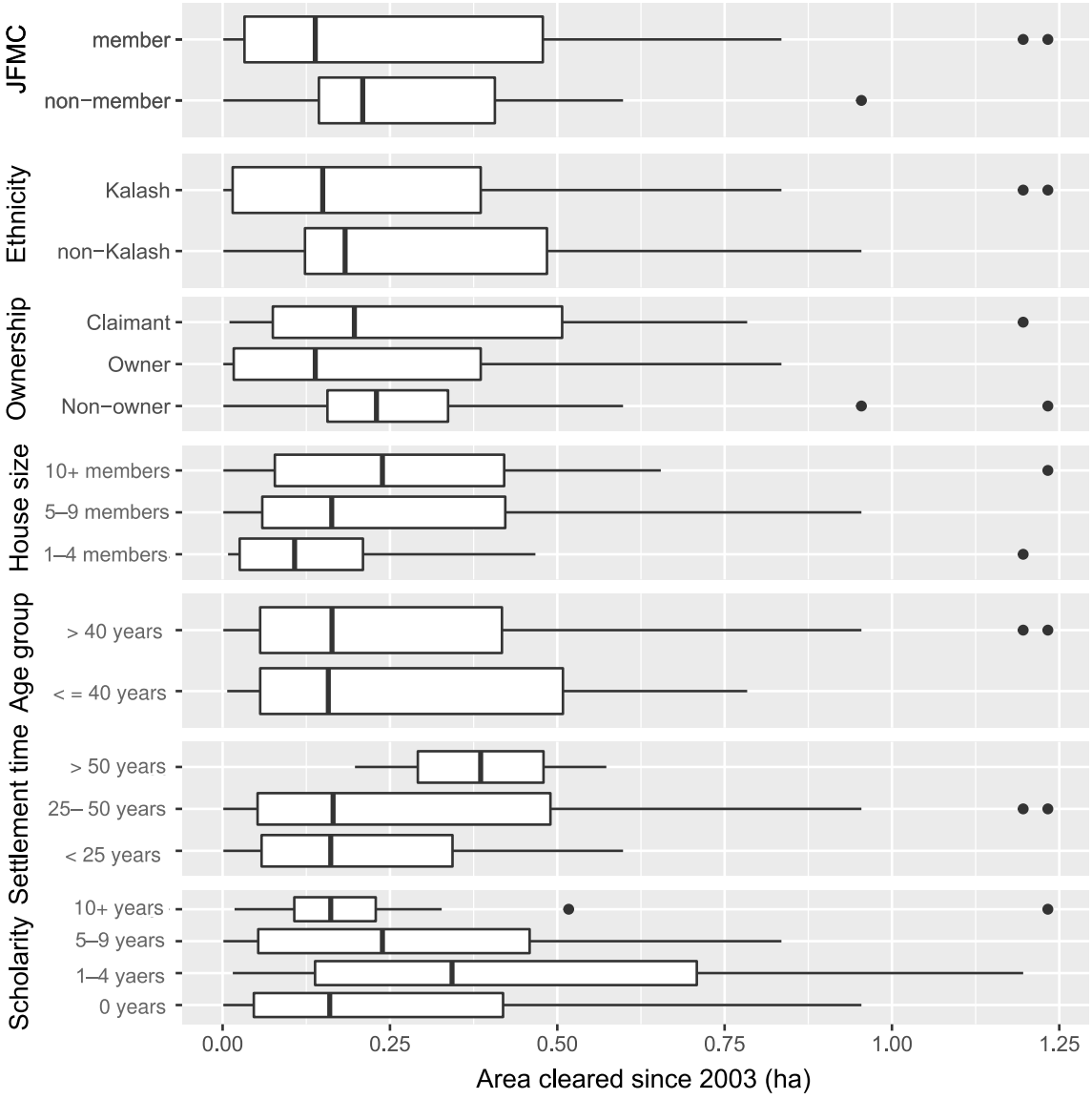

Fig. 3. Household survey results for socioeconomic and demographic variables in relation to the area cleared since 2003. The boxplots indicate how the predictor variables are associated with the median and quartiles of forest clearing values for these households.

wage laborer means less time is available for agriculture (Pan et al., 2007; Kassie., 2017; Busch and Ferretti-Gallon., 2017; Bou Dib et al., 2018). Our results confirm these expectations and they are also consistant with recent research conducted on indigenous community living in Ecuadorian Amazon (Vasco et al., 2018). They found that households recieving off-farm income were less likely to be involved in agriculture production: off-farm earnings reduce the needs to clear forest and expand agriculture land. Indigenous commmunities worldwide are natural resource dependent (O'Faircheallaigh, 2013). Off-farm empolyment may help achive forest conservation, if the activites or opportunities are environmentally friendly.

5.2. Household wealth

Some studies argue that most land is deforested by the poor (Pandit and Thapa, 2003; Sapkota and Odén, 2008; Aggrey et al., 2010; Hubler, 2017; Van Khuc et al., 2018). However, other research showed the link between income and forest clearing resembling an inverted U, with clearing peaking among middle income households (Adhikari et al., 2004; Reetz et al., 2011). Our results generally confirm the former expectation with the poorest households in the Kalasha valleys mostly relying on forest products for their annual income, while the opposite was true for the richest households.

An obvious reason for the poor to clear more land could be the subsistence nature of agriculture in the region that constantly pushes them to clear more land to survive, given the lack of alternative employment opportunities. Poor households are resource dependent, and unemployed members of the household will supplement the income through clearing and wood collection.

Worldwide, indigenous people are the poorest and most

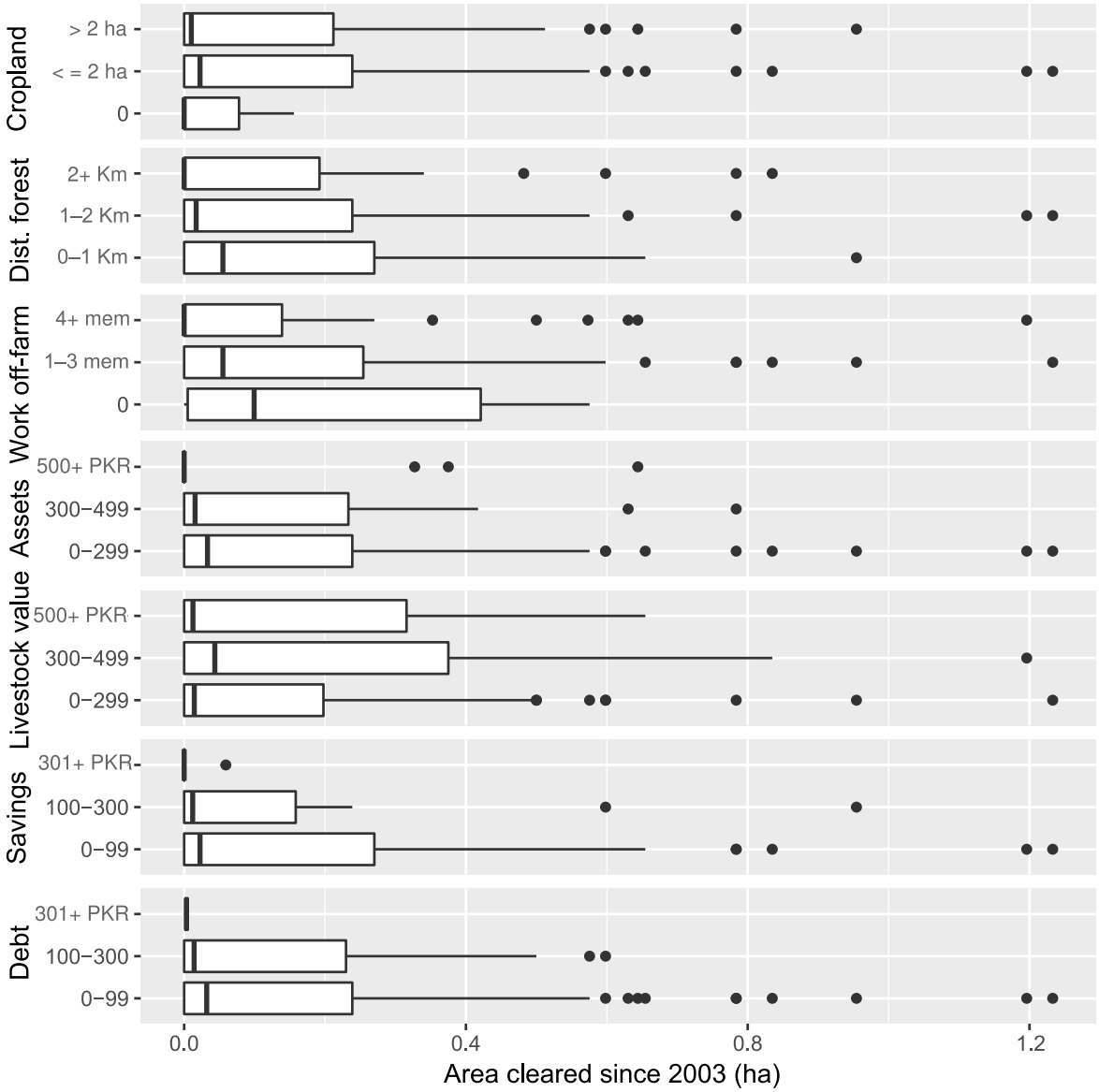

Fig. 4. Household survey results for financial and physical assets in relation to the area cleared since 2003. The boxplots indicate how the predictor variables are associated with the median and quartiles of forest clearing values for these households.

marginalized groups in society with higher poverty rates and larger poverty gaps than national averages (Coria and Calfucura, 2012).

5.3. Household size

Household composition has been linked to forest conversion on forest margins due to its association with high demand for food and surplus labor (Walker et al., 2002; VanWey et al., 2007; Carr, 2005; Sellers, 2017). In our analysis, household size had a significant effect on probability of clearing and area cleared. Households in the area are larger than the national average, and landholding size is small due to sub-division as generations pass. Large households generally mean more labor being avalailble for clearing and wood collection, and natural forests are the only source of firewood in the region.

5.4. Market access

The negative relationship of probability of area cleared with distance to the market village of Ayun is consistent with prior studies (de Souza Soler and Verburg, 2010; Caviglia-Harris and Harris, 2011). This relationship appears to be well explained by the von Thünen theory of land rent, which suggests that the rents to agricultural lands are highest near markets (Caviglia-Harris and Harris, 2011), thus creating an incentive to clear those lands first. Another possibility to explain the negative relationship between distance to market and forest clearing is that the effect of fuelwood collection for sale. The closer to market, the lower transportation cost of fuelwood is, which may lead the household allocate family labor to fuelwood collection. Fuelwood harvesting followed by cropland expansion in the study area is the most common and significant cause of deforestation and has a major impact

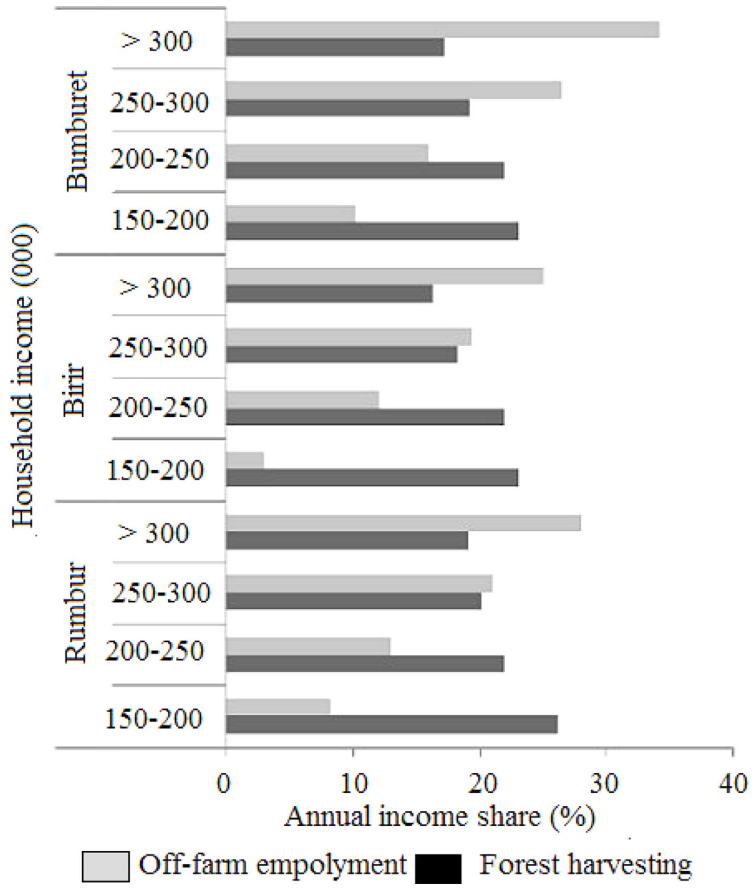

Fig. 5. Comparsion of income share from off-farm empolyment and forest resource use.

on resources. The average household burns 13 tons of wood annually to cope with severe winters.

The effect of market integration depends on nearby markets. If, the nearby market is used for the sale of agriculture and forest produce, deforesation will be higher in area close to market (Vasco et al., 2015). In case, the nearby market is use for off-farm jobs, deforestation will be lower in area close market (Vasco et al., 2015). Off-farm jobs may help achieve both economic wellbeing and forest conservation since it provides higher incomes while reducing household labor allocated to farm work. However, it is worth noting that well paid jobs are rare for indigenous people and they mostly trade raw natural resource-based products in local markets. Local market development through promoting environment friendly business activities such as tourism, ecotourism, local made handicraft, and commercialization of non-timber forest products may be the best policy options for indigenous communities.

5.5. Ownership and ethnicity

In many studies, ownership and ethnicity are important social variables that play key roles in the forest clearing decision (Vergara and Potvin, 2014; Robinson and Lokina, 2011; Finley, 2007, 2018; Holland et al., 2017). In our analysis, neither ownership nor ethnicity had a statistically significant effect on the probability of land clearing or the area cleared. The lack of repsonse to ownership and ethnicity may be related to the current logging ban policy. In 1993, the government completely banned commercial cutting: owners received their last payment of timber sale proceeds in 1996. The ban adversely impacted forest owners who depended on income from commercial timber proceeds of Forest Department for their livelihood. Due to this ban, owners may have lost any financial incentive for sustainable forest management and forest protection. Financial incentive programs create sense of ownership and responsibility among the community and reduce deforestation. A recent study in Amazon reported a 70% reduction in deforestation attributable to the ongoing conservation incentive program (Jones et al., 2016).

6. Conclusions and policy implications

This study used household level approach by relating household level forest clearing with socio-economic predictor variables. The approach captures the household level heterogeneity and complexity that may be lost at the higher level of aggregation. Methods that focus only on the market and physical attributes of land such as biophysical and geographic variables under-emphasize the role of household specific characteristics. We find that household's socio-economic and demographic characteristics such as household size, off-farm employment, value of physical assets, membership in JFMCs, and distance to market are related to both the probability of a household clearing forest and the area cleared by the household.

Single policy prescriptions, such as the 1993 logging ban, designed to affect broad-scale changes in land management practices without reference to specific landowners and their circumstance have proven ineffective (Zeb et al., 2019). To effect the greatest change, a diversity

of policies targeting households with different socio-economic conditions is more likely to achieve the desired environmental outcomes. We conclude that programs focusing on off-farm income generation opportunities targeted towards the poorest households would be the most effective policy intervention. This is of particular importance for the Kalasha valleys, where job opportunities are limitted and inaccessibility limits movement of labour for off-farm work to urban centers. Also, the internal infrastructure is poor and it is difficult for local entrepreneurs to start off-farm enterprises.

Policy makers may also reduce deforestation through providing financial incentives for forest protection, for example by implementing REDD + incentives meant to reward sustainable forest management and forest conservation to enhance carbon sequestration.

Measures to control population growth may also be beneficial. Larger households were associated with the highest probability of clearing and the largest areas cleared. Initiatives targeted at education of women, improved medical facilities, and income security would all contribute to a reduced need for large families that currently drive population growth in the Kalasha valleys.

Indigenous people around the world share many characteristics and are confronted by similar problems (e.g. geographic isolation, high population growth, poverty, and low employment opportunities). We believe that our analysis and conclusions are not only helpful for describing the socio-economic drivers of forest conversion in the Kalasha indigenous communities but will likely also be applicable to other indigenous and marginalized forest-dependent communities that share similar socio-economic conditions.

Declaration of Competing Interest

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Acknowledgments

This work is sponsored by Higher Education Commission of Pakistan and Shaheed Benazir Bhutto University, Sheringal Dir Pakistan under Award Letter no.: SBBU/Estb/Ord/13-305.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.gloenvcha.2019.102004.

References

Adhikari, B., Salvatore, D.F., 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.

Aggrey, N., Wambugu, S., Karugia, J., Wanga, E., 2010. An investigation of the poverty-environmental degradation nexus: a case study of Katanga basin in Uganda. Res. J. Environ. Earth Sci. 2, 82–88. https://doi.org/10.1111/dpr.12212.

Alix-Garcia, J., de Janvry, A., Sadoulet, E., 2005. A tale of two communities: explaining deforestation in mexico. World Dev. 33, 219–235. https://doi.org/10.1016/j.worlddev.2004.07.010.

Angelsen, A., Brockhaus, M., Sunderlin, W.D., Verchot, L., 2012. Analyzing Redd+: challenges and choices. In: CIFOR. Centerfor International Forestry Research (CIFOR). Bogor, Indonesia.

Ayub, Q., Mezzavilla, M., Pagani, L., Haber, M., Mohyuddin, A., Khaliq, S., Tyler-Smith, C., 2015. The Kalash genetic isolate: ancient divergence, drift, and selection. Am. J. Hum. Genet. 96, 775–783. https://doi.org/10.1016/j.ajhg.2015.03.012.

Babigumira, R., Angelsen, A., Buis, M., Bauch, S., Sunderland, T., Wunder, S., 2014. Forest clearing in rural livelihoods: household-level global-comparative evidence. World Dev. 64, 67–79. https://doi.org/10.1016/j.worlddev.2014.03.002.

Busch, J., Ferretti-Gallon., K., 2017. What drives deforestation and what stops it? A meta-analysis. Rev. Environ. Econ. Policy 11, 3–23. https://doi.org/10.1093/reep/rew013.

Caviglia-Harris, J., Daniel, H., 2011. The impact of settlement design on tropical deforestation rates and resulting land cover patterns. Agric. Econ. Res. Rev. 40, 451–470.

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.

Carr, D., 2005. Forest clearing among farm households in the Maya Biosphere Reserve. Prof. Geogr. 57, 157–168 http://www.tandfonline.com/doi/abs/10.1111/j.0033-0124.2005.00469.x.

Carr, D.L., Lopez, A.C., Bilsborrow, R.E., 2009. The population, agriculture, and environment nexus in Latin America: country-level evidence from the latter half of the twentieth century. Popul. Environ. 30, 222–246. https://doi.org/10.1007/s11111-009-0090-4.

Chowdhury, R.R., 2010. Differentiation and concordance in smallholder land use strategies in southern Mexico's conservation frontier. Proc. Natl. Acad. Sci. https://doi.org/10.1073/pnas.0905892107. 200905892.

Coria, J., Calfucura, E., 2012. Ecotourism and the development of indigenous communities: the good, the bad, and the ugly. Ecol. Econ. 73, 47–55. https://doi.org/10.1016/j.ecolecon.2011.10.024.

de Souza Soler, L., Verburg, P.H., 2010. Combining remote sensing and household level data for regional scale analysis of land cover change in the Brazilian Amazon. Reg. Environ. Change 10, 371–386.

Dib, J.B., Alamsyah, Z., Qaim, M., 2018. Land-use change and income inequality in rural Indonesia. For. Policy Econ. 94, 55–66. https://doi.org/10.1016/j.forpol.2018.06.010.

Duveiller, G., Defourny, P., Desclée, B., Mayaux, P., 2008. Deforestation in Central Africa: estimates at regional, national and landscape levels by advanced processing of systematically-distributed Landsat extracts. Remote Sens. Environ. 112, 1969–1981. https://doi.org/10.1016/j.rse.2007.07.026.

Evans, T.P., Kelley, H., 2008. Assessing the transition from deforestation to forest regrowth with an agent-based model of land cover change for south-central Indiana (USA). Geoforum 39, 819–832.

FAO., 2011. State of the World's Forests 2011. Food and Agricultural Organization of the United Nations, Rome (ISBN 978-92-5-106750-5).

Fisher, M., 2004. Household welfare and forest dependence in Southern Malawi. Environ. Dev. Econ. 9, 135–154. https://doi.org/10.1017/S1355770X03001219.

Finley-Brook, M., 2007. Indigenous land tenure insecurity fosters illegal logging in Nicaragua. Int. For. Rev. 9, 850–864.

Garnett, S.T., Burgess, N.D., Fa, J.E., Fernández-Llamazares, Á., Molnár, Z., Robinson, C.J., Collier, N.F., 2018. A spatial overview of the global importance of Indigenous lands for conservation. Nat. Sustain. 1, 369–374. https://doi.org/10.1038/s41893-018-0100-6.

Gujarati, D.N., Porter, D.C., 2003. Basic Econometrics. 4th.

Haan, L., Annelies, Z., 2005. Exploring the frontier of livelihoods research. Dev. Change 36, 27–47. https://doi.org/10.1111/j.0012-155X.2005.00401.x.

Hall, G.H., Patrinos, H.A. (Eds.), 2012. Indigenous Peoples, Poverty, and Development, Eds. Cambridge University Press.

Holland, M.B., Jones, K.W., Naughton-Treves, L., Freire, J.L., Morales, M., Suárez, L., 2017. Titling land to conserve forests: the case of Cuyabeno Reserve in Ecuador. Global Environ. Change 44, 27–38. https://doi.org/10.1016/j.gloenvcha.2017.02.004.

Hübler, M., 2017. How to curb poverty-related deforestation? Appl. Econ. Lett. 24, 374–380. https://doi.org/10.1080/13504851.2016.1194959.

Jones, K.W., Holland, M.B., Naughton-Treves, L., Morales, M., Suarez, L., Keenan, K., 2016. Forest conservation incentives and deforestation in the Ecuadorian Amazon. Environ. Conserv. 44, 56–65. https://doi.org/10.1017/S0376892916000308.

Kassie, G.W., 2017. The Nexus between livelihood diversification and farmland management strategies in rural Ethiopia. Cogent. Econ. Finance 5, 127–143. https://doi.org/10.1080/23322039.2016.1275087.

Khan, S.R., Khan, S.R., 2009. Assessing poverty-deforestation links: evidence from Swat, Pakistan. Ecol. Econ. 68, 2607–2618. https://doi.org/10.1016/j.ecolecon.2009.04.018.

Khan, N., Shaukat, S.S., Ahmed, M., Siddiqui, M.F., 2013. Vegetation-environment relationships in the forests of Chitral district Hindukush range of Pakistan. J. For. Res. 24, 205–216.

Lapola, D.M., Schaldach, R., Alcamo, J., Bondeau, A., Koch, J., Koelking, C., Priess, J.A., 2010. Indirect land-use changes can overcome carbon savings from biofuels in Brazil. Proc. Natl. Acad. Sci. U.S.A. 107, 3388–3393. https://doi.org/10.1073/pnas.0907318107.

Nepstad, D., Schwartzman, S., Bamberger, B., Santilli, M., Ray, D., Schlesinger, P., 2006. Inhibition of Amazon deforestation and fire by parks and indigenous lands. Conserv. Biol. 20, 65–73. https://doi.org/10.1111/j.1523-1739.2006.00351.x.

Nuno, A., John, F.A.S., 2015. How to ask sensitive questions in conservation: a review of specialized questioning techniques. Biol. Conserv. 189, 5–15. https://doi.org/10.1016/j.biocon.2014.09.047.

Nusser, M., Dickore, W.B., 2002. A tangle in the triangle: vegetation map of the eastern Hindukush (Chitral, northern Pakistan). Erdkunde 56, 37–59 https://www.jstor.org/stable/23218603.

O'Faircheallaigh, C., 2013. Extractive industries and indigenous peoples: a changing dynamic? J. Rural Stud. 30, 20–30. https://doi.org/10.1016/j.jrurstud.2012.11.003.

Pan, W., Carr, D., Barbieri, A., Bilsborrow, R., Suchindran, C., 2007. Forest clearing in the Ecuadorian Amazon: a study of patterns over space and time. Popul. Res. Policy Rev. 26, 635–659. https://doi.org/10.1007/s11113-007-9045-6.

Pandit, B.H., Thapa, G.B., 2003. A tragedy of non-timber forest resources in the mountain commons of Nepal. Environ. Conserv. 30, 283–292. https://doi.org/10.1017/S0376892903000286.

Patton, M.Q., 2002. Two decades of developments in qualitative inquiry: a personal, experiential perspective. Qual. Soc. Work 1, 261–283. https://doi.org/10.1177/1473325002001003636.

Porro, R., Lopez-Feldman, A., Vela-Alvarado, J.W., Quiñonez-Ruíz, L., Seijas-Cardenas, Z.P., Vásquez-Macedo, M., Cardenas-Ruiz, J., 2014. Forest use and agriculture in

Ucayali, Peruvian Amazon: interactions among livelihood strategies, income and environmental outcomes. Tropics 23, 47–62 10.3759/tropics.23.47.
Rafiq, M., Sahafiaullah., 2008. Demand analysis of recreation visit to Kalash valleys. In: Paper presented at the 24th AGM of PIDE. Islamabad, Pakistan. http://www.heritage.gov.pk.
RAISG., 2015. Deforestacion en la Amazônia (1970–2013). www.raisg.socioambiental.org, Lima, Peru.
Reetz, W.H., Schwarze, S.S., Brümmer, B., 2011. Poverty and tropical deforestation in forest margin areas: evidence from central Sulawesi. In: Conference on International Research on Food Security, Natural Resource Management and Rural Development. University of Bonn, Indonesia.
Rindfuss, R.R., Walsh, S.J., Ii, B.L.T., Fox, J., Mishra, V., 2004. Developing a science of land change: challenges and methodological issues. Int. J. Epidemiol. 101, 13976–13981. https://doi.org/10.1073/pnas.0401545101.
Robinson, E.J.Z., Lokina, R.B., 2011. A spatial-temporal analysis of the impact of access restrictions on forest landscapes and household welfare in Tanzania. For. Policy Econ. 13, 79–85. https://doi.org/10.1016/j.forpol.2010.08.003.
Robinson, B.E., Masuda, Y.J., Kelly, A., Holland, M.B., Bedford, C., Childress, M., Lawry, S., 2018. Incorporating land tenure security into conservation. Conserv. Lett. 11, 1–12. https://doi.org/10.1111/conl.12383.
Rosa, I.M., Purves, D., Souza Jr., C., Ewers, R.M., 2013. Predictive modelling of contagious deforestation in the Brazilian Amazon. PLoS ONE 8, 440–451. https://doi.org/10.1371/journal.pone.0077231.
Sapkota, I.P., Odén, P.C., 2008. Household characteristics and dependency on community forests in Terai of Nepal. Int. J. Soc. For. 1, 123–144.
Schwartzman, S., Moreira, A., Nepstad, D., 2000. Rethinking tropical forest conservation: perils in parks. Conserv. Biol. 14, 1351–1357. https://doi.org/10.1046/j.1523-1739.2000.99329.x.
Sellers, S., 2017. Family planning and deforestation: evidence from the Ecuadorian Amazon. Popul. Environ. 38, 424–447 10.1007/s1111.
Shively, G., Pagiola, S., 2004. Agricultural intensification, local labor markets, and deforestation in the Philippines. Environ. Dev. Econ. 9, 241–266. https://doi.org/10.1017/S1355770X03001177.
Soares-Filho, B.S., Nepstad, D.C., Curran, L.M., Cerqueira, G.C., Garcia, R.A., Ramos, C.A., Schlesinger, P., 2006. Modelling conservation in the Amazon basin. Nature 440, 520–523 10.1038/nature04389.
Stevens, C., Winterbottom, R., Springer, J., Reytar, K., 2014. Securing Rights, Combating Climate Change: How Strengthening Community Forest Rights Mitigates Climate Change. World Resources Institute, Washington, DC, USA, pp. 56.
Taj, A., Ali, S., 2018. Erosion of Kalasha's religio-cultural identity in Northern Pakistan: context, causes and implications. FWU J. Soc. Sci. 12, 35–47.
VanWey, L.K., D'Antona, Á., Brondízio, E.S., 2007. Household demographic change and land use/land cover change in the Brazilian Amazon. Popul. Environ. 28, 163–185. https://doi.org/10.1007/s11111-007-0040-y.
Van Khuc, Q., Tran, B.Q., Meyfroidt, P., Paschke, M.W., 2018. Drivers of deforestation and forest degradation in Vietnam: an exploratory analysis at the national level. For. Policy Econ. 90, 128–141. https://doi.org/10.1016/j.forpol.2018.02.004.
Vergara-Asenjo, G., Potvin, C., 2014. Forest protection and tenure status: the key role of indigenous peoples and protected areas in Panama. Global Environ. Change 28, 205–215. https://doi.org/10.1016/j.gloenvcha.2014.07.002.
Vasco, C., Bilsborrow, R., Torres, B., 2015. Income diversification of migrant colonists vs. indigenous populations: contrasting strategies in the Amazon. J. Rural Stud. 42, 1–10. https://doi.org/10.1016/j.jrurstud.2015.09.003.
Vasco, C., Bilsborrow, R., Torres, B., Griess, V., 2018. Agricultural land use among mestizo colonist and indigenous populations: contrasting patterns in the Amazon. PLoS ONE 13, e0199518. https://doi.org/10.1371/journal.pone.0199518.
Walker, R., Perz, S., Caldas, M., Silva, L.G.T., 2002. Land use and land cover change in forest frontiers: the role of household life cycles. J. Mt. Sci. 25, 169–199. https://doi.org/10.1007/s11629-015-3545-3.
Zeb, A., Hamann, A., Armstrong, G.W., Acuna-Castellanos, D., 2019. Identifying local actors of deforestation and forest degradation in the Kalasha valleys of Pakistan. For. Policy Econ. 104, 56–64. https://doi.org/10.1016/j.forpol.2019.04.005.