Trends, causes, and actors of deforestation and forest degradation in the Kalasha valleys of Pakistan: A multi-level analysis

by

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Abstract

Prevention of forest loss is a high priority in Pakistan, where deforestation has been linked to catastrophic flooding in 1992 and 2010. Under the United Nation's REDD+ program, new incentive schemes are developed to encourage forest protection and reforestation, while implementing social safeguards for forest-dependent indigenous groups. The overall objective of the study is to map and compare forest cover changes in the Chitral District of Pakistan and evaluate how deforestation and degradation rates are influenced by major changes in policy (*i.e.* a general logging prohibition implemented in 1993). This study also aims to identify actors who have caused deforestation in the past, and recommend policy improvements that protect forests as well as the Kalasha's culture and traditional livelihoods. The Kalasha are a unique indigenous people that are under enhanced protection of the UNESCO Intangible Cultural Heritage list. This thesis combines a regional remote sensing analysis, a district-level socioeconomic analysis for three valleys inhabited by the Kalasha people, and empirical household-level research to identify trends, causes, and actors of deforestation and forest degradation. This research includes a long-term analysis of deforestation and forest degradation for Pakistan's Chitral district, using Landsat MSS/TM/OLI TIRS-8 images to quantify forest cover changes prior (1973-1993) and after (1993-2015) a nation-wide logging ban in 1993. Forest cover changes were further evalu-

ated in the context of access and enforcement measured through distances to administrative boundaries, human activities, and topography. The results show that, despite a complete ban on commercial green felling, deforestation continued at a high rate. Agriculture land in the study area expanded in the pre-ban period but actually decreased by 12% post-ban, primarily due to flooding and erosion. The analysis showed that deforestation in the pre-ban period occurred in valuable high elevation conifer forests, while during the post-ban period deforestation shifted to low elevation oak forests near human habitation. High elevation conifer forests instead suffered from forest degradation during the post-ban period, presumably due to illegal selective cutting and legal high-grading through selective cutting of the most valuable trees.

The remote-sensing based historical analysis was further interpreted in the context of a socioeconomic analysis and expert surveys regarding the causes of deforestation. The results suggest that government actors have significant power to influence land use practices in the region, although their policy instruments may not have had the intended effects. A logging ban in 1993 caused a shift to small-scale selective cutting but could not stop forest loss. Near human habitation, forest loss actually increased after the ban. In household surveys, self-reported clearing of forests conformed to remote sensing data, and fuel wood use was identified as the primary pressure on forest resources. Results from expert interviews, however, revealed contradictory perceptions regarding the actors responsible for forest loss. Both local residents and government officials point to the other side as primarily responsible, while rationalizing their own contribution. Based on the remote sensing and field surveys, I selected 123 households on the forest margins for a detailed socioconomic survey to study factors related to household-level decision making with respect to forest clearing. The analysis was based on a contrast of 75 households that cleared nearby forested land with 48 households that did not expand. I found that families with more members, more livestock but fewer physical and financial assets were more likely to clear forested land for agricultural expansion. Families with more members employed off-farm were less likely involved in forest clearing. Social factors, such as education, ethnicity, and forest ownership were not significantly associated with clearing of forests.

I recommend policy changes towards more balanced power structure in joint forest management committees. In addition, alternative heating methods would remove the currently largest pressure on forest extraction for fuelwood. Since fuelwood production for regional consumption constitutes one of the largest sources of income for the poorest households, REDD-based compensation schemes would have to support the most affected households of the indigenous Kalasha. Alternative livelihood support and off-farm employment programs should also focus on the households that are most likely to continue forest clearing, namely asset-poor large families. I also recommend maintaining the logging ban, but that additional policies are necessary, namely forest management strategies for high-elevation conifer forests that reverse the effects of high-grading, for example reforestation activities with suitable planting stock, as well as better enforcement of protection of a specific set of timber species found in these forest ecosystems.

Preface

The ethics approval for the research was obtained through the Human Research Ethics Review process at the University of Alberta Ethics Board (Approval ID Pro00063604, May 16, 2016)

Chapter 2 of this thesis is currently prepared for submission as a journal article. The contributors are Zeb, A., Acuna-Castellanos, D., Hamann A, and Armstrong, G.W. The study was conceived and designed by myself. I conducted the remote sensing analysis with support from AH and GWA. DAC helped with GIS-based evaluation of spatial data. I wrote the first draft of the chapter. AH and DAC contributed to interpreting the results and editing the manuscript.

Chapter 3 of this thesis has been submitted as Zeb, A., Hamann A., Armstrong, G.W. and Acuna-Castellanos, D. (2018). Identifying local actors of deforestation and forest degradation in the Kalasha valleys of Pakistan. Forest Policy and Economics (revisions submitted). The study was conceived and designed by myself, with input from AH and my committee member John Parkins. I conducted the expert interviews and household surveys. GWA contributed a regional timber market analysis. I analyzed the remote sensing and GIS data with support by DAC, AH, and GWA. I wrote the first draft of the chapter. AH, GWA and DAC contributed to interpreting the results and editing the manuscript.

Chapter 4 of this thesis is currently prepared for submission as a journal article. The contributors are Zeb, A., Armstrong, G.W. and Hamann A. The study was conceived and designed by myself with input from AH and my committee member John Parkins. I conducted the expert interviews and household surveys. I analyzed the survey data with support from GWA. I wrote the first draft of the chapter and GWA contributed to interpreting the results and editing the manuscript.

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Chapter 1

Introduction

1.1 Deforestation and forest degradation in Pakistan

Deforestation and forest degradation in developing countries has been of concern to policy makers for at least the past two decades. This concern has largely been due to the contribution of forest loss and degradation to soil erosion, biodiversity loss and, more recently, climate change (J. Alix-Garcia, Janvry, and Sadoulet 2005). According to the FAO (2011), about 13 million ha of forest disappears each year worldwide. Deforestation refers to the conversion of forest or related ecosystems into less diverse ecosystem such as pasture land or cropland (Kricher 1989). Forest degradation is associated with a substantial reduction in forest production capacity over a long period of time within the forest through non-sustainable harvest (Hosonuma et al. 2012). Deforestation causes fragmentation through increasing edge and isolation of patches, and by decreasing size and connectivity of patches, while degradation affects biodiversity and ecosystem services (Foley et al. 2005; Haines-Young 2009).

In Pakistan, current deforestation rates and overall proportional loss of forest area are far above the global average. According to Government of Pakistan statistics remaining forests cover about 4.8% of the total land area. However, independent sources claim only 2% of the total land area in Pakistan remains as forest (FAO 2011). Forty percent of the country's forests are in Khyber Pakhtunkhwa (KP) province (Hassan, 2007). The forests of the KP province are spread over the high mountain ranges of Swat, Dir, Chitral and Hazara districts and remain under heavy social pressure (Steinmann 2005). It is one of the major reasons that most of the natural forests in these areas are depleted, which is evident from the current rate of deforestation in the country, which is considered to be among the highest in the South Asia at 2.2% per year (FAO 2011). The situation is worse in qualitative terms. Forests having canopy cover of 50% or more cover less than 0.5% of the total land area of the country. In fact, it estimated that if nothing is done to check the process most of the country's remaining forest will be gone by the year 2025 (Steinmann 2005).

Deforestation in the mountain regions of Pakistan in general, and in KP in particular, is harmful because it has resulted in large changes in local ecology and hydrology that have nationwide impacts (Oxley 2011). Over the years, major floods have occurred with increasing frequency in Pakistan; most prominent are the floods of 1992 and 2010. According to UN estimates, 1,600 people died in the 2010 floods, while 20 million people were affected, losing their homes, livelihood and assets; the estimated cost is as high as $43 billion (Oxley 2011). It is believed that extensive clearing of coniferous forests for agriculture, timber and fuelwood in Chitral, Swat, Dir and Manshera districts within KP is responsible for these downstream water problems (Cedar 2011; Oxley 2011). Further deforestation in the area would not only increase the overland flows and siltation problems in rivers and water reservoirs but will also accelerate soil erosion in the fragile watersheds of the area (Rehman and Sabir 2003).

There is disagreement on the underlying causes of deforestation and forest degradation in Pakistan. Previous studies in Pakistan have linked deforestation and forest degradation to various actors and their associated attributes. Fuelwood gathering and timber extraction and agriculture expansion by local communities (J. Ali and Benjaminsen 2004; J. Ali, Benjaminsen, et al. 2005; T. Ali et al. 2007; M. A. Khan et al. 2013; Qasim, Hubacek, and Termansen 2013; Shahbaz, T. Ali, and Suleri 2007), government policy failure with respect to clear forest rights and access (Fischer et al. 2010; Sultan-i-Rome 2007; Yusuf 2009), and to forest departments for their ineffective forest management and culture of corruption (Hasan 2001) have all been identified as causes of deforestation and degradation. There is limited consensus locally on who is responsible for the causes of deforestation and forest degradation and how it is to be stopped or slowed. This leads to a variety of explanations for deforestation processes creating uncertainty and policy grid-lock.

1.2 Policies to halt deforestation and forest degradation in Pakistan

Knowing drivers of deforestation and forest degradation is essential to define proper policies, strategies and implementation plans (Boucher et al. 2011). Forest conservation policies include protected areas, logging regulations, payment for ecosystem services and logging prohibitions (Brandt, Butsic, et al. 2015; Brandt, Kuemmerle, et al. 2012). A logging prohibitions or moratorium is a policy tool used in response to environmental, socio-economic, political and other concerns and issues that threaten the forest and the resources within

(Durst et al. 2001). This policy tool has been used in many countries including India, Bangladesh, Thailand, Indonesia, New Zealand, Pakistan, and China (Brandt, Butsic, et al. 2015; Durst et al. 2001). The success of this instrument as policy tool is variable. In some areas the ban is successful in conserving forest (Brandt, Butsic, et al. 2015; Brandt, Kuemmerle, et al. 2012) while in other areas the ban failed to achieve the desired objectives (Bugayong 2006; Sarker, Deb, and Halim 2011).

In Pakistan, a logging ban was introduced in 1993 after a catastrophic flood hit the country (Fischer et al. 2010). The severity of the flood was attributed to the large scale cutting of forests in the catchment areas of the main rivers. Deforestation is not new in Pakistan; its origin can be traced back to the colonial era. The commercial exploitation under British administration between 1850 and 1860 in the area has been termed as the first period of massive deforestation (Tucker 2012). Forest resources were mainly managed for revenue generation, railway construction, and to bear the cost of local administration (Das 2010). After liberation in 1947, Pakistan continued exploitative forest management plans focused on revenue generation through timber harvesting. Over cutting by timber contractors under the legal permit issued by the Forest Department was viewed as the leading cause of deforestation in the country (Knudsen 1996).

To control over-felling at the hand of forest contractors, the contract system was abolished in 1973 and the Forest Development Corporation was created for harvesting, transportation and sale of timber (Hasan 2007). Forest depletion continuesd at high rate mostly because of improper forest policies and political patronization (Shahbaz 2009). In order to depoliticize forestry affairs and give more control to people over their resources, in 1981 the government organized locals in the Hazara Division into forest management societies known as Forest

Co-operative Societies (FCS). The FCSs were responsible for felling and marketing operations (Knudsen 1996). Unfortunately, the co-operative societies also failed to control over-felling and were abolished by the federal government in 1993 (Fischer et al. 2010). The ban was accompanied by an action plan for reforestation and afforestation to increase forest cover from 5% to 10% of the country total area by 2010. Except for a one year relaxation in 2001, the ban has continued to be in force until the present.

1.3 REDD+ implementation in Pakistan

Pakistan is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and REDD+ (Reducing Emissions from Deforestation and Forest Degradation). It receives targeted funds to develop a readiness roadmap and a national forest monitoring system (Munawar, Khokhar, and Atif 2015; Qamar et al. 2011). Pakistan could earn between $400 million and $4 billion each year for carbon stored in the country's forests after successful implementation of REDD+. However, the lack of reliable data on forest cover, deforestation rates and localized causes of deforestation and degradation is a substantial hindrance to the effective implementation of REDD+ in the country (Hussain and Fatima 2015; Iqbal and I. A. Khan 2014).

In addition to the lack of reliable forest data and associated drivers of deforestation and degradation, there is a risk of neglecting the rights and interests of forest communities and indigenous groups. Any future REDD+ regime thus needs to incorporate social safeguards. This is particularly important in the case of Kalasha, an ethnic and religious minority of Pakistan. The Kalasha people are heavily depend on forests not only for their livelihood but also for their ritual practices.

1.4 Social and legal background

The Kalasha are an isolated and unique indigenous people of Indo-Aryan roots with a fusion of Indo-European culture and traditions (Ayub et al. 2015). A study by Rosenberg et al. (2006), employing genetic testing, concluded that they are a distinct population with only minor contributions from outside peoples. Starting in the 14th century, the Kalasha were largely displaced from their ancestral homes of Chitral by invaders from current Afghanistan who enforced the Muslim religion in the area. The Kalasha culture was reduced to a few valleys in southern Chitral. The dominant Muslim rulers governed Chitral as an independent monarchy until 1885 (IUCN 2004). After a period of colonial rule of the British Indian Empire, the Chitral District was fully absorbed into Pakistan in 1969 as part of the Northwest Frontier Province.

The Kalasha people's livelihood is based on a mixed mountain economy of small scale agriculture combined with livestock husbandry. Grain crops together with fruit and walnut trees are cultivated on a subsistence basis in the Kalasha valleys on tiny irrigated and terraced fields at an altitude around 1800 m. The Kalasha people practice an animistic religion that revolves around objects, places and creatures of the forests including mythical spirits and characters that live in the high mountains. They have traditionally relied on timber and non-timber products from the species rich and productive mid-elevation oak forests as well as the higher elevation conifer forests.

Historic land management is influenced by the Muslim rulers between the 14th and 19th century, who introduced Islamic law to govern many aspects of the legal system. However, they also recognized many of the Kalasha's customary laws that had evolved in the prior centuries, particularly with respect to issues related to natural resource use and sharing. Under customary law, committees of notables (*Jirga*) settled resource disputes between individuals and communities or clans, and in most cases their decision was final and binding on all parties. Matters involving common pool resources, such as pasture, forests and water channels were decided by the *Jirga*, and violators were fined (IUCN 1998; IUCN 2004).

In 1975, the Government of Northwest Frontier Province (now KP) declared all forests, pastureland and hunting parks as state property. However, communities share property rights with the state based on the accepted customs at the time the forests were taken over by the state (Hasan 2007; Shahbaz, Mbeyale, and Haller 2008). Based on the statutory and customary laws, villagers in the vicinity of forest maintain some ownership rights. They can extract standing timber for domestic use upon payment of concessionary fee. They are entitled to free grazing in the forested land and pasture (Hasan 2007). They have rights to collect dry, diseased and decayed trees for fuelwood use, and they are also entitled to a 60% share of timber sale royalties (Hasan 2001; Hasan 2007).

After the 1993 ban, the 60% share of timber sale royalties to local residents was terminated, but locals were permitted to harvest some live trees for their own use for building and repairing structures. Use of the forest is now administered at the village-level through a Joint Forest Management Committee (JFMC), consisting of forest department officials, local forest resource users and other local representatives. Inhabitants of forest districts of KP can legally obtain some trees for their own use through timber permits issued by forest department on recommendations of the JFMCs, which entitles them to harvest and transport a specific volume of timber.

1.5 Thesis structure and objectives

This thesis is a collection of three studies, tied together with this introductory chapter and a concluding chapter. The overall objective of the study is to map and compare forest cover changes in the Chitral District of Pakistan and evaluate how deforestation and degradation rates are influenced by major changes in policy: the imposition of a general logging prohibition in 1993. This study also investigates how multiple factors (topographic, distance and socio-economic) are affecting forest and agriculture land cover changes. The study was conducted at three different levels: region, valley and household level.

In my first data chapter, I contribute an analysis of effects of the 1993 general logging ban on rates and patterns of deforestation and forest degradation. I used Landsat MSS/TM/OLI TIRS-8 images, maximum likelihood classification and change detection techniques to analyze changes in forest cover in two distinct forest policy periods: 1973–1993 and 1993–2015. The study also analyzes the secondary role of topographic variables and spatial attributes of land in the absence and presence of logging prohibitions. The specific objectives of this study are: (1) to quantify rates and patterns of deforestation, forest degradation and agriculture expansion in the pre-ban era, *i.e.*, two decades before the logging ban (1973–1993), and in the post-ban timespan, *i.e.*, over two decades of the logging ban (1993–2015), (2) to evaluate and compare the relative importance of elevation, slope, aspect, distances (to administrative boundary, road, river, market and agriculture) on deforestation and forest degradation between the two periods, and (3) use this information to infer to the likely causes of deforestation and forest degradation and recommend policy changes to the existing forest management practices that could improve the effectiveness of logging ban.

For the second data chapter, I contribute an analysis to support Pakistan's REDD+ readiness activities that affect the Kalasha, a unique indigenous people nominated for enhanced protection of the UNESCO Intangible Cultural Heritage list. I aim to identify actors who have caused deforestation in the past, and analyze the effect of past policies meant to improve the protection of forests. The analysis relies on 191 household surveys in 15 villages in three valleys. The sample represents 15% of all households and covers all areas inhabited by the Kalasha. For context, I quantify deforestation and forest degradation patterns before and after the Pakistani federal government instituted a logging ban in 1993. I also conducted expert interviews of the district's government employees in the forest department, local community leaders involved in the management of forests, and regional NGOs that operate on livelihood and forest conservation and development. The central objective of this study is to understand the interests and motivations of the actors involved in forest depletion, infer the power structures among these actors, and investigate if their perceptions are consistent with the observed patterns of deforestation and forest degradation. We conclude with recommendations for improvements to policies that protect forests as well as the Kalasha's culture and traditional livelihoods.

In my third data chapter, I link household level forest clearing (agriculture expansion) with the socio-economic and demographic characteristics of households and physical attributes of land parcel cleared. This study used Google Earth for on-screen digitization of farm polygon based on their current status, remote sensing data to identify farm polygon with changes, and GPS to locate their position. The study then used field survey to quantify household level forest clearing if household were involved in forest clearing. The overall objective of this chapter is to analyze which of a series of possible household's attributes best explain the observed household level forest clearing in the Kalasha valleys of Chitral district. The study tested some of the dominant hypothesis in the field. 1) Larger households clear more forest because they have more workers and more mouths to feed, as explained by Chayanov, (1986) in household life cycle model. 2) Households with more members in off-farm employment less likely involved in forest clearing. 3) Asset poor household clear less forest because they do not have means to clear or clear more forest as they have need to clear, a means vs needs hypothesis. 4) Socially privileged households are more likely to clear forest as they have more access and control over natural resources as compare to socially underprivileged. I used household's ethnicity, membership, JFMC and forest ownership as proxy of their social capital.

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Chapter 2

Spatial and temporal trends of forest cover in the Chitral district of Pakistan in response to the national logging ban

2.1 Summary

Conservation policy instruments, such as logging bans or protected area designations, are meant to reduce rates of deforestation and forest degradation. However, such interventions are not always effective. Also, the effectiveness may vary locally with accessibility due to topographic and structural characteristics of the land, and with varying human pressures for particular human resource use. Understanding local variation of effectiveness of polices, such as regional or national logging bans, can help managers to set priority areas with highest threats of deforestation and forest degradations to focus on enforcement or on providing alternatives for livelihoods and resource use.

Here I contribute a long-term analysis of deforestation and forest degradation for Pakistan's Chitral district, using Landsat MSS/TM/OLI TIRS-8 images to quantify forest cover changes prior to (1973-1993) and after (1993-2015) a nation-wide logging ban was imposed in 1993. Forest cover changes were further evaluated in the context of access and enforcement measured through distances to administrative boundaries, human activities, and topography. I found that despite a complete ban on commercial green felling, deforestation continued at a high rate. Agriculture land in the study area expanded in the pre-ban period, but actually decreased by 12% post-ban. The decrease may be due to erosion of the agricultural landbase as a consequence of severe floods. Notably, the imposition of the logging ban shifted the patterns and rate of forest conversion. The analysis showed that deforestation in the pre-ban period occurred in valuable high elevation conifer forests, while during the post-ban period deforestation shifted to low elevation oak forests near human habitation. High elevation conifer forests instead suffered from forest degradation during the post-ban period, presumably due to through selective cutting of the most valuable trees.

We recommend forest management strategies for high-elevation conifer forests that reverse the effects of high-grading, for example reforestation activities with improved planting stock, as well as better enforcement of protection of a specific set of timber species found in these forest ecosystems. Forest management in lower elevation oak forests should focus on providing alternatives for fuelwood to relieve pressure on forest resources near human settlements.

2.2 Introduction

Deforestation and forest degradation in Pakistan has led to a number of environmental issues such as floods, soil erosion, greenhouse gas emissions, biodiversity loss and decreasing supply of forest products. Low forest area (4.8 million ha) and high deforestation rate (39,000 ha/year) placed Pakistan among the hot spots of deforestation with the second highest deforestation rate in Asia (FAO 2011; Pakistan 2009). The driving forces of deforestation and forest degradation in the country are many and complex including combination of fuelwood collection, timber extraction, livestock grazing, agriculture and infrastructure expansion, inefficient administration and lack of forest policies that also accommodate local people (J. Ali and Benjaminsen 2004; J. Ali, Benjaminsen, et al. 2005; S. R. Khan and S. R. Khan 2009; Qasim, Hubacek, and Termansen 2013; Shahbaz, T. Ali, and Suleri 2007). Most of Pakistan's forests are spread over the upper slopes of high elevation mountain ranges in Khyber Pakhtunkhwa (KP) (40%), Gilgit-Baltistan (15.7%) and Azad Kashmir (6.5%) (Hasan 2007). In Khyber Pakhtunkhwa the forests are mostly spread over the upper slopes of district Dir, Swat, Manshera and Chitral (Steinmann 2005).

This study focuses on the forest of Chitral, which is of special interest due to its ecological diversity, importance as a watershed, and socio-economic importance for indigenous local communities. Chitral is among the highest elevation populated regions of the world with elevation range of 1070 m to 7708 m. The forest is distributed between range of 1,300 m (mostly deciduous forest) to 4,000 m (mostly coniferous forest) (Nüsser and Dickoré 2002). Forests in Chitral protect an important watershed that influences the water basin of various hydropower stations (N. Khan, Shaukat, et al. 2013). The forest is located on steep slope and rugged terrain. Deforestation and forest degradation in Chitral is linked to recent incidence of frequent floods and landslides that have considerably affected the livelihoods and well-being of people through the loss of agricultural land and property (N. Khan, Shaukat, et al. 2013; Naeem, Hashmi, and Shakir 2013). The cropland at the bottom of the valley is most affected by recent floods, attributed to ongoing deforestation taking place uphill. Further cutting in the area would lead to severe shortage of fuelwood as forest in the southern Chitral is the only source of fuelwood and timber for the whole district. Most of the northern Chitral is substantially treeless (Nüsser and Dickoré 2002). Low cover of high elevation coniferous and low elevation oak forest pose serious threats to the survival of the region's wildlife species through habitat loss and high competition for fodder with domestic animals (Karlstetter 2008). Efforts to conserve and expand forest area in Chitral are essential through proper policy interventions.

To control deforestation, Pakistan, like many other developing countries, attempts to protect its forests through the creation of protected areas, improvement of forest governance through the involvement of local people, and regional logging prohibitions (Faruqee and Kemal 1996; Fischer et al. 2010; Shahbaz, Mbeyale, and Haller 2008). The logging prohibition is a major policy that has wide economic and social impacts for the government and forest dependent communities in the area. The logging ban was imposed after a catastrophic flood hit the Northwest Frontier Province (now KP). The blame for the severity of flood was placed, by the government, on the mismanagement of forest at the hand of cooperative societies in Hazara district. Cooperative societies were created in 1981 after Forest Development Corporation (FDC) was blamed for overcutting under the legal permit at the hand of timber contractors (Knudsen 1996). The ban was instituted by the central Government in 1993 over commercial felling with an action plan to increase forest cover from 5% to 10% of the country's total area by 2010 (Fischer et al. 2010).

Given the high deforestation rate and decrease in forest cover, it seems that the logging ban has failed to curtail harvesting. Legal logging under a forest management plan has stopped. This affects the local communities and the Forest Department as 60% and 40% respectively shareholders in timber sale proceeds. The Forest Department was bound to spend the revenue generated from timber sale proceeds on community development and forest regeneration (Hasan 2001).

A logging prohibition is a policy tool used in response to environmental, socio-economic, political and other concerns and issues that threaten the forest and the resources within (Durst et al. 2001). Prohibitions on logging, including full or partial bans as a forest protection measure have been used in many countries (*e.g.* India, Bangladesh, Thailand, Indonesia, New Zealand, Pakistan, and China) to stop deforestation and forest degradation (Brandt, Butsic, et al. 2015; Durst et al. 2001). The success of a logging ban as a policy tool is variable. In countries such as New Zealand, China and Sri Lanka the ban has been successful in conserving forest (Brandt, Butsic, et al. 2015; Brandt, Kuemmerle, et al. 2012) while Thailand, Philippines and Bangladesh continue to struggle to implement their existing logging ban (Bugayong 2006; Durst et al. 2001; Sarker, Deb, and Halim 2011). The success or failure of logging bans has been attributed to whether or not governments implement the ban with supportive policies, such as providing alternative livelihoods, and supplemental programs and strategies for enforcing conservation and protection (Angelsen 2010; Durst et al. 2001; Lambin et al. 2014). The successes of logging ban in New Zealand, China, and Sri Lanka are largely attributed to the large scale plantation as alternative source of timber, local livelihood support policies and efficient monitoring (Brandt, Allendorf, et al. 2017; Durst et al. 2001).

The success of forest protection policies is also influenced by the biophysical and spatial attributes of land, as these factors significantly affect access and suitability of a land for a particular use (Arima 2016; Chen et al. 2001; Kumar et al. 2014; López and Sierra 2010; Lorena and Lambin 2009; Serneels and Lambin 2001; Stage and Salas 2007; Vu et al. 2014). For example, Elsen, Monahan, and Merenlender (2018) quantified the global patterns of protection of elevational gradients by analyzing the elevational distributions of protected areas in mountain ranges. They observed that, on average, mountain ranges in North America and Oceania have the highest elevational protection followed by ranges in Europe and South America while Asia and Africa have the lowest elevational protection. E. J. Z. Robinson and Lokina (2011) studied the effects of benefits of community restriction on forest conservation and observed that extraction activities have been shifted to more distance forests that may have been under protection in the absence of restrictions. J. M. Alix-Garcia, Shapiro, and Sims (2012) found that the National Payment for Ecosystem Program in Mexico leads to leakage in form of high deforestation in other areas with no payment program and areas within markets of high program participation. Proximity variables such as distance to road, market and river are other important determinants of deforestation and forest degradation (Angelsen 2010; Arima 2016; Vu et al. 2014). Potential monetary benefits due to easy access also encourage forest cutting (Angelsen 2010; Cropper et al. 2001; Pender et al. 2004). Similarly, policy influence also varies with management regulations and forest types. For example, Brandt, Butsic, et al. (2015) found that the implementation of a logging ban imposed in 2002 in south west China resulted in more cutting in the old-growth forests managed by local institutions under traditional rules. However, they found positive forest conservation outcomes for newly regenerated pine forest.

In this study, I contribute an analysis of effects of the 1993 general logging ban on rates and patterns of deforestation and forest degradation. I used Landsat MSS/TM/OLI TIRS-8 images, maximum likelihood classification and change detection techniques to analyze changes in forest cover in two distinct forest policy periods from 1973 to 2015. The study also analyzes the secondary role of topographic variables and spatial attributes of land in the absence and presence of logging prohibitions. The specific objectives of this study are: (1) to quantify rates and patterns of deforestation, forest degradation and agriculture expansion in the pre-ban era (*i.e.*, two decades before the logging ban (1973–1993) and approximately two decades of the logging ban (1993–2015)), (2) to evaluate and compare the relative importance of elevation, slope, aspect, distances (to administrative boundary, road, river, market and agriculture) on deforestation and forest degradation between the two periods, and (3) use this information to infer to the likely causes of deforestation and forest degradation and recommend policy changes to the existing forest management practices that could improve the effectiveness of logging ban.

2.3 Materials and Methods

2.3.1 Study area profile

Chitral district is located in the extreme north of the Khyber Pakhtunkhwa part of HKH region, bordering Afghanistan, situated between 36°15'- 37°08' N and 72°22' -74°6' E (Fig. 2.1) (N. Khan, Shaukat, et al. 2013). The district covers an area of 14,850 km^2 with a population density of 21 people per km^2, divided into two administrative subdivisions (tehsils): Chitral and Mastuj. The district is characterized by rugged topography with high mountain ranges (Fig. 2.1) (N. Khan, Shaukat, et al. 2013). There are 100 peaks in the district with elevation of above 6,000 m; the highest "Tirich Mir" is at an elevation of 7,778 m (Nüsser and Dickoré 2002). The district is remote and lacking communication infrastructure both within and outside the district. Vehicle access is through Lowari Pass, which is usually closed to vehicular traffic for six months from December to June (Nüsser and Dickoré 2002). The climate of the district is typical continental with summer temperature varying from very hot at lower elevations to warm in the mid lands, and cool at higher elevations.

Study area is restricted to southern Chitral as forests are restricted to southern part, whereas northern part and the inner valley floors are substantially treeless. The distinctive climatic conditions and extreme deviation in altitude and aspect has resulted diverse ecosystems and vegetation zones. Four distinct ecoregions each associated with different elevation, moisture, and exposure and soil configuration are found in Chitral (Nüsser and Dickoré 2002).

Deciduous forests dominated by walnut (*Juglans* spp) and birch (*Betula utilis*) are distributed in the elevation range of 1,300 to 3,400 m. Evergreen oak forests are dominated by oak species: *Quercus dilatata* is mostly found in a higher and relatively narrow altitudinal belt between 1,828 to 2,286 m on the southern slopes and *Quercus baloot* is distributed from 1,770 to 2,770 m elevation predominantly on the east and north slopes (N. Khan, Ahmed, et al. 2010). Coniferous forests dominated blue pine (*Pinus wallichiana*), Chilgoza pine (*Pinus gerardiana*), East Himalayan fir (*Abies spectabilis*), silver fir (*Abies pindrow*), Morinda spruce (*Picea smithiana*) and Deodar cedar (*Cedrus deodara*) are distributed from 2,500 to 3,500 m elevation. Alpine areas (above the tree line at 3,300 m) are covered with alpine shrubs and sedge meadows (N. Khan, Shaukat, et al. 2013). Until its merger with Pakistan in 1969, the forests of Chitral were owned by the state of Chitral. Local communities were only permitted to use the forests to graze animals and collect firewood and fodder. After the merger, ownership of these forests passed to the provincial government. In 1976, the North-West Frontier Province (now KP) government allotted a 60 per cent share in the proceeds from the sale of timber to customary owners (rights holders).

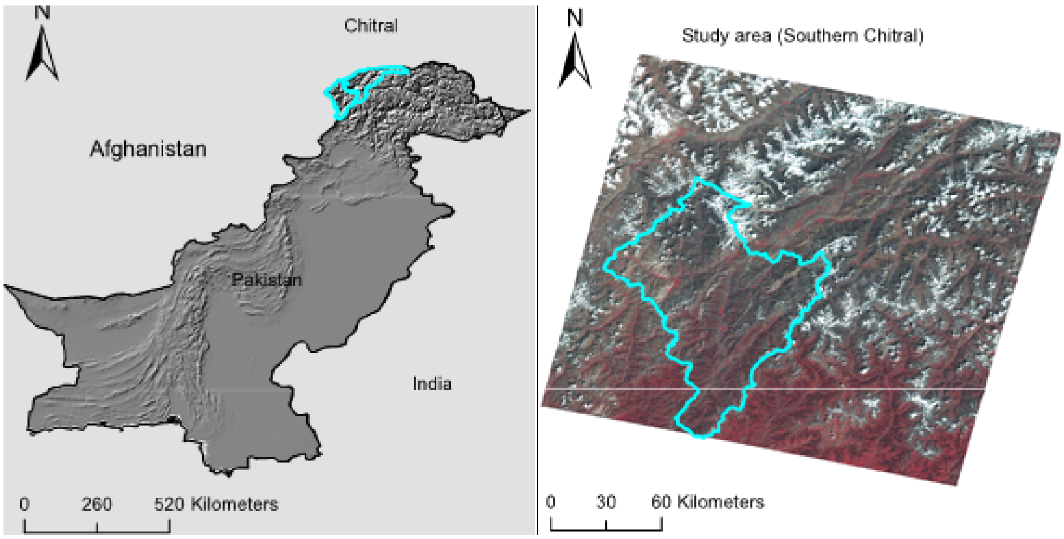

Figure 2.1: The location of the study area in the Chitral district of Pakistan.

2.3.2 Satellite data and image classification

The basic data for quantifying land cover and land use changes in the southern Chitral were obtained from the Earth Explorer of the United States Geological Survey (USGS) (`https://earthexplorer.usgs.gov`). Scenes were selected which contained the whole southern Chitral, were acquired during the summer months (June, July, August, September), during the daytime, and which had less than 10% cloud cover. The scenes were obtained from MSS/TM/OLI TIRS-8 datasets for the years 1973, 1993 and 2015 respectively. The study area is contained within the Landsat path 151 and rows 34 and 35. The spatial resolution for the scene collected for 1973 is 60 m; the resolution for the others is 30m. For 1973 image, band 1 (blue; 0.45μm to 0.52 μm), 2 (green; 0.52μm to 0.60 μm), 3 (red; 0.63μm to 0.69 μm), and 4 (near infrared; 0.76μm to 0.90 μm) were used. For the rest of images, band 4 (green; 0.5μm to 0.6 μm), 5 (red; 0.6μm to 0.7 μm), 6 (near infrared; 0.7μm to 0.8μm) and 7 (near infrared; 0.8μm to 0.11μm) were used to create the multiband layer.

Supervised maximum likelihood classification (MLC) was used for the spectral classification of the Landsat images. Supervised MLC method is preferred if examples of land cover classes can easily be identified by a person familiar with the study area. The major land cover classes selected for this area were dense forests, sparse forest, cropland and other classes mainly include rangeland and bare mountains. Training data polygons were restricted to areas that did not show any changes in land cover over the course of the study period (based on visual inspection of all remote sensing scenes), so that all scenes were classified with the same training data for consistency. Initially, I had hoped to also identify pasture, bare rock, river bed, and ice but I was unable to adequately separate the classes. These four other types were aggregated as "other classes".

After classification of individual year imagery, I used a multi-date post-classification change detection method to determine land cover changes following standard methodological approaches. The first comparison mapped land cover changes in the in the pre-ban era, *i.e.*, two decades before the logging ban (1973–1993), and the second mapped land cover changes in the post-ban timespan, *i.e.*, two decades of the logging ban (1993–2015). Forest cover changes were further categorized into deforestation (*i.e.*, forest conversion to other classes), agriculture expansion (*i.e.*, forest conversion to agriculture only), forest degradation (*i.e.*, dense forest conversion to sparse forest) and forest regeneration (*i.e.*, conversion of other classes and agriculture back to forest).

After the classification of the satellite images, accuracy analysis were made for the thematic maps obtained using validation data. A total of 352 locations for the 1973 date, 399 locations for the 1993 date, and 343 locations for the 2015 date were used in an evaluation of classification accuracy. The reference points for 1973 and 1993 images were obtained from the satellite image for the same land cover classes we used in classification; Forest, snow and glaciers, rangeland, agriculture land, bare mountains. Reference data is compared to map data through an error matrix to find out if the class type on classified map equals to class type determined from reference data. After the creation of error matrices, kappa statistics were calculated for each matrix (Table 2.1). In addition to the kappa statistics of the individual classes, kappa statistics of the total general accuracy, user and producer accuracy was also calculated (Table 2.1). The 2015 image classification accuracy was evaluated using Google Earth™ (`https://earth.google.com`) imagery and ground observations for validation. Ground observations were collected during three months of field work, from July to September of 2016 at different locations for each land cover type to aid the image classification. Approximately 25% of the training areas for forest, agriculture, snow area, bare mountains and rangeland classes were collected from the high-resolution Google Earth imagery and 75% in the field.

2.3.3 Topographic and distance data

Topographic factors were extracted from the digital elevation model (DEM) included elevation, slope and aspect. Elevation and slope were used as continuous variables while aspect was categorized as either north or south, as I was expecting different patterns of land use changes particularly, of oak forest on south facing slopes of the valley. Distance factors were calculated as optimal path distance with the ESRI ArcGIS Spatial Analyst package, considering slope and elevation, from a pixel to the nearest road, market, agricultural

Table 2.1: Classification accuracy of land cover predictions from a supervised classification procedure against reference data. Google Earth imagery from 2015 was used for 2015 classifications, and raw Landsat imagery was used as reference data for 1973 and 1993 classifications.

	Reference data for validation					Classification accuracy		
	FOR	S&G	RL	AL	BM	User	Producer	kappa
1973 Classified data								
Forest (FOR)	**100**	0	0	0	0	100	88.2	0.88
Snow & Glaciers (S&G)	0	**95**	4	0	1	95.1	90.6	0.95
Rangeland (RL)	1	0	**87**	8	4	86.8	93	0.99
Agriculture land (AL)	6	0	8	**77**	8	77.5	90.2	0.86
Barren Mountains (BM)	1	10	0	0	**89**	88.6	87.5	0.99
Total Accuracy						**88.9**		**0.87**
1993 Classified data								
Forest (FOR)	**100**	0	0	0	0	100	96.7	0.97
Snow & Glaciers (S&G)	0	**93**	3	0	4	93.5	100	0.93
Rangeland (RL)	0	0	**96**	2	2	95.5	97.3	0.98
Agriculture land (AL)	1	0	0	**99**	0	98.6	95.9	0.97
Barren Mountains (BM)	0	0	0	0	**100**	100	93.1	0.93
Total Accuracy						**96.8**		**0.98**
2015 Classified data								
Forest (FOR)	**97**	0	0	3	0	100	96.9	0.97
Snow & Glaciers (S&G)	0	**99**	1	0	0	98.8	100	0.99
Rangeland (RL)	0	0	**83**	0	17	98.1	80	0.82
Agriculture land (AL)	0	0	0	**100**	0	96.7	98.3	0.98
Barren Mountain (BM)	0	0	2	0	**98**	83	98.4	0.84
Total Accuracy						**94.9**		**0.96**

polygon, or administrative boundary.

To analyze the different influences of the logging ban according to the topographic and distance attributes of forest, forest cover changes were further categorized into deforestation (*i.e.*, forest conversion to other classes), agriculture expansion (*i.e.*, forest conversion to agriculture only), forest degradation (*i.e.*, dense forest conversion to sparse forest). Deforestation, forest degradation and agriculture expansion maps were therefore created for two time periods: pre-ban and post-ban. The cover type maps were then converted into point format to establish pixel to pixel link with the topographic factors and distance variables.

2.4 Results

2.4.1 Total area changes in land cover classes

The accuracy of the classification turns out to be better than the expected. The overall accuracy for year 1993 and 2015 were higher than 1973 (Table 2.1). The kappa coefficient lies between 0 and 1, with a value of 1 indicating complete agreement.In my case, kappa value for the year 1993 and 2015 was higher than 1973 (0.87). The lowest user's accuracy was observed for agriculture (77%) and highest for forest (Table 2.1). Producer's accuracy was highest for bare mountains and lowest for rangeland (Table 2.1).

The land use pattern revealed that in total 35% of dense forest and 16% of sparse forest disappeared over the entire study period (Fig. 2.2, Table 2.2). However, when comparing pre-ban and post-ban policy periods, these changes showed different patterns. For example, in case of dense forest most conversion occurred during the post-ban policy period with while in case of sparse forest a slightly more forest area is converted during the pre-ban policy period (Fig.

2.2, light and dark green areas). As compared to pre-ban, during the ban period the annual rate of conversion of dense forest has significantly increased (twice that of pre-ban) (Table 2.2). Cropland expanded during the pre-ban policy period with high annual conversion rate of 5.2% (Fig. 2.1, deep pink). Forest land cover and land cover changes related to forests and agriculture pre-ban (left) and post ban (right).

2.4.2 Land cover transitions: deforestation and forest degradation

Analysis of land use transition matrix (Table 2.3) shows that most of the deforested land in Chitral is either use as rangeland (other classes) or cropland (Fig. 2.3). However, it is interesting to note that as compared to dense forest most deforestation occurred in sparse forest over the whole study period (Table 2.3). However, the conversion of dense forest to sparse forest increases during the policy period (1993-2015). Cropland in the area is mainly expanded at the cost of forest during the pre-ban period and rangeland (other classes) during the policy period (Table 2.3, Fig. 2.3, deep pink area). The contraction mainly occurred in the main valley along both sides of the rivers which could be attributed to floods in the area (Fig. 2.3).

Comparison across the two periods shows different patterns of change in deforestation and forest degradation. For example, in case of deforestation more were observed during the pre-ban period (Table 2.4). While in the case of forest degradation more conversion occurred during the policy period (Table 2.4). The land transition matrix (Table 2.4) also showed regeneration. However, the annual regeneration rate is much lower than the deforestation and forest degradation rates.

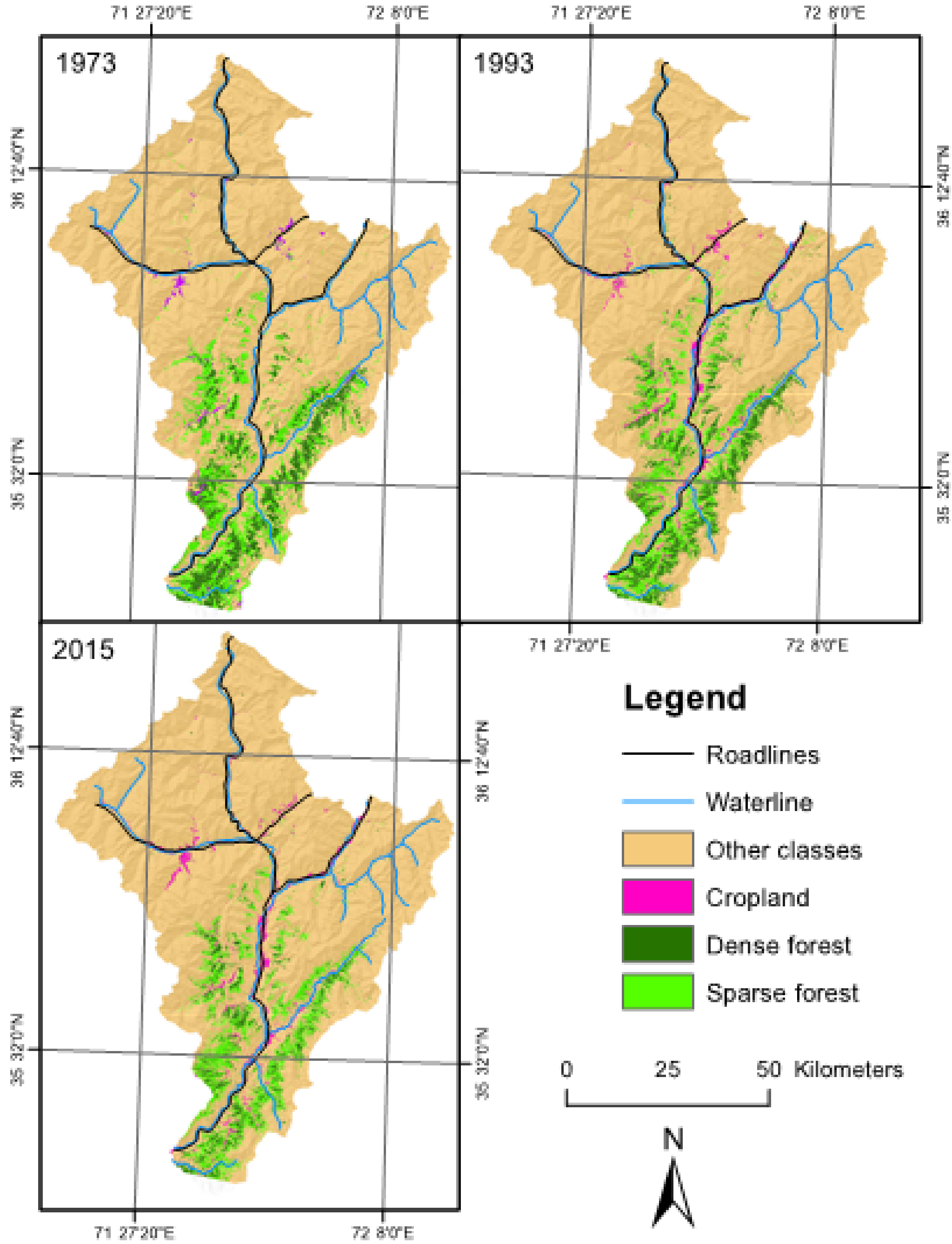

Figure 2.2: Land cover classes in 1973, 1993 when a logging ban was implemented, and in 2015.

Table 2.2: Area of land cover types at three times to analyze area changes approximately two decades before and after implementation of logging ban in 1993.

Land cover	Area (ha)			Annual rate of change (%)		
type	1973	1993	2015	1973-1993	1993-2015	1973-2015
Forest	89,938	82,540	68,904	-0.43%	-0.82%	-0.63%
Dense forest	33,510	30,830	21,529	-0.42%	-1.62%	-1.05%
Sparse forest	56,429	51,709	47,375	-0.44%	-0.40%	-0.42%
Cropland	5,408	14,937	12,049	5.21%	-0.97%	1.93%
Other classes	514,893	512,762	529,285	0.02%	0.14%	0.07%

Table 2.3: Detailed transition matrix of land cover types for the two decades before the logging ban was implemented in 1993.

	1973-1993 Transition to:			
From:	Dense forest	Sparse forest	Cropland	Other classes
Dense forest	**19,055**	9,741	294	4,420
Sparse forest	4,094	**22,942**	2,826	26,567
Cropland	147	639	**2,241**	2,381
Other classes	7,534	18,387	9,577	**479,395**
	1993-2015 Transition to:			
From:	Dense forest	Sparse forest	Cropland	Other classes
Dense forest	**14,468**	11,439	101	4,823
Sparse forest	5,061	**23,885**	1,319	21,444
Cropland	306	1,713	**7,186**	5,732
Other classes	1,694	10,339	3,442	**497,287**

2.4.3 The role of topographic and distance factors

Most of the deforestation in the pre-ban period occurred in the high elevation range (3,000 to 4,000 m) close to the administrative boundary, while during the ban period more can be observed in the low elevation range (2,500 and 3,500 m) away from the district administrative boundary (Fig. 2.4 and Fig. 2.3, left and right panel red areas). Similarly, the probability of a pixel being deforested, when it is on north, northwest and west facing slopes increased during the pre-ban and decreased during the post-ban period (Fig. 2.4 and Fig. 2.3, left and right panel red areas). Opposite to deforestation, forest degradation shifted from low elevation range (2,500 to 3,000 m) in the pre-ban period to high elevation range (3,000 to 3,500 m) during the post-ban period (Fig. 2.5 and Fig. 2.3, right and left panel yellow areas). The highest conversion during the pre-ban was observed on slope facing south, southwest close to human habitation while during the post-ban period conversion shifted to north, west and northwest regions of mature forest (Fig. 2.5).

Overall, it appears that deforestation in the pre-ban period occurred at the

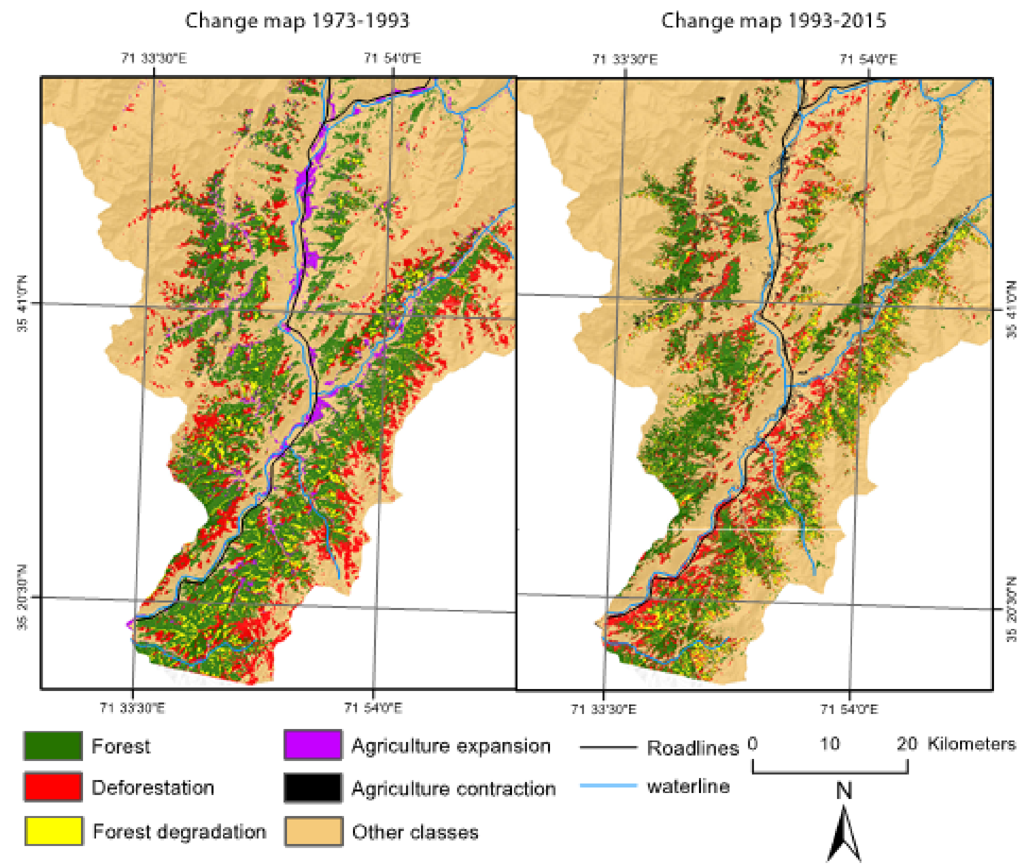

Figure 2.3: Forest land cover and land cover charges related to forests and agriculture pre-ban (left) and post ban (right).

high elevations, while during the post-ban period more were observed at the low elevation regions and on southern facing slopes dominated by oak forests. On the other hand, forest degradation shifted from lower elevations during the pre-ban period to higher elevations of mature and old growth stands during the post-ban period. Distance to existing agriculture land and administrative boundary were the factors that behaved differently between the two periods in case of deforestation and forest degradation. Agriculture is expanded mainly in flat areas on southern aspects due to ease of agriculture operations, such ploughing and irrigation, soil fertility and closer proximity to human habitation (Fig. 2.3, deep pink area).

2.5 Discussion

2.5.1 Shifts in deforestation rates and patterns

Deforestation and forest degradation continue at a high rate in the Chitral district, despite a ban on commercial felling of green timber which was imposed in 1993. My data suggest that more forest disappeared during the post-ban period (13,636 ha) as compare to the pre-ban period (7,398 ha) (Table 2.2). However, the imposition of the logging ban has shifted the patterns and rate of forest extraction. Understanding these changes has management applications at the district level that could improve the effectiveness of this policy tool.

Deforestation shifted from high elevation areas close to administrative boundary of adjacent district (Dir Upper) to low elevation region. A plausible explanation for the low elevation deforestation during the post-ban period could be the closure of high elevation natural forest (coniferous forest) after imposition of the logging ban, which diverted firewood collection and timber extraction for local use to the low elevation oak forest on southern facing slopes

Table 2.4: Detailed transitions from Table 2.3 summarized to represent rates of deforestation, forest degradation, agriculture expansion and forest regeneration.

	Pre-ban (1973-1993)		Post-ban (1993-2015)	
Conversion type	Area (ha)	Annual rate	Area (ha)	Annual rate
Deforestation				
Dense forest to non-forest	4,713	-0.76%	4,924	-0.79%
Sparse forest to non-forest	29,393	-3.61%	22,764	-2.60%
Forest degradation				
Dense forest to sparse forest	9,741	-1.70%	11,439	-2.09%
Cropland conversion				
Dense forest to cropland	294	-0.04%	101	-0.01%
Sparse forest to cropland	2,826	-0.26%	1,319	-0.12%
Regeneration				
Non-forest to dense forest	7,681	-0.07%	5,387	-0.05%
Non-forest to sparse forest	19,026	-0.19%	12,052	-0.10%
Sparse to dense forest	4,094	-0.38%	4,369	-0.40%

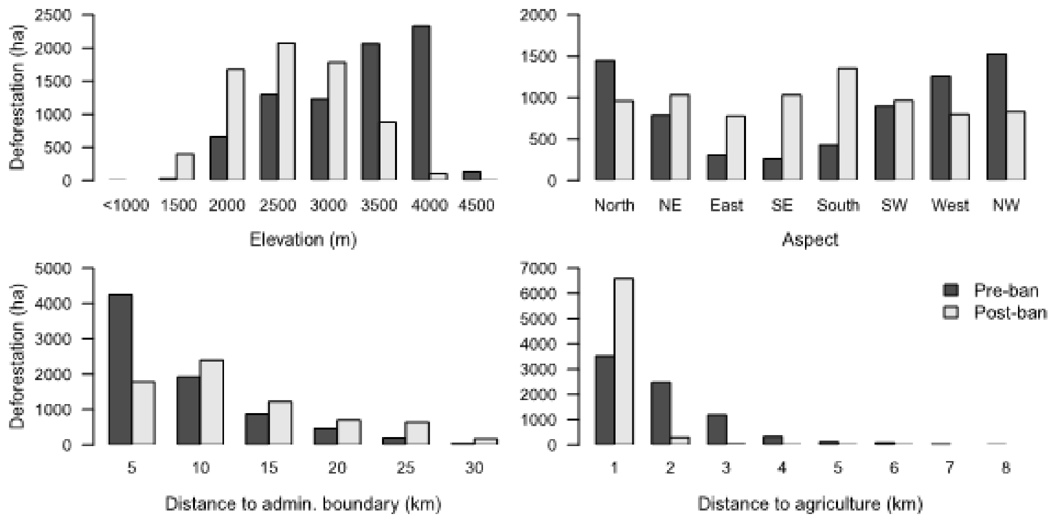

Figure 2.4: Deforestation related to topographic and distance variables pre-ban and post-ban.

(Fig. 2.3, right panel, red area). It is highly likely that before the logging ban people relied on softwood forests for timber and firewood and oak forests were used to feed animals. After the ban, the low elevation oak forest is not only used as a food source for animals but also cut for firewood and timber. Oak forest in Chitral is located in low elevation range (1200 to 2500 m) owned and managed by local communities under traditional management systems. The remote sensing analysis suggests that the imposition of the logging restrictions have decreased the deforestation of the high elevation forest, but it seems to have caused an increase in deforestation of the low elevation forest (Fig. 2.3, right and left panel, red area). The observed phenomenon is in line with the findings of other researchers studied resources extraction patterns under changing management regulations (J. M. Alix-Garcia, Shapiro, and Sims 2012; Ewers and Rodrigues 2008; Gan and McCarl 2007; Henders and Ostwald 2014; Murray 2008; Murray, McCarl, and Lee 2004; Warman and Nelson 2016). They observed a similar increase in the deforestation of surrounding areas of forest protected under logging concession and other management regulations, *e.g.* protected areas.

2.5.2 Shifts in forest degradation rates and patterns

Forest degradation shifted from low elevations in the pre-ban period to high elevations during the post-ban period (Fig. 2.3, right and left panel, yellow area). Although, the degradation in the two periods occurred in the same elevation range (Fig. 2.5) that covers important commercial forest species *i.e.* cedar (*Cedrus deodara*), blue pine (*Pinus wallichiana*), Pindrow fir (*Abies pindrow*), Morinda spruce (*Picea smithiana*) and Himalayan nut pine (*Pinus gerardiana*). Several factors may have increased the likelihood of forest degradation at high elevations. First, unavailability of good quality softwood timber at low elevations as much high-quality timber was extracted during the pre-ban period. This can also be seen in Fig. 2.3, in the form of large clearing patches (left panel, red area) during the pre-ban period at high elevations. Legal cutting under the management plan focused at high elevations where mature forest of high market value was present. The high elevation logging during the second period could also be the result of the selective legal logging under legal permit. Local community in the vicinity of the forest can extract timber for home use and construction purpose under legal permit issued by the forest department. This trend can be attributed to the effect of logging ban policy that shifted logging from large-scale harvesting to small scale illegal selective cuts in high elevation, valuable conifer forests (Fig. 2.3, right panel yellow areas). A similar trend in forest cutting is observed by other researchers in the neighboring districts (Qamer et al. 2016; Qasim, Hubacek, Termansen, and Fleskens 2013).

The remote sensing analysis also showed that both deforestation and forest degradation is prevalent around the administrative boundaries during the

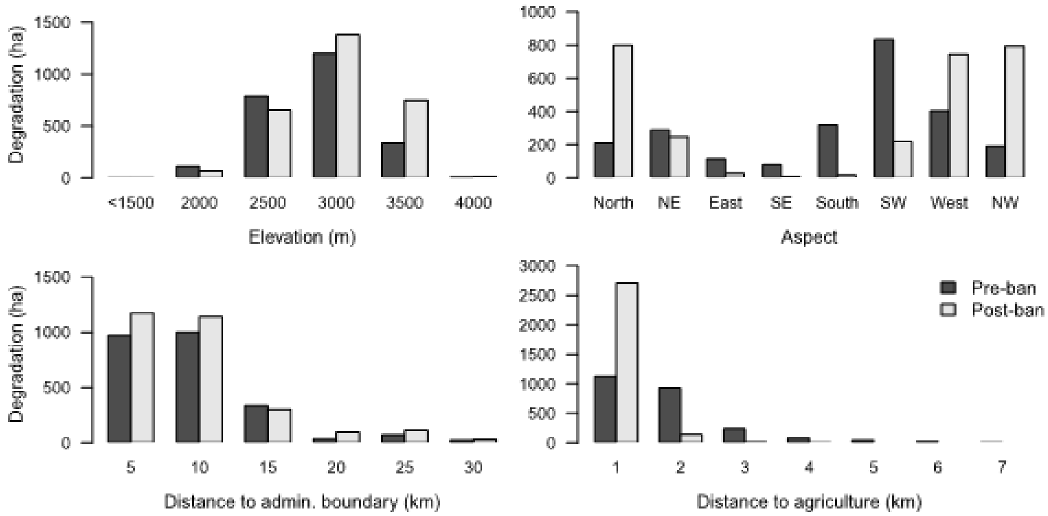

Figure 2.5: Forest degradation related to topographic and distance variables pre-ban and post-ban.

pre-ban period and away during the post-ban period (Fig. 2.3, red area). A potential explanation could be the inter-districts forest conflicts due to the ambiguity in jurisdiction between the forests of adjacent district (Dir Upper) that motivates local tribes of the adjacent district to harvest timber from neighboring units before losing access to the resource. Forest boundaries demarcation between districts was completed in 1993 under the first forest working plan. A similar trend was observed by Qamer et al. (2016) focusing on the whole Himalayan regions including Chitral and attributed this shift to the inter-districts conflicts over the forest resources.

2.5.3 Policy and management implications

In Chitral, flood is the most significant hazard type, followed by landslide and landslip that cause losses to human lives and property (Naeem, Hashmi, and Shakir 2013; Rafiq and Blaschke 2012). These two hazards are frequent and repetitive during the monsoon season. Floods are not new to Chitral. However, their intensity and the damages they caused increased manifold over the past two decades. The remote sensing analysis suggest that forest degradation of high elevation dense forest during the second period has severely affected the water retention capacity of the watershed that resulted an overflow of the Chitral river. According to the local people, landslides are a new phenomenon, whose frequency and intensity have significantly increased over the past two decades. Landslides in Chitral are more damaging on the south-facing slopes and have buried many villages completely. One of the reasons for this recent increase in landslides and slope failure could be the deforestation of the low elevation oak forest (Fig. 2.3) especially on south-facing sides just above the human habitation, which leaves the land vulnerable to slides and slips. The low elevation oak forest are fast depleting, leaving many villages at high risk of landslides and flooding.

Agriculture contracted during the second period (Fig. 2.3). The contractions mainly occurred in low elevation region on both sides of the River Chitral which are attributed to recent floods. In high elevation valleys, the erosion due to recent floods will trigger cropland expansion. Further expansion onto the steep slopes is of high risk of soil erosion. In hilly areas, soil erosion and thus loss of fertile surface soil is a common phenomenon, but more severe on high gradient land with less or no vegetation cover. The remaining pine and mixed pine forests cover is on a steep slope, which is an important watershed area for river Chitral. Continued deforestation in the area would accelerate erosion in the fragile watershed of Chitral that could increase overland flows and siltation of river beds and water reservoirs (Rehman and Sabir 2003). According to the FAO (2005), about 14.2 million ha of land in the Himalayan hills of Pakistan are subject to severe erosion, with 20–40 tonnes/ha/year soil loss.

The rationale for protecting higher elevation coniferous forest are both the value of this resource for timber, and for protection of biodiversity. The coniferous forests are habitat for several globally endangered species, among those, the snow leopard (*Panthera uncia*), the screw horn goat or markhor (*Capra falconeri*), a wild sheep: urial (*Ovis orientalis*), the musk deer (*Moschus cupreus*), and the Himalayan black bear (*Ursus thibetanus*) which are all red-listed large mammals (IUCN 2018; Karlstetter 2008). Habitat loss and high competition for fodder with domestic animals has caused severe decline of wild ungulates (Qamar et al. 2011). In particular, oak and juniper are not only important fodder and cover species for markhor, ibex, urial, and musk deer, but also preferred firewood trees for the local people. The cutting of oak is seriously depleting the winter food source of markhor. Removal of juniper, birch and willows adversely affects ibex and musk deer (Karlstetter 2008).

In conclusion, this study found that deforestation and forest degradation continue at high rate even after the imposition of the ban on commercial cutting in 1993. This could be interpreted that legal commercial cutting under management plan is not the main cause of deforestation and forest degradation in the region. The high level forest degradation could be attributed to illegal logging either by local people or some timber contractors while the low elevation deforestation could be linked with fuelwood and livestock grazing. The legal ban on commercial cutting could have accelerated illegal cutting to meet the increasing demand of fuelwood and timber. Though the ban seems to be successful in controlling commercial cutting, it has no effect on illegal harvesting. Given the small area of remaining forest, it would be unwise to lift the logging ban. However, adjustment to the existing management could improve the effectiveness of this policy tool. I recommend forest management strategies for high-elevation conifer forests that reverse the effects of high-grading, for example reforestation activities with improved planting stock, as well as better enforcement of protection of a specific set of timber species found in these forest ecosystems. Forest management in low elevation oak forests should focus on providing alternatives for fuelwood to relief pressure on forest resources near human settlements.

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Chapter 3

Identifying local actors of deforestation and forest degradation in the Kalasha valleys of Pakistan

3.1 Summary

Prevention of forest loss is a high priority in Pakistan, where deforestation has been linked to catastrophic flooding in 1992 and 2010. Under the United Nation's REDD+ program, new incentive schemes are developed to encourage forest protection and reforestation, while implementing social safeguards for forest-dependent indigenous groups. A remote-sensing based historical analysis showed that government actors have significant power to influence land use practices in the region, although their policy instruments may not have had the intended effects. A logging ban in 1993 caused a shift to small-scale selective cutting but could not stop forest loss. Near human habitation forest loss

actually increased after the ban. Results from expert interviews reveal binary and contradictory perceptions regarding the actors responsible for forest loss. Both local residents and government officials point to the other side as primarily responsible, while rationalizing their own contribution. I recommend policy changes towards more balanced power structure in joint forest management committees. In addition, alternative heating methods would remove the currently largest pressure on forest extraction for fuelwood. Since fuelwood production for regional consumption constitutes one of the largest sources of income for the poorest households, REDD-based compensation schemes would have to support the most affected households of the indigenous Kalasha.

3.2 Introduction

Forest loss in Pakistan has been a concern for many decades due to deforestation rates that are among the highest in the South Asia at 2.2% per year (FAO 2011). As a consequence of damage to regional watersheds, forest loss has been linked to catastrophic flooding in 1992 and 2010. In response to the 1992 floods, the Government of Pakistan instituted a ban on commercial felling of green trees, but this has not stopped the decline of forest areas in Pakistan. Deforestation rates as well as the total proportional loss of the forest area remain above the global average (FAO 2011). According to Government of Pakistan, remaining forests cover about 4.8% of the total land area. FAO assessments are more pessimistic, estimating that only 2% of the total land area in Pakistan remains as forest. Of the remaining forest area, a high proportion represents degraded ecosystems. Forest with canopy cover of 50% or more comprises less than 0.5% of the total land area of the country and could be depleted by the 2020s (Steinmann 2005).

While there is consensus among the general public as well as policy makers and resource managers that deforestation continues to pose a significant threat in Pakistan, opinions are divided over who is responsible for the causes of deforestation and forest degradation and how it is to be stopped or slowed. Previous studies in Pakistan have linked deforestation and forest degradation to local people (J. Ali and Benjaminsen 2004; J. Ali, Benjaminsen, et al. 2005; S. R. Khan and S. R. Khan 2009; Shahbaz, T. Ali, and Suleri 2007), to government policy of forest rights and access (Fischer et al. 2010; Sultan-i-Rome 2007; Yusuf 2009), and to ineffective forest management and forest protection by government departments (Hasan 2007; Pellegrini 2007). The research indicates that causes of deforestation are not easily generalized and depend to varying degrees on actors, governance, and power structures that are interlinked and collectively determine deforestation and forest degradation. The factors vary regionally due to different socio-economic situations, cultural backgrounds and traditions as well as regional forest management histories (Aspinall 2004).

Most of the country's forests (40%) are in Khyber Pakhtunkhwa (KP) province and specifically in the Chitral, Dir, Swat and Hazara districts within the KP province (Steinmann 2005). The Chitral district is home to the Kalasha, an indigenous people under enhanced protection of the Intangible Cultural Heritage list of the United Nations Educational, Scientific and Cultural Organization. As a signatory of the United Nations Framework Convention on Climate Change (UNFCCC) in 2005, Pakistan has committed to report on conserving carbon stock through sustainable use and management. In addition, Pakistan has also committed to the UN Reducing Emissions from Deforestation and forest Degradation (REDD+), which outlines REDD readiness activities to ensure social safeguards for forest-dependent indigenous groups, protecting their livelihoods and cultural and spiritual identities.

In this paper, I contribute an analysis to support Pakistan's REDD+ readiness activities that affect the Kalasha. I aim to identify past causes of deforestation, and analyze the effect of past policies meant to improve the protection of forests. The analysis relies on 191 household surveys in 15 villages in three valleys. The sample represents 15% of all households and covers all areas inhabited by the Kalasha. For context, I quantify deforestation and forest degradation patterns before and after the Pakistani federal government instituted a logging ban in 1993. I also conducted expert interviews of the district's government employees in the forest department, local community leaders involved in the management of forests, and regional NGOs that operate on livelihood and forest conservation and development. The central objective of this study is to understand the interests and motivations of the actors involved in forest depletion and investigate if their perceptions are consistent with the observed patterns of deforestation and forest degradation. I conclude with recommendations for improvements to policies that protect forests as well as the Kalasha's culture and traditional livelihoods.

3.3 Data and methods

3.3.1 Study area

The Kalasha Valleys (Rumbur, Bumburet, and Birir) are situated in the southwest of the Chitral District of Pakistan (Fig. 3.1). The Chitral District also contains a high percentage of remaining forests and wildlife with a high biodiversity conservation value in Pakistan, and is home to the prominent Chitral Gol National Park. The district is diverse in topography, climate, and vegetation, with dry temperate coniferous forests found on the higher slopes of the

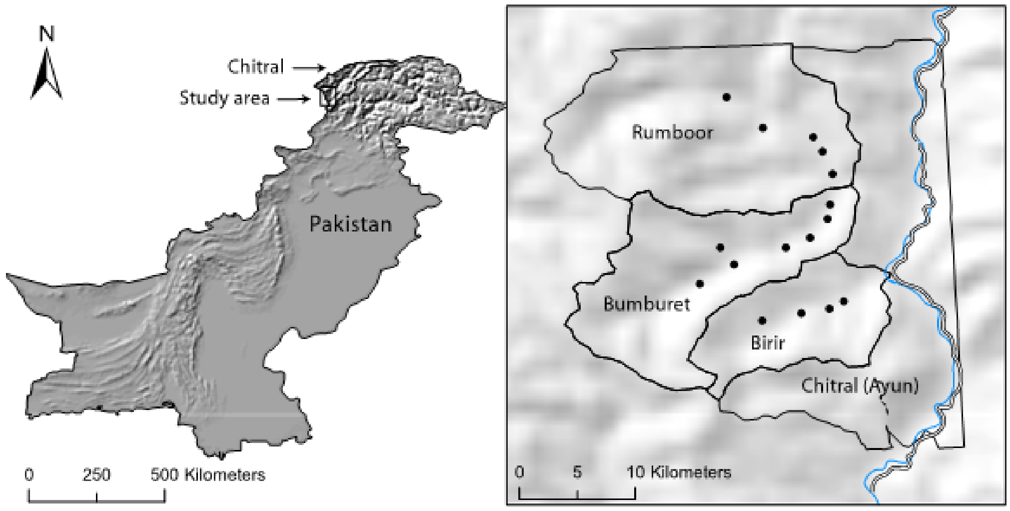

Figure 3.1: The location of the study area in the Chitral district of Pakistan, and the location of the valleys and villages (•) of the indigenous Kalasha people.

valleys dominated by *Cedrus deodara*, *Pinus wallichiana*, *Abies pindrow*, and *Juniperus excelsa*, while lower elevation forests are dominated by oak species, including the valuable timber species *Quercus incana* (N. Khan, Shaukat, et al. 2013). The northern part of the Chitral District has very little forest cover due to high elevation. Due to rugged terrain, access to cultivable agriculture land in Chitral is constrained, and freezing temperatures prevent double cropping in higher elevation locations (Nüsser and Dickoré 2002).

3.3.2 Assessing land cover changes

The remote sensing data for quantifying deforestation and forest degradation in the Kalasha Valleys were Landsat imagery obtained from the United States Geological Survey (USGS, 2017). Scenes with less than 10% cloud cover, and acquired during the summer months (June, July, August, and September) are listed in Table 3.1. The spatial resolution for the scene collected for 1973 is 60 m; the resolution for the others is 30 m. Before classification and analysis,

Table 3.1: Remote sensing data scenes used for land use and land cover change analysis.

Year	Landsat sensor	Acquisition Date	Path/Row
1973	MSS	7/12/1973	163/35
1993	TM	6/19/1993	151/35
1996	TM	9/22/1996	151/35
1997	TM	7/7/1997	151/35
2003	ETM+	8/5/2003	152/35
2013	OLI TIRS-8	7/3/2013	151/35
2015	OLI TIRS-8	9/15/2015	151/35

the 30 m resolution images were re-sampled to a 60 m resolution.

The satellite images were classified using the Interactive Supervised Classification tool of the Spatial Analyst Extension of ArcGIS. The classification was based on the maximum likelihood method, with an equal *a priori* weight. Training samples were identified for the following classes: dense forest, sparse forest, crops, and other through visual inspection of the remote sensing scenes, aided by high-resolution imagery from Google Earth. Training data polygons were restricted to areas that did not show any changes in land cover over the course of the study period based on visual inspection of all remote sensing scenes, so that each scene was classified with the same training data for consistency. Initially, I had hoped to also identify pasture, bare rock, river bed, and ice but I was unable to adequately separate pasture and bare rock. These four other types were aggregated as "other". A multiband image layer was used for the classification of each of the scenes. For the 1973 image, bands 1 (green; 0.5 μm–0.6 μm), 2 (red; 0.6 μm–0.7 μm)), 3 (near infrared; 0.7 μm–0.8 μm)), and 4 (near infrared; 0.8 μm–1.1 μm)) were used to create the multiband layer. For the rest of the images, bands 4 (blue; 0.45 μm–0.52 μm), 5 (green; 0.52 μm–0.60 μm), 6(red; 0.63 μm–0.69 μm), and 7 (near infrared; 0.76 μm–0.90 μm) were used.

The area of each of the four land classes was recorded for each of 7 years for which images were collected. Analysis focused on the periods 1973-1993, and 1993-2015. The earliest available image for the study area was captured in 1973. The year 1993 corresponds to the imposition of the commercial logging ban, and 2015 represents the most recent image available at the time of analysis. Annual change rates for the pre-ban period (1973-1993), the post-ban period (1993-2015), and the complete study period (1973-2015) was calculated as:

$$i = \sqrt[n]{\frac{V_n}{V_0}} - 1 \tag{3.1}$$

where i is the annual change rate, n is the number of years in the time period, V_0 is the area in the land cover class at the beginning of the time period, and V_n is the area at the end of the time period.

3.3.3 Resident surveys and expert interviews

I rely on both qualitative and quantitative research, using 27 expert interviews and 191 household surveys of the Kalasha people in 15 villages. The selection of households was informed by the remote sensing analysis above. This survey covers all main villages of the three Kalasha valleys, however households were not chosen at random, but selected based on their location close to forest margins and areas of recent deforestation. The objective was to focus on households that are engaged in forest extraction or deforestation activities. Households on forest margins were dependent on forest for fuelwood, timber, and livestock grazing in open-canopy forests. I targeted around 15 households that met these criteria in each of five villages in each of the three valleys. In total, I surveyed 65 households in the Rumbur valley, 60 in Bumburet, and 66 in Birir.

I used structured village and household level surveys based on the Poverty Environment Network survey instrument, available on-line (www.cifor.org/pen). The survey is designed for a consistent, comprehensive analysis of tropical forests and poverty. The interview questionnaire focused on gathering household's information on patterns of forest use with a detailed section on demographic information, land use and agriculture production, firewood and timber collection and livestock grazing. My modified survey is available as supplemental material (Appendix A).

Household and village-level surveys were complemented with expert interviews that were primarily qualitative in nature, focusing on the causes and main actors of deforestation in the context of existing policies. Participants were selected for suitability on the basis of widely used selection criteria first described by (Tremblay 1957). Tremblay's "key informants" are characterized as participants who play a central role in the community, who are knowledgeable in the subject matter of the interviews, who have the required communication skills and are impartial regarding the interview topic as far as this is possible. For the purpose of this study I selected individuals from NGOs and the government sector with formal university training in the fields of forest management, agriculture or sociology, and who worked in managerial positions. I followed the principle of quota sampling to target 10 participants for each of the following groups government forest managers, NGO employees involved in forest conservation and development, and community leaders involved in local forest management. The final sample included 11 forest officers, 10 NGO workers as well as 6 village leaders.

Interview participants were selected by first compiling a comprehensive list of candidates, based on records of managerial employees of local government offices and NGOs. Then, candidates were selected to maximize representation, *i.e.* I avoided inviting colleagues from the same government branch or NGO. Expert interviews were conducted face-to-face in private settings in the participant's offices. The interviews conducted between June 2016 and October 2016. Responses are reported in aggregate in order to protect confidentiality. The ethics approval for the questionnaires was obtained through the Human Research Ethics Review process at the University of Alberta Ethics Board (Approval ID Pro00063604, May 16, 2016). The interview questions are available as supplemental material (Appendix B).

3.4 Results

3.4.1 Remotely sensed deforestation and forest degradation

The land cover classification for the Kalasha Valleys for 1973, 1993, and 2015 is shown in Fig. 3.2. In case of dense forest, most conversion occurred during the post-ban policy period (dark green areas). Cropland is expanded during the pre-ban policy period with high annual conversion rate (deep pink). However, loss of agricultural land overweight expansion during the post-ban policy period. Overall, the temporal analysis of land use change showed a decrease in the area of both sparse and dense forest and an increase in the area of cropland and other classes over the period of 1973 to 2015.

I observe a marked shift as to where deforestation takes place before and after the logging ban was implemented in 1993 (Fig. 3.3), although the overall deforestation trends are not drastically changed in response to the logging ban (Fig. 3.4). In the 1973-1993 period, most deforestation occurred at higher elevations in valuable conifer forests, and that deforestation has shifted to the lower elevation oak forests in the 1993-2015 period (Fig. 3.3, red areas). There

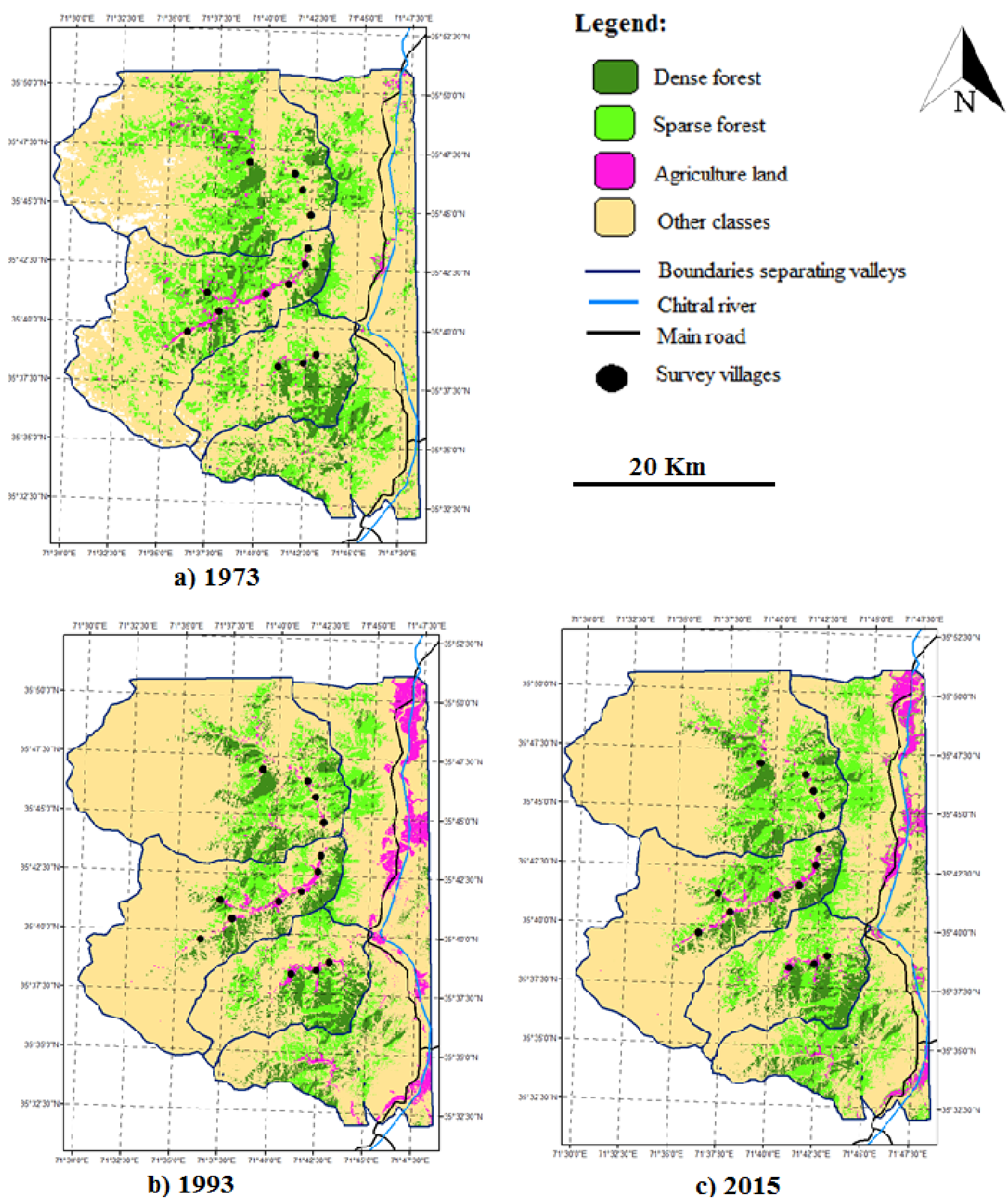

Figure 3.2: Land cover classification for the Kalasha Valleys for 1973, 1993, and 2015.

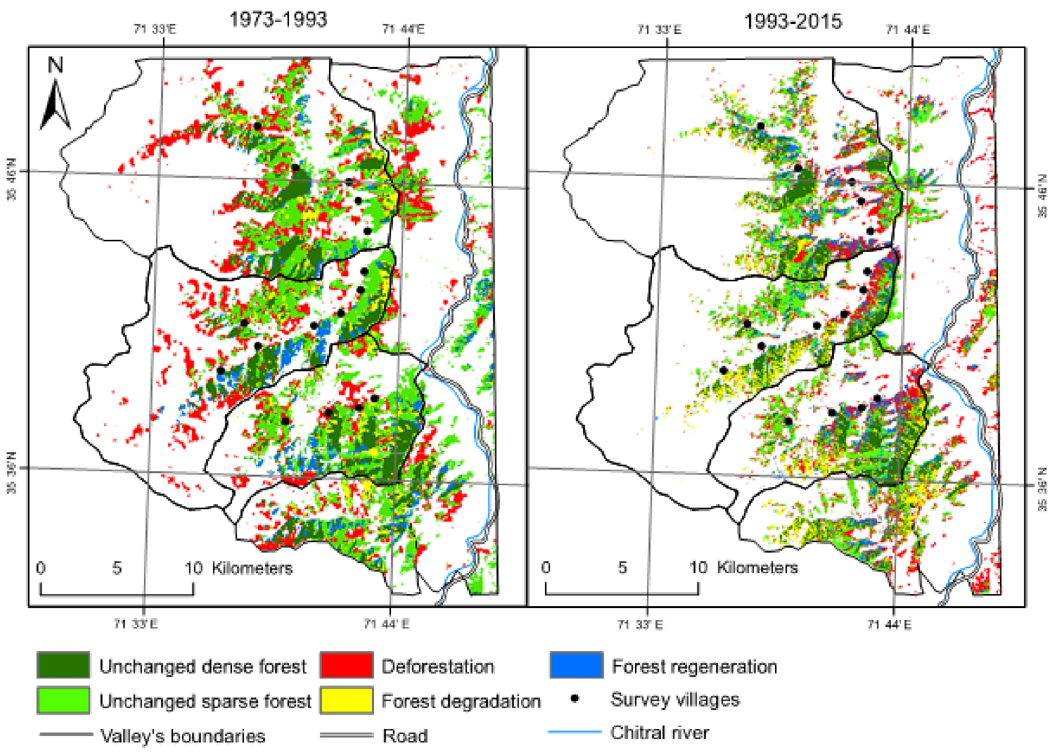

Figure 3.3: Land cover change over a period of approximately two decades before (left panel) and after (right panel) a logging ban was implemented in 1993.

also appears to be an increase in forest degradation at the higher elevations in the 1993-2015 period (Fig. 3.3, right panel, yellow areas) as opposed to deforestation in the 1973-1993 period. For the total loss of forest cover, I do see inflection points around the time that the logging ban was implemented in 1993 (Fig. 3.4). This is most notable for the valleys of Bumburet and Rumbur, and was primarily driven by a slower overall decline of sparse forest due to the conversion of dense forest into sparse forest, *i.e.* yellow area in the right panel of Fig. 3.3. Overall, it appears that the logging ban has primarily contributed to a marked shift in the type of forest use and degradation, while overall declines have continued at a somewhat reduced rate of between 0.6% and 0.9% per year in the different valleys for overall forest cover decline between 1993 and 2015.

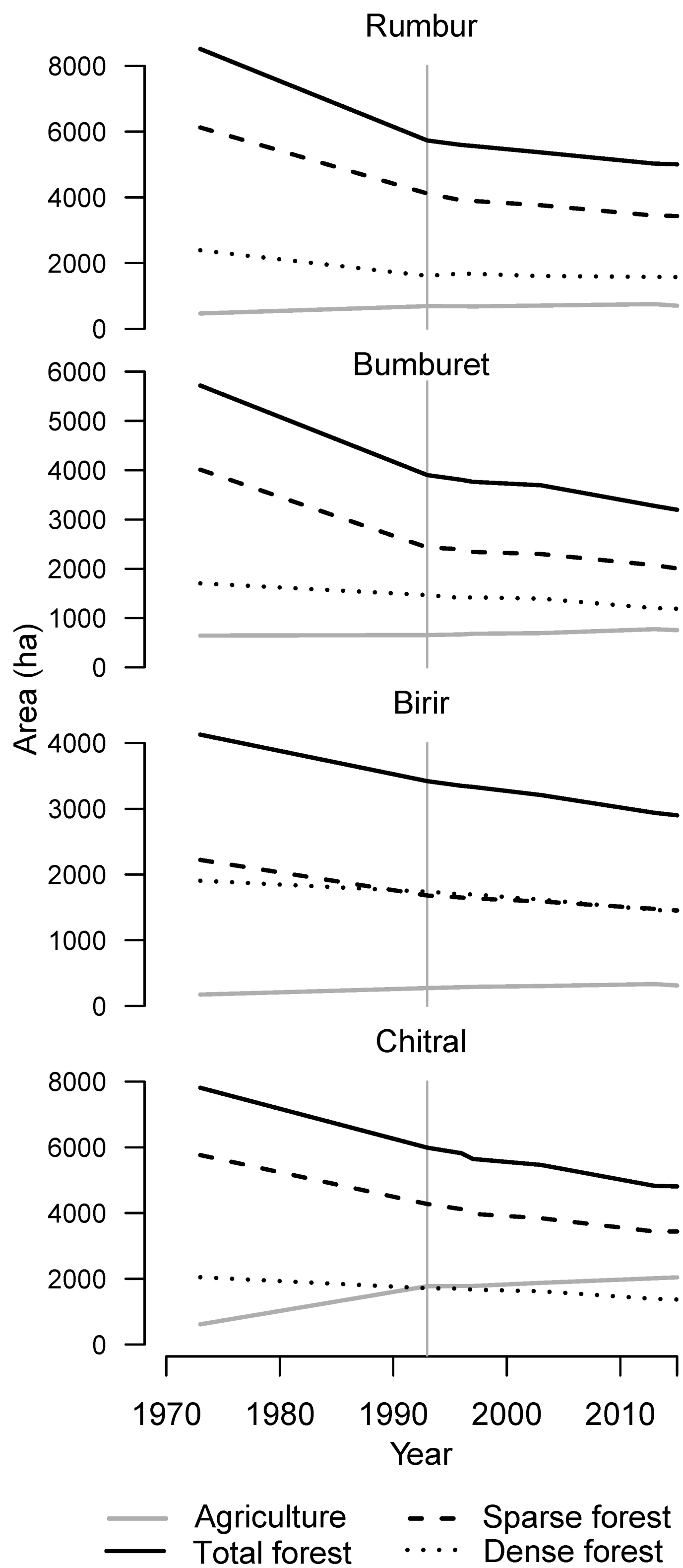

Figure 3.4: Total are of land cover classes ("Total forest" being the sum of "Dense forest" and "Sparse forest" broken down by valley. A logging ban was implemented in 1993 and shown as a vertical gray line.

All of the valleys show an increase in the area of cropland over the period 1973-2015, which appears to slow after 1993 when the logging ban was implemented. Land conversion to agriculture was most pronounced in the main valley, and less prevalent for all three side valleys that are home to the Kalasha people. It is also apparent in all three Kalasha Valleys that the decrease in area of forest over time is much greater than the increase in cropland, indicating that small-scale timber logging, extraction of fuelwood, and use of sparse forests as pasture, preventing regeneration, appear to be the primary candidates for drivers of forest loss in the area, while conversion to agriculture is a minor factor.

3.4.2 Perceptions of responsibility according to expert interviews

My results from expert interviews reveal a binary perception regarding the actors responsible for forest degradation and forest loss. The first view, held by forest officers employed by the government, holds local people responsible. In their interview responses, they score timber extraction by locals, livestock grazing, agricultural expansion, and firewood extraction by locals as the most important factors (Fig. 3.5, dark gray bars). In contrast NGO workers and community leaders perceive government policies, government mismanagement, demographic and socioeconomic factors, and organized illegal logging as the main reasons for the forest decline (Fig. 3.5, medium and light gray bars). This is also illustrated by the following statements made by interviewees.

> “We are blamed for deforestation and forest degradation by the general masses and media when they see trucks full of logs on roads. It is worthy to note that we are managing forest under

scientific management plan and allowed to extract windfall, dry and disease trees. This is not only good for the health of the forest but also a source of revenue for the province." (Forest Officer)

"Illegal cutting by timber contractors under the legal permit issued by the Forest Department is more threatening to forest than the legal cutting. Timber contractors acquire tree permit for a specific quantity of timber but they cut more than double of the permit quantity due to weak control and lack of cross verification by Forest Department at the check posts. Forest officers are backing the timber mafia (mostly contractors) in over marked cutting. Forest officers also, issues hand written letter (with no official record) locally called *Chitti* to local influential that help them to cross forest check posts." (Community leader)

"The winter is harsh and long and more firewood is needed to keep the houses warm in addition to cooking needs. We also aware of the fact that our forests are dwindling fast and after 20-25 years from now they would have no forest and survival will be impossible in Chitral in general and highland valleys in particular due to long and harsh winter. It is also costly to get firewood from other districts, as Chitral is the most isolated and far away district of the province. But we only collect dry, diseased and dead trees branches." (Community leader)

"Local people living in the vicinity of forest are allowed to collect dry and diseased trees for fuelwood and allowed to cut green timber under legal permit approved by local JFMCs and Forest Department. However, we observed that local people do not respect forest department rules and cut living trees both for fuelwood and sale."

(Forest Officer)

> "Most JFMC members are hand-picked by the Forest Department and misuse timber permits for their own benefits and benefits of the forest officers." (Local leader)

> "In a response to question that deforestation in hilly areas are affecting the whole country through climate change and floods, you said that you want us to kill our kids due to harsh winter in order to provide safe and healthy environment to people living down the hills. It is not the fuelwood extraction alone responsible for deforestation; illegal logging by timber mafia is a major cause of forest depletion. In order to protect the forest the government should provide use alternative source of fuelwood." (Local leader)

> "It is the poverty in the region that compelled local to use timber for cooking and heating purposes. Everybody wants to use LPG for cooking and heating purposes but they are expensive. The government should focus on alternative livelihood sources." (NGO worker)

Another notable result is that agricultural expansion was identified as an important cause of deforestation by government employees, which is contradicted by the remote sensing analysis with respect to the Kalasha valleys. Only in the main Chitral district does expansion of agricultural land play a role. In summary, the contrasting views point to a variety of potential causes of deforestation that appear to reflect stakeholder perceptions. Government employees point to local people as the primary actors, and local leaders and NGO employees point to government actors as those responsible for forest degradation and deforestation. Some of the perceptions are not supported by

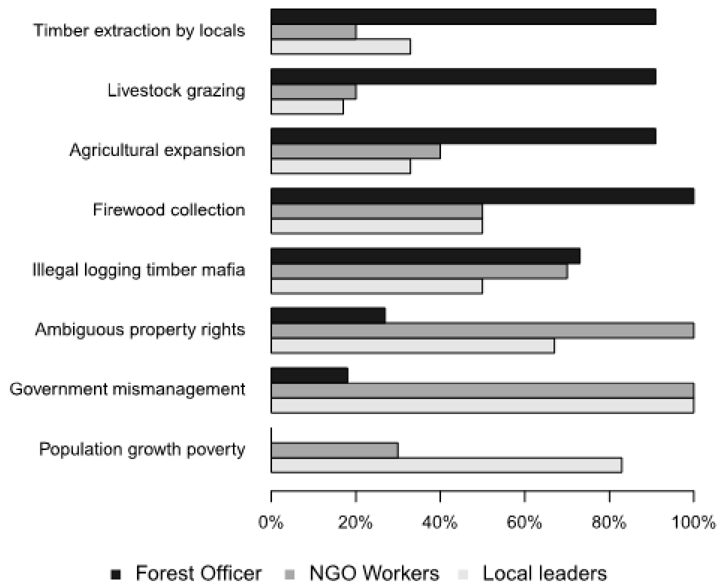

Figure 3.5: Summary of the results from expert interviews, grouped by forest officers, NGO workers and community leaders, regarding the causes of deforestations listed on the left axis.

the remote sensing analysis for the Kalasha valleys, such as the importance of agricultural expansion.

3.4.3 Deforestation factors inferred from household surveys

Household surveys provide additional data to narrow down likely actors and mechanisms of deforestation. According to the survey, all households collect fuelwood and extract timber for domestic use and for sale. Compared to the global average of wood consumption of approximately 0.5 m^3/person/year for both developing and developed countries (Bruinsma 2003), wood use by the Kalasha people is high (Table 3.2). A substantial portion of their labor is dedicated to wood extraction (around 20 hrs/week/household), and the main driver of wood consumption is fuelwood, which is driven by fuelwood demand

Table 3.2: Average household labour and the resulting timber and fuelwood extracted by valley. The data were reported by household, and converted to units per person based on an average household size of 7.2. Fuelwood was reported in original units of long tons (UK) with a conversion factor of 1.6 m^3/ton).

Valley	Labour (hours/week)	Green timber extracted (m^3/year/person)	Fuelwood extracted (m^3/year/person)	
			Own use	Sale
Rumbur	19.9	0.33	1.8	2.1
Bumburet	20.9	0.44	1.7	1.7
Birir	25.2	0.40	1.5	1.5

for heating in a region that has six months of snow cover. Most households reported that they only collect dry, diseased and dead trees branches, although Forest Department officers and NGO workers say that they frequently observe cutting of large living trees for fuelwood. Surplus fuelwood and timber are sold in the local and district markets. The average amount of fuelwood extracted for sale was about the same as the amount of fuelwood extracted for household use (Table 3.2).

Self-reported forest clearing for the purpose of agriculture collected through the household survey were small (3.3), and approximately match results from the remote sensing analysis. Based on the survey respondents, the total area cleared for agriculture for the three valleys before the logging ban was approximately 800 ha, with an additional 200 ha after the logging ban was instituted (Table 3.3). Remote sensing data for the three villages detected a total agricultural expansion of 330 ha pre-ban and 153 ha post-ban. Given different methodological approaches and a positive sampling bias in the household surveys near the forest edge, the numbers appear reasonably close. Both estimates confirm that the overall area lost to agriculture is not a major factor in forest loss for the three valleys.

Table 3.3: Self-reported average area cleared by each household for agricultural use in the approximately two decades before and after the logging ban was implemented in 1993.

	Number of	Average area cleared per household		Total area cleared (ha)	
Valley	households	1973-1993	1993-2015	1973-1993	1993-2015
Rumbur	348	0.49	0.14	171	49
Bumburet	725	0.71	0.14	515	102
Birir	225	0.58	0.21	131	47

Table 3.4: Average number of livestock per household and estimated total numbers of livestock by valley.

	Rumbur		Bumburet		Birir	
Livestock	Household	Valley	Household	Valley	Household	Valley
Cattle	2.5	368	2.2	1784	3.0	750
Goats	7.5	1119	7.0	5624	10.0	2500
Sheep	2.2	326	2.0	1600	3.6	900

In the study area, livestock production provides food, and supplements the small-holders' income through sale of animals and animal-based products such as wool and hides. The livestock contributing most to the forest degradation are goats and sheep by grazing on regenerating oak forests. By far the highest numbers of goats and sheep are found in the Bumburet valley (Table 3.4). The Bumburet valley also has the highest rates of forest decline for the 1993 to 2015 period (0.90% per year) compared to Birir (0.61% per year) and Rumbur (0.75% per year).

3.4.4 Role of illegal logging inferred from market prices

According to the remote sensing analysis, illegal logging appears to continue in the higher elevation conifer forests. However, instead of clear cutting prior to the logging ban (Fig. 3.3, left panel, red areas), the method of extraction

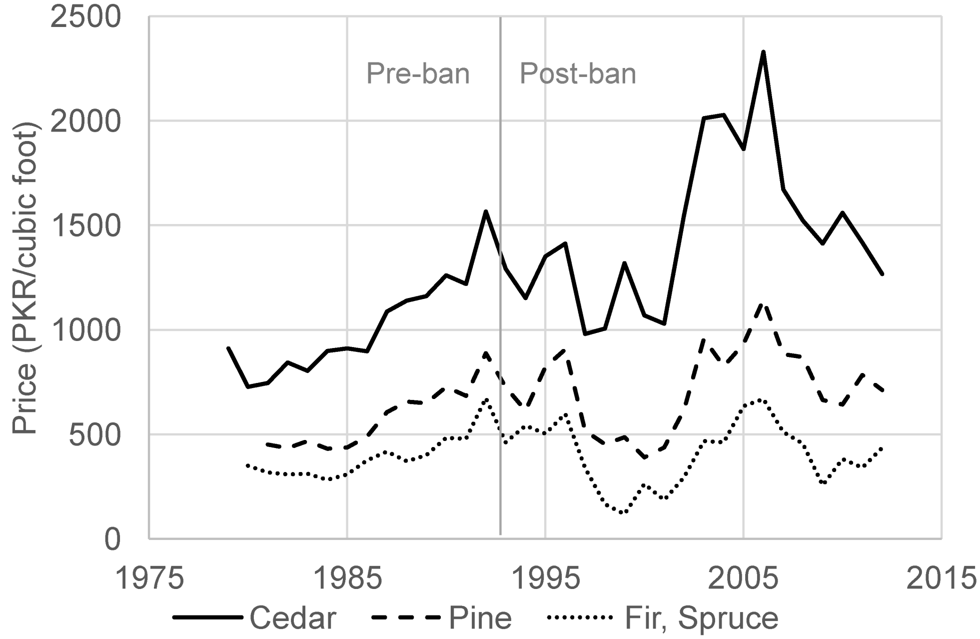

Figure 3.6: Price trends for conifer tree species from higher elevation forest ecosystems in the study area. The data represents the timber market for the districts of Chitral and two adjacent districts, and prices are adjusted for inflation and expressed in constant 2012 PKR values)

appears to have shifted to selective logging (Fig. 3.3, right panel, yellow areas), which would make illegal harvesting less obvious to the forest authorities. An analysis of market values for local timber species also provides some indirect evidence that the logging ban had little or no influence in reducing supply of timber (Fig. 3.6). In the years following the logging ban, prices for the most common local timber species (fir, spruce, and pine) actually declined, suggesting an increase of timber supply, presumably from illegal logging activities that matched or exceeded previous harvest levels. The price development after the year 2000 does, however, show significant increases. According to the timber price development, the logging ban appears to have been initially counterproductive, leading to a short-term increase in deforestation. Price increases after the year 2000 imply a subsequent scarcity of timber supply.

3.5 Discussion

3.5.1 Government officials and contractors as actors in forest degradation

My data suggests that following the 1993 logging ban, government employees appear to be the most likely actors of forest degradation as opposed to local residents who now appear primarily responsible for deforestation (the reverse situation compared to the period prior the logging ban). The data suggests that government actors certainly have significant power to influence land use practices in the region, although their policy instruments may not have had the intended effects. Remote sensing analysis indicates a major shift in practices following the logging ban, where large-scale commercial clear-cuts were replaced by selective cutting, leading to patterns of forest degradation rather than deforestation. A price analysis suggests that the overall rate of timber extraction may have initially increased, indicated by falling prices for seven years after the logging ban was implemented (Fig. 3.6). The subsequent increase in prices (after adjustment for inflation) could be due to better enforcement of the logging ban, but a plausible alternative explanation is that price increases may have been the result attributable to exhausting high-elevation conifer forest resources. The value of the most highly priced conifer in the region (the cedar species *Cedrus deodara*) is perhaps driven by high protection measures and high fines for cutting the species relative to the lower-value conifer species (pines, spruce, and firs).

The government actors themselves acknowledge the role of illegal logging and activities of the so called "timber mafia", although they deny their own role in the form of government mismanagement (Fig. 3.5). The timber mafia refers to corrupt politicians, bureaucrats, forest department officials and timber contractors who profit from illegal harvesting of timber. It seems unlikely that the initial increase in conifer wood, inferred from market price trends would be attributable to locals cutting high elevation forest. It appears that the logging ban simply shifted clear-cut operations to unregulated selective cutting, likely conducted by the same contractors and involving the same officials as the previous legal operations. The shift to selective cutting has led to the high levels of forest degradation visible in Fig. 3.3 (right panel, yellow).

Even after the logging ban, there were several ways to justify timber extraction. The Forest Department was allowed to issue legal permits for local use, but these permits may have been used to pass checkpoints and bring the timber to regional markets, even though the intention was to only allow local use (Knudsen 1996). Another loophole, recently closed, allowed for legal harvest of old trees that were marked as unfit for further growth. This rule appears to have been exploited to extract the most valuable trees at an uncontrolled rate following the logging ban, a practice known as high-grading and widely recognized as one of the most destructive forest management approaches because all regeneration comes from the remaining low value trees, degrading the capability of forests to recover in the long term.

In summary, it appears that Government officials do have the power to act in their own interest rather than for the common good. Legal loopholes allowed them to maintain a narrative of proper forest management, despite their management practices not being scientifically sound. Nevertheless, the stated perception of government officials is that the responsibility for forest degradation and deforestation lies overwhelmingly with local people.

3.5.2 The Kalasha people as actors in deforestation

Local people's perception is that of powerlessness as logging trucks with valuable resources come down from the mountains leaving them without benefit, noted in open-ended survey responses. Their conclusion is that government mismanagement is to blame (Fig. 3.5). At the same time they overlook their substantial contribution to the problem. Their traditional wood consumption is one of the highest in the world per capita. While their needs for normal wood use is in line with the global average for both developing and developed countries (0.5 m^3/person/year), their consumption of fire wood for heating is an additional 1.5 m^3/year/person or more for domestic use, plus another 1.5 m^3/year/person for regional sale for the households surveyed.

This large pressure on forest resources has been amplified by rapid population growth over the last decades. Between 1981 and 2015, the population of the Chitral District increased at an annual rate of 2.5%. This equates to an 81% increase in the population over that 24 year period. It should be noted that reducing regional reliance on fuelwood could have problematic socioeconomic consequences for the Kalasha people. Satisfying regional demand for fuelwood is a major contributor to their livelihood, largely through the sale of fuelwood. The sale of fuelwood is particularly important for the poorest households in each of the Kalasha valleys, accounting for a quarter of their household income on average (Table 3.5).

In addition to fuelwood and timber extractions, animal grazing is an important potential contributor to forest degradation and deforestation through inhibiting the natural regeneration of forests. The pasture areas are common areas with no local management plan. The lack of individual property rights causes the pasture areas to suffer from the tragedy of the commons as described by (Hardin 1968). The households share pasture land but livestock

Table 3.5: Sources of income by valley and income class from 191 household surveys in the Kalasha valleys.

Valley	Annual income ('000 PKR)	Percentage of respondents	Contribution to household income (%) Crops	Livestock	Forest	Off-farm
Rumbur	150-200	57	42.5	23.1	26.2	8.2
	200-250	17	40.7	24.2	22.1	13
	250-300	14	35.9	23	20.1	21.1
	>300	12	31.7	21.3	19.1	28
Bumburet	150-200	75	41.3	25.3	23.1	10.3
	200-250	17	39.3	22.8	22	15.9
	250-300	11	33.2	21.2	19.1	26.4
	>300	2	29.6	20.1	17.2	34.2
Birir	150-200	67	51.8	22.1	23.1	3
	200-250	19	44.8	21.1	22	12.1
	250-300	12	39.2	23.2	18.3	19.3
	>300	2	37.6	21.1	16.2	25.2

production is the responsibility of individuals, who raise as many livestock as possible. This leads to more animals than the carrying capacity of the land, which is an obstacle to forest regeneration in lower elevation open oak forests, where the livestock are kept.

Recent deforestation trends near human habitation are also evident in the remote sensing analysis, with at lower elevations particularly prevalent for the 1993-2015 time period (Fig. 3.3, red areas). This constitutes a large proportion of the recent deforestation and occurs in lower elevation oak forests. This is likely due to a combination of cutting of the oak for fuel and lack of regeneration due to overgrazing by livestock, particularly goats and sheep which feed on oak seedlings and saplings. One notable observation is that by far the highest numbers of goats and sheep are found in the Bumburet valley (Table 4). This may indicate that livestock numbers may play a significant role in forest decline, because no other factor from the household survey could explain the higher deforestation rate in Bumburet (0.9% per year) compared to the adjacent valleys (0.61% for Rumbur and 0.75% for Birir per year) for the 1993-2015 period.

3.5.3 Policies to mitigate deforestation and forest degradation

My analysis suggests that policy changes are need to provide better incentives to protect the remaining forest resource, and to create a more balanced power structure that empowers local Kalasha people in deciding how their forests should be managed. In addition, alternative livelihood options and investments in alternative technologies for fuelwood are needed to relieve the pressure on the remaining forest resource.

Perhaps one of the most effective prescriptions would be offering alternatives to the reliance on fuelwood for heating and cooking. Less than 1% of households in the district use gas for cooking, so there are opportunities for reducing a portion of the required fuelwood demand through programs that invest in liquefied petroleum gas (LPG) equipment and distribution. LPG may also be used for rural heating systems, but the investments required would be much higher. A much cheaper way to provide relief on the remaining forest resources would be a switch to regionally abundant coal resources for heating. While this has negative environmental impacts both in terms of pollution and carbon emissions, this will likely be partially or fully compensated by preventing further deforestation and carbon sequestration by allowing regeneration of low-elevation forests.

A shift to LPG and coal to meet local and regional energy needs likely comes with severe negative socioeconomic impacts for the Kalasha people, especially for the poorest households where fuelwood accounts for 25% of household income. This is where REDD+ incentive schemes may play a crucial role. REDD+ could contribute to poverty alleviation by providing extra income from carbon credit payments, and other co-benefits such as improved tenure or carbon ownership. This is particular important in the context of indigenous communities of Kalasha where forest is not only a source of income but also deeply rooted in their cultural and religious practices. As Pakistan is in REDD+ readiness phase, this study also highlighted the importance of additional social safeguards for the indigenous Kalasha. These include but are not limited to the acknowledgment of their customary rights over forest, and their traditional management systems.

My analysis also suggests that better communication and joint management of natural resources between government agencies and local people may have benefits. The present situation appears to be that both groups maintain narratives that shifts responsibility to the others, and both sides overlook their own contributions to deforestation and forest degradation. Joint responsibility for forest management where both sides have equal power in decision making may introduce the needed checks and balances. Joint Forest Management Committees (JFMCs) do, in fact, already exist. They consist of forest department officials, representatives of the Kalasha people who collectively own forest land in their valleys, representative of non-forest land owners, village leaders and elders. The JFMCs primary role is to recommend permitting for timber cutting to meet local demand at the village level, *e.g.* for construction of new houses.

However, in open-ended interview questions, respondents reported that the JFMCs lack democratic legitimacy and true representation of local stakeholder interests, with members being appointed by the forest department, enabling misuse of permits for member's and department's benefits. Furthermore, the forest department still has the final say over all recommendations made by the JFMCs. To better represent local actors, members of the JFMCs should be elected by a democratic process, and representatives of stakeholders should have full voting rights over permitting decisions. JFMCs with democratic legitimacy would also be well positioned to administer REDD+ programs and ensure that their benefits are shared with those that contribute to the protection and regeneration of forest areas.

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Chapter 4

Forest conversion for agriculture in the Kalasha valleys, Pakistan: A household level analysis of socioeconomic drivers

4.1 Summary

One of the main causes of forest depletion in Pakistan is land conversion of forests to agriculture by rural communities located in and around the forest. Like many other developing countries, Pakistan's government agencies attempt to protect their forests through the creation of protected areas, improvement of forest governance and regional logging prohibitions. However, these policies failed to achieve the desired results and have actually increased deforestation close to human habitation in the Kalasha valleys of Pakistan. Here, I contribute a socio-economic analysis at the household level to understand why deforestation has continued at a high rate, and how policies might be improved

or better targeted towards the actors of deforestation and forest degradation. Based on the remote sensing and field surveys, I selected 123 households on the forest margins for a detailed socioeconomic survey to study factors related to household-level decision making with respect to forest clearing. The analysis was based on a contrast of 75 households that cleared nearby forested land with 48 households that did not expand since 2003. This study only considers farms on forest margins with potential for expansion into forested land. Survey results indicated that prime motivator for land conversion of forests was expansion for farming (77%) and livestock grazing (17%) and orchards (5%). I found that families with more members and fewer physical and financial assets were more likely to clear forested land for agricultural expansion. Families with more members employed off-farm were less likely involved in forest clearing. There was also a strong negative association of household income with reliance on forest products versus off-farm employment. For poor households, forest products constituted the largest part of their total income and off-farm income the smallest. Social factors, such as education, ethnicity, and forest ownership were not significantly associated with clearing of forests. I conclude that programs focusing on off-farm income generation opportunities targeted towards the poorest households would be the most effective policy intervention.

4.2 Introduction

The main causes of forest depletion in developing countries are agriculture expansion, livestock grazing and forest extraction by rural communities located in and around the forest for fuel wood and timber. Farming is one of the most important livelihood strategies in the mountain areas of KP. Farmers practice both extensive and intensive methods of cultivation and bring marginal land under cultivation through encroachment of forests and of steep slopes (T. Ali et al. 2007). According to a recent study by Qasim, Hubacek, and Termansen (2013) a third of the forest loss is caused by agricultural expansion. Unclear, insecure and unequal property rights are important causes of agriculture expansion because this activity is a way of laying claim to disputed land titles. The government claims that the legal title lies with government but the locals make competing claims (Pellegrini 2007).

Pakistan, like many other developing countries, attempts to protect its forests through the creation of protected areas, improvement of forest governance and regional logging prohibitions (Faruqee and Kemal 1996). But these policies have failed to achieve the desired results because subsistence agriculture, and livestock grazing and forest extraction by local communities are the primary causes of deforestation and forest degradation. Previous studies in the area approached the issues of deforestation and forest degradation from individual aspects *i.e.* livelihood and livelihood dependency (S. R. Khan and S. R. Khan 2009; Shahbaz 2007; Steinmann 2005), property rights and access (Pellegrini 2007; Sultan-i-Rome 2007), and forest management and corruption (Hasan 2001; Yusuf 2009). These factors are, however, interlinked and collectively determine deforestation and forest degradation. Research and policy actions that considers multiple factors including those outside of the forest sector could contribute to slowing deforestation without severely compromising the farm household income of forest dependent communities.

At the household level, small farmers are widely believed to be the main agents of forest clearing (Carr 2005). The forest clearing decision of the agents depend on certain choice variables (resource allocation, consumption and management decision), their own characteristics and external decision variables (market factors, shocks, policy and institutional arrangements) (Kaimowitz and Angelsen 1998). Research findings indicate that a household's socio-economic and demographic characteristics, such as property size, initial wealth, education, tenure status and available labor, are related to forest clearing and degradation (Angelsen, Larsen, et al. 2011; Babigumira et al. 2014).

At the farm level, there are varied drivers of deforestation. Some studies argue that most land is deforested by the poor (Angelsen 1999; Fisher 2004; S. R. Khan and S. R. Khan 2009; Shively and Fisher 2004). Others demonstrate that wealthy people clear more forest (Adhikari, Salvatore, and Lovett 2004; Babigumira et al. 2014; Reetz, Schwarze, and Brümmer 2011). Similarly, studies argue that secure tenure rights and formal titling of common-property are associated with better forest management and high rate of success in controlling deforestation (E. J. Z. Robinson and Lokina 2011; Vergara-Asenjo and Potvin 2014).

Most research on deforestation links landscape level clearing with socio-economic data aggregated at a regional level, and subsequently makes inferences about individual and household level behavior (Duveiller et al. 2008; Lapola et al. 2010; Soares-Filho et al. 2006). I have used the same approach in the two previous chapters of this thesis. However, according to Rosa et al. (2013), the limitation of regional deforestation model is the use of the overall deforestation rate as a top-down input, and the preferred approach should be a bottom-up approach of linking individual land clearing decisions by households to their socioeconomic circumstances. 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 individual household clearing activities (Schneider 2001).

The approach therefore requires ground truthing, and ideally accurate selfreporting of historical forest conversion activities by residents. Researchers mostly rely on household's self-reported clearing. For example, Babigumira et al. (2014) base their global comparative analysis on self-reported clearing of 7,172 households from 24 developing countries. They state that the accuracy and reliability of self-reported data on land clearing for agriculture is likely 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 respondent may purposely choose not to report or to under report forest clearing due to fear of retaliation, which may lead to inaccurate results and misleading interpretations.

Here, I complement the regional and valley level analysis of the previous chapters with a detailed socio-economic analysis of agricultural expansion at the household level, which may contribute to understanding how policies might be improved or better targeted towards individual residents that engage in land conversion of forests into agricultural lands. To avoid the social desirability bias we pre-select contrasting households near the forest edge that have been adjacent to agricultural expansion apparent from remote sensing data over the last decade. These were contrasted with households that did not expand. To avoid accuracy issues, cropland expansion or lack thereof was then confirmed through interviews with household heads. Specifically, this study tested some of the dominant hypotheses in the field. 1) Larger households clear more forest because they have more workers and more family members to sustain; 2) Households with more members employed off-farm are less likely to be involved in forest clearing. 3) Asset-poor households clear less forest because they do not have means to clear or clear more forest as they have need to clear. 4) Socially privileged households are more likely to clear forest as they have more access and control over natural resources as compared to socially underprivileged. I used household's ethnicity, membership, forest ownership and membership of forest management organizations as additional predictor variables for clearing decisions.

4.3 Theoretical framework

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 the land use decision. The LF is one of the most frequently used framework in micro-level studies focusing on household economic strategies (Ellis and Freeman 2004), income diversification (Ellis 2000), human migration (Ellis 2003), poverty (Sayer et al. 2006). The framework is also used in studies focusing on deforestation and agriculture expansion (Angelsen, Larsen, et al. 2011; Babigumira et al. 2014). The livelihood framework was developed by the United Kingdom's Department for International Development (DFID) to coordinate and improve organization efforts to eliminate poverty.

The core idea of livelihood framework is based on the availability of and access to assets that determine the strategies people can adopt to attain the livelihood outcomes in a given policy, institutional and processes constraints (Haan and Zoomers 2005). Most of rural people in developing countries maintain diversified livelihood strategies because they cannot obtain sufficient food from any single strategy to survive and also to reduce the risk of vulnerability (Shahbaz, T. Ali, and Suleri 2011). They depend on agriculture, livestock, forest products, and wage labor (Sunderlin et al. 2005). Forest products include the collection of fuel wood, timber, wild nuts, and medicinal plants both for domestic use and sale. Agriculture expansion through forest clearing on forest margin is also an important livelihood strategy in the mountain areas. It is not only used to meet the food needs of growing household but also to cope with the vulnerabilities (Angelsen and Wunder 2003).

Access to more remunerative strategies is determined by the asset status of the household; those with more assets tend to have a range of options to switch between strategies (Nielsen et al. 2013). Household's assets are grouped into five categories: natural, human, physical, social, and financial. Natural capital includes land, forests, water and pastures (DFID 1999). Human capital includes skill, knowledge, labor, health status and leadership potential that varies with household size. Physical capital includes agriculture land, farm tools and machines and other valuable household items. Social capital includes membership organization, ethnicity, and social networking and connections. The strategies adopted based on the available assets are mediated by the processes and context. According to DFID (1999) and Babigumira et al. (2014), these processes and context include: 1) institutions that determine rules of access and use: 2) accessibility to market which effect transportation cost and relative prices and 3) external environment referred as vulnerability context *e.g.* death, human and livestock loss, job loss *etc.*

4.4 Data and Methods

4.4.1 Study site

The Kalasha valleys are situated in the Chitral District of Pakistan, southwest of the district's main town (Chitral). The Kalasha Valleys are Bumburet, Rumbur and Birir. The boundaries of three valleys and their location within Chitral district are shown in Fig. 4.1. The total area of the Rumbur valley is

249 km^2, Bumburet is 300 km^2 and Birir is 100 km^2. The Kalasha valleys are inhabited by the Kalasha tribe, an ethnic and religious minority of Pakistan. Some believe the Kalash to be descended from soldiers of Alexander the Great's army. Others believe that they migrated from Afghanistan in the 2nd century B.C., having Indo-Aryan roots with a fusion of Indo-European culture and traditions (Ayub et al. 2015). The Kalash people heavily depend on forest not only for their livelihood but also for their ritual cultural practices.

Despite being a non-Muslim minority with a unique culture, Kalasha livelihood is comparable with that of the Muslim majority of the Hindu-Kush range. They practice a mixed mountain economy of small scale combined with livestock husbandry. Grain crops and fruit and walnut trees are cultivated, on a subsistence basis, in the Kalasha valleys on tiny irrigated and terraced fields at an altitude around 1800 m. Major crops grown in the valleys are wheat, maize, potato, red bean and a variety of vegetables. Important fruits grown in the valleys include apples, apricots, walnut, mulberry, pear and grapes. Grapes and walnut are the most favored fruit crops grown in the area. Both men and women share farmland labor, but women are mostly engaged in weeding and thinning whereas watering, harvesting and plowing are mostly done by men. Local farmers use both traditional and mechanized methods of farming depending on the availability of access roads.

All people belonging to the Kalasha tribe are legal collective owners of forest lands in the Kalasha valleys under customary laws. Non-owners are small in number and mostly migrated from other parts of the Chitral district. Residents of two villages: Shakhandeh (Rumbur) and Shakhandeh (Bumburet) are claiming owners whose ancestors migrated from Afghanistan long ago. However, the Kalash people still consider them non-local.

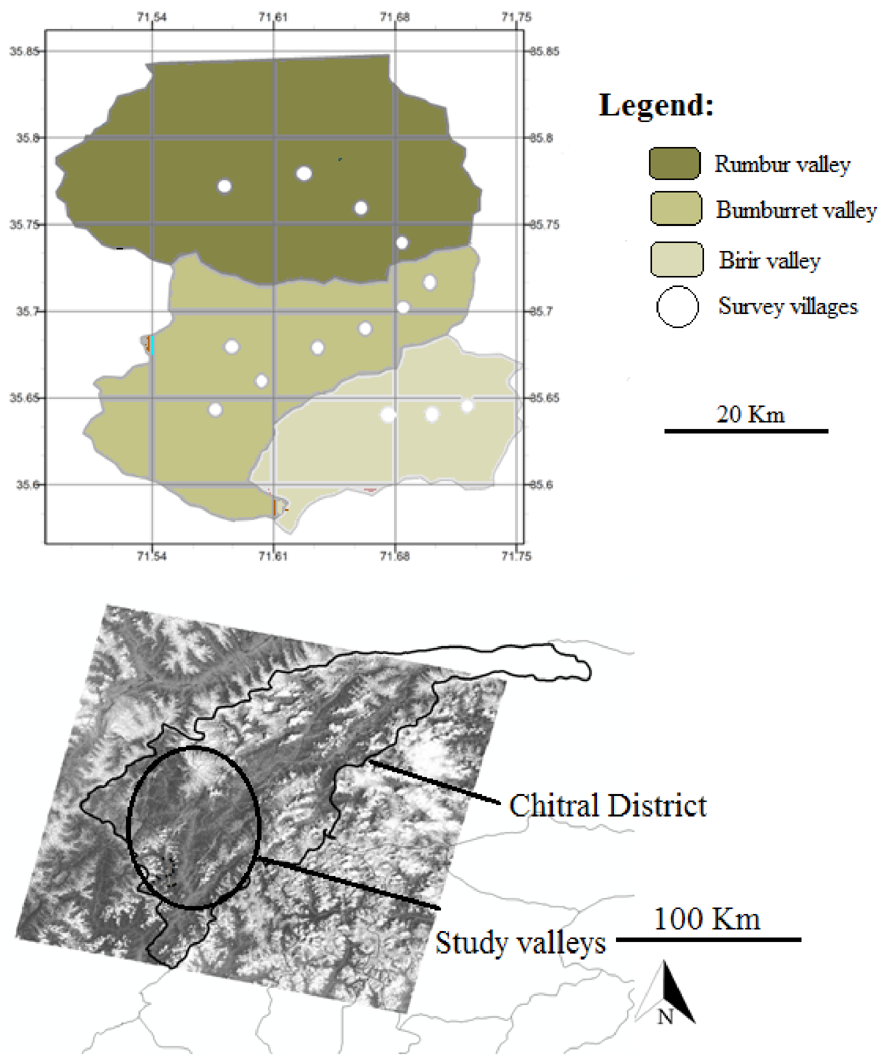

Figure 4.1: Location of the study area showing Chitral district in Pakistan (A), the Kalasha valleys in Southern Chitral (B) and the location of the villages in the Kalasha valleys (C)

4.4.2 Predictor variables and expectations

My statistical analysis relies on a binary response variable, indicating whether or not 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 factors related to household's human, social, physical and financial attributes that may relevant to forest clearing. The expected relationships between the dependent and independent variables are summarized in Table 4.1.

4.4.3 Farm polygons selection

To be included in our sample for household surveys, I only considered farms on forest margins with potential of expansion into forest. To select farms with the potential of expansion, to identify those expanded or not to nearby forested land and their owners, I used three different sources of data: (1) Google Earth imagery to select and digitize farms with potential of expansion; (2) Landsat images of 2003 and 2015 were used to group the farms with expansion and with no expansion into forested land; and (3) field survey and measurement to adjust the boundaries of the on screen digitized polygons. A total of 190 farm polygons were initially selected. However, I was only able to identify the owners of 123 farms polygons, 34 in Barir valley, 55 in Bumburet and 34 in Rumbur. In a few cases, two or more than two polygons belong to the same owner. I use geographic coordinate information attached to the farms and local representatives from each village to identify the owners of those agriculture farms. In total sample, 75 households cleared nearby forested land for agriculture and 48 did not expand. The schematic representation of the sampling design is shown in Fig. 4.2.

The sampling design conforms to the purposive selection method, first to

Table 4.1: 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 (0/1)	+/-
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 (PKR)	-/+
Distance from forest	Distance of cleared land from forest	-
Cropland area (2003)	Agriculture land owned by the household in 2003 (ha)	-
Financial capital		
Livestock value	Estimated value of livestock in PKR	+
Saving	Total saving in 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 in 103 m	-

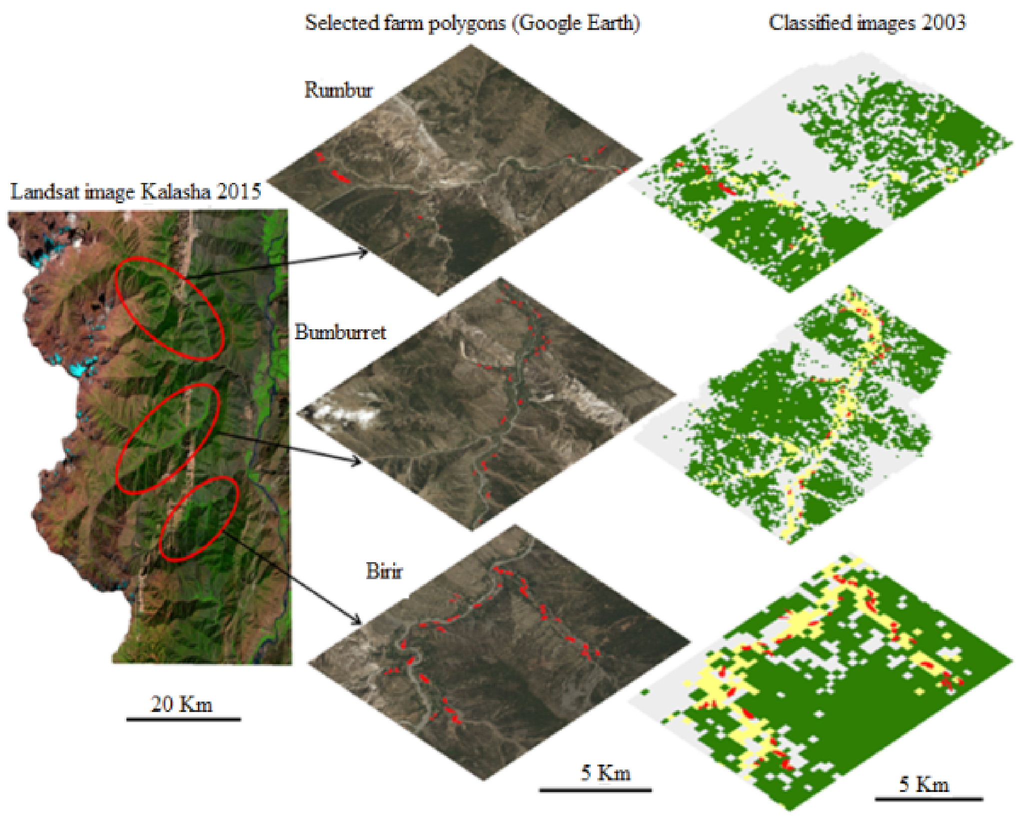

Figure 4.2: Methodology schematic showing the selected farm polygons in red (center column) and their remotely sensed land cover in 2003 (right column),where yellow indicates cropland land and green indicates forest. Households were selected based on clearing activities between 2003 and 2015.

focus on farms with expansion potential and second to select a contrast that is potentially rich in information. Though not a random sample, the procedure increases the statistical power to detect potential drivers of deforestation decisions. By using a non-random sample, I do narrow the inferences that may be drawn, however. For examples, our results do not apply to households not located near the forest edge and without the potential for agricultural expansion. My sample does include non-Kalasha households with ethnicity being one of the predictor variables and a wide spectrum of income levels, ownership and membership with forest management associations. As such, the sample ensures a good representation of communities of the study area.

4.4.4 Household surveys

For household data collection I used a modified version of Poverty Environment Network (PEN) survey instrument (`https://www.cifor.org/pen`). The PEN questionnaire was developed by CIFOR (Center for International Forestry Research) in the early 2000s to collect uniform information on the household income, including income from forests, wages, business, crops, livestock and others. The PEN questionnaire also includes detailed section on household assets, forest access and forest types, and aspects of forest governance. The PEN questionnaire is based on the widely cited research of Cavendish (2000). See Appendix A for the survey instrument used for my study.

The principal objective of the household survey conducted was to determine the relative importance of household demographic, socio-economic and land parcel characteristics in forest clearing decision and area cleared. The primary respondent in each interview was the head of the household. The household survey itself was a semi-structured interview that consisted of two main surveys. The survey focused on recording assets available to the households which include human, social, natural, physical and financial capital. It also includes questions on distance variables such as distance (to household's residence, market, roads and rivers) and topographic variables such as slope, aspect and elevation of the cleared land.

Six non-local enumerators (forestry students from Shaheed Benazir Bhutto University Sheringal) were trained to conduct the surveys that were conducted over a 6 month period starting in June 2016. Enumerators were selected on the basis of education level, previous experience in surveys and willingness to work in the remote and harsh environment. Before the field work started, the enumerators had four days of training. Many communities in this area are used to participating in research or development projects. Still, enumerators often had to assure households about the confidentiality of their answers. Likewise some questions about forest revenues were sensitive as forest product collection was prohibited for many of the villages. Villagers were also often wondering how our research could contribute to the development of their village. To ensure the confidentiality and anonymity of participants I hired enumerators from outside the district and did not collect any names or personal information on the questionnaires.

Survey took place in three Kalasha valleys and I stayed in each of the valley for the week of the survey. This facilitated contact with community members and allowed interviews to be conducted when most convenient for them, either early in the morning or late in the afternoon. During my stay in the community I developed relationships that helped me with the acceptance of me and my survey team by the community.

4.4.5 Statistical analysis

I use 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 3.1. Because 48 of the 123 sampled households cleared no land in the period, techniques which take into account the data left-censored at zero. I estimate two models to which take the censoring into account: a logit model which predicts the probability of any land clearing, and a tobit model which predicts the area cleared (including zero area).

Logit model

I use a logit model to explain the relationship between a binary variable indicating if any land has been cleared between 2003 and 2015 and the set of explanatory variables for household and farm characteristics. The basic form of the logit model is shown in Eq. 4.1 (Gujarati 2003).

$$\text{logit}(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 x_{1,i} + \cdots + \beta_m x_{m,i} \tag{4.1}$$

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 m-th independent variable for observation i.

The logit model was estimating using the `glm` command from the `R` (R Core Team 2018) package `MASS` (Venables and Ripley 2002).

Tobit model

A tobit model is a type of regression model that works with censored data. In my case, many of the households cleared no land in the period 2003–2005: the variable representing area cleared is left-censored at 0. As a result, tobit models are a type of limited dependent variable regressions models (Gujarati 2003). The tobit model allows us to use all of the data, not just those observations with a positive value for the dependent variable. Solution procedures for tobit models use the method of maximum likelihood.

The estimated coefficient provide an equation for a latent variable, y_i^*, which is related to the observable dependent variable through the ramp function in Eq. 4.2.

$$y_i = \begin{cases} y_i^* & \text{if } y_i^* > 0 \\ 0 & \text{if } y_i^* \leq 0 \end{cases} \tag{4.2}$$

The tobit model was estimating using the `tobit` command from the `R` (R Core Team 2018) package `AER` (Kleiber and Zeileis 2008).

4.5 Results & Discussion

4.5.1 Household characteristics

In our sample of 123 households, 60% of the respondents expanded their agriculture farms to forested land since 2003 and 40% did not (Table 4.2). The median forested land cleared for the purpose of agriculture since 2003 was 0.22 ha (Table 4.2). Land area under crop in 2003 and 2015 are given in Table 4.2. Prime motives behind forest clearing were primarily expansion of cropland, to a lesser degree expansion of pasture land, and orchard plantations. Out of the total household involved in clearing 77% respondents cleared forest land for crop production followed by pasture land 17% and a small proportion for orchards (Table 4.2). The principal crops grown on the cleared land were wheat, maize and bean. Due to the prevalence of subsistence agriculture in the area the highest proportion of the surveyed farmer was using the cleared land for wheat (55%) and maize (41%) production. Households in the area are involved in livestock production and depend on wheat and maize straw as a winter food for livestock.

The family size in the study area is higher than the national average of 6.8 persons per family (Table 4.2). The maximum household size recorded was 32 members in Birir. However, most households were in the 1–4 and 5–9 size categories. Most of the household's head were in their productive age and have established families with a median settlement time of 31 years as a family. In the sample households, the years of schooling were low and most of the farmers did not complete primary level education. Off-farm employment is the only source of winter income for majority of the households. Families send their members to outsides districts during winter when the area is covered with snow. On average two members in each family are working in off-farm sector (Table 4.2). The study sample also includes households that are member JFMC (65%), legal owners of forest (50%) and belong to the Kalasha community (51%) (Table 4.2).

4.5.2 Factors influencing forest clearing

The relationship between land area cleared and the values of various predictor variables is visualized with box-plots because the data are highly non-normal (Figs. 4.3 and 4.4). The median amount of land cleared for a particular group is represented by a vertical line, 50% of respondents fall within the box of the box-plot, and the range and outlier observations are indicated by the horizontal lines and dots, respectively. Household size, off-farm employment, saving, livestock value and physical asset classes show relationships to the area cleared. Area cleared increases with household size and livestock value and decrease

Table 4.2: Descriptive statistics for land usage, land conversion, and motives of agricultural expansion. Non-normally distributed data is described by the median value and the interquartile range (IQR), representing the range of the central 50% of the data. Some variables are represented as a count of households and a percentage of the total.

Variables	Summary statistics	
	Unit	Median (IQR) or Count (%)
Land use and land conversion		
Area used for crops in 2003	hectare (IQR)	1.61 (1.47)
Area used for crops in 2015	hectare (IQR)	2 (1.41)
Forest area cleared since 2003	hectare (IQR)	0.22 (0.20)
Household expanded	Households (%)	74 (61%)
Household not expanded	Households (%)	49 (39%
Motivation for expansion		
Addition of cropland	Households (%)	57 (77%)
Addition of rangeland	Households (%)	13 (18%)
Addition of orchard	Households (%)	4 (5%)
Principal crop on expansion		
Wheat	Households (%)	41 (55%)
Maize	Households (%)	31 (41%)
Bean	Households (%)	3 (4%)
Household socio-demographic		
Household headcount	Headcount (IQR)	7 (3)
Age of head	Years (IQR)	46 (15)
Education	Years (IQR)	0 (10)
Employed off-farm	Headcount (IQR)	2 (3)
Member JFMC	Households (%)	81 (66%)
Forest ownership	Households (%)	61 (49%)
Kalash (ethnicity)	Households (%)	63 (51%)
Settlement length	Years (IQR)	28 (16)
Physical assets	PKR (IQR)	42,000 (67,000)
Livestock	PKR (IQR)	238,000 (410,900)
Savings	PKR (IQR)	31,000 (80,000)
Debt	PKR (IQR))	37,000 (50,000)

with off-farm employment, saving and physical assets. The relationships between area cleared and off-farm employment and household size appear to be the strongest based on a first visual assessment of the raw data.

These relationships make intuitive sense. Larger households are likely to have more labor available to clear land, and likely need more land to feed the household. Households with a larger number of members employed off-farm will have less labor available for clearing, and are likely to be more money available for purchasing food. However, Fig. 4.4 shows that households with up to four members employed off-farm also engaged in maximum clearing while with above four member showed a significant decrease in area cleared. Similarly households with maximum savings cleared less forested land as compare to households with no savings (Fig. 4.4. Also, households with middle livestock value cleared more forest as compare to low and high (Fig. 4.4. Households with high livestock value depend on livestock income for food purchase and rarely involved in crop production, while households with less livestock are mostly engaged in off-farm activities. More livestock owned by farm families leads to more cutting of oak trees that will make more land available for cropland expansion.

I conduct two statistical tests for associations between area cleared and the predictor variables (a tobit model), and for the binary response variable whether a household cleared forest or not (logit model). I included household's socio-demographic, physical and financial variables besides farm-level characteristics (Table 4.2).

The results for the logit model indicate that the coefficients for variables corresponding to household size, number of members employed off-farm, value of physical assets, and savings were significant at the $p<0.1$ level, which was the level of significance I chose to use for this study (Table 4.3). As expected,

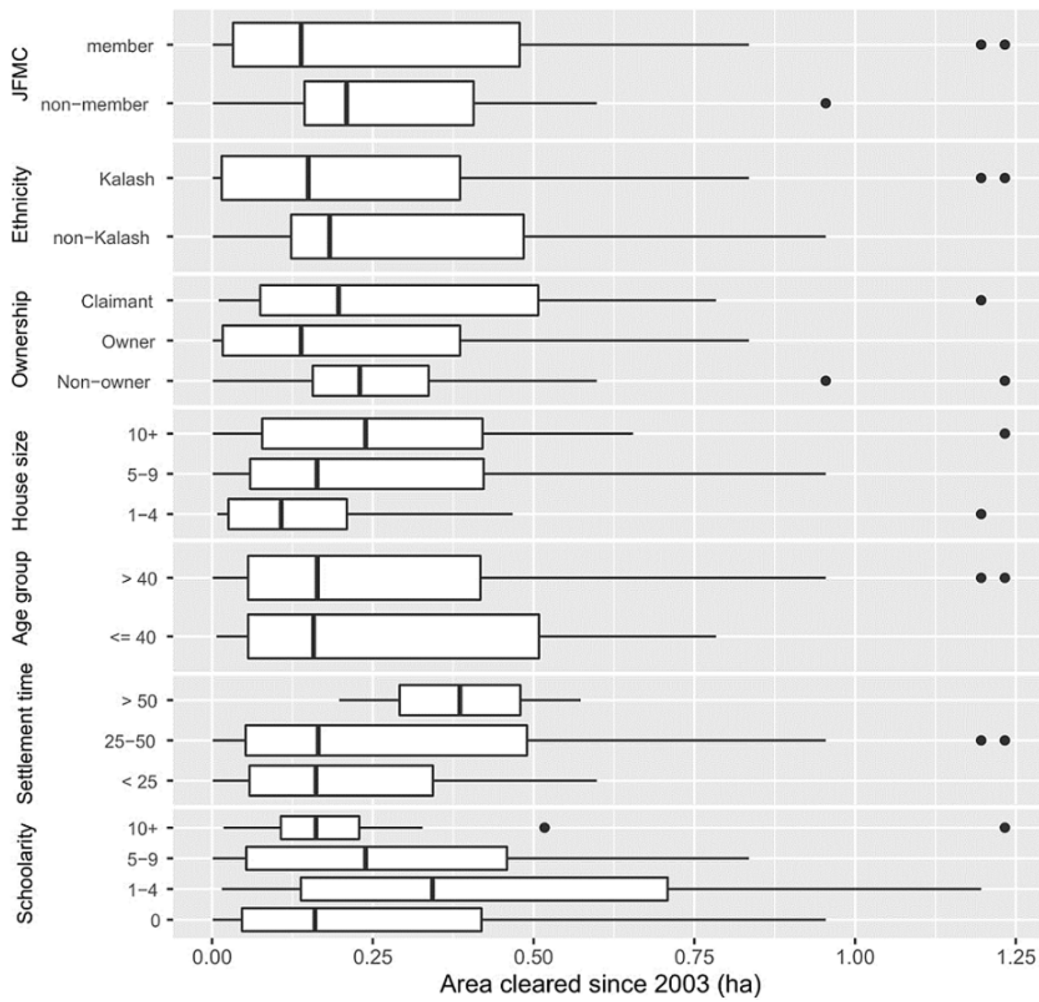

Figure 4.3: Household survey results for socioeconomic and demographic variables in relation to the area cleared since 2003. The box-plots indicate how the predictor variables are associated with the median and quartiles of forest clearing values for these households.

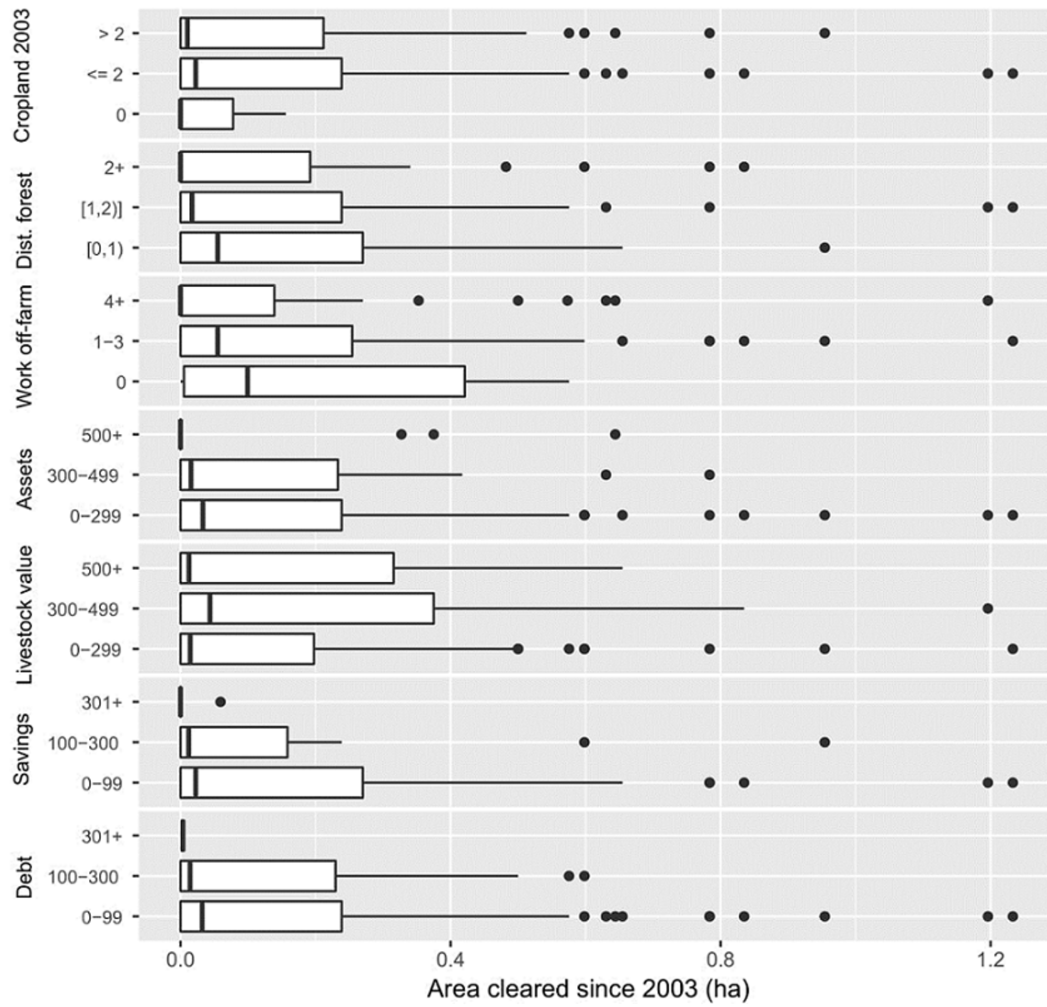

Figure 4.4: Household survey results for financial and physical assets in relation to the area cleared since 2003. The box-plots indicate how the predictor variables are associated with the median and quartiles of forest clearing values for these households.

larger the household size more likely to clear forest. 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 are less likely to expand farm into forested land as expected. This may be because the households with members in off-farm sector will have less labor available for clearing and are likely less dependent on subsistence agriculture. Richer households and households as measured by physical assets and household savings are less likely to take the cropland expansion decision. Richer households are mostly involved in off-farm sector and likely not as dependent on subsistence agriculture.

The general results from the tobit model are similar. The coefficients for household size, number of members employed off-farm, and value of physical assets are significant at the $p<0.1$ level (Table 4.3). The results are largely consistent with expectations. Area cleared was positively related to household size. Area cleared was negatively related to the household's members working off-farm, value of physical assets. I was unable to find any significant relationship of area cleared (and probability of clearing) with ethnicity, ownership class, area of cropland in 2003, slope, and elevation of the cleared parcel.

4.5.3 Off-farm employment versus forest products income

The survey on what sources of income most contribute to the total household income showed some notable opposite associations that were consistently observed in villages across the three Kalasha valleys. The poorest households relied disproportionately on forest products for their annual income share and least on off farm income, while the opposite was true for the overall richest households (Fig. 4.5).

Table 4.3: Results of regression analysis for factors influencing forest clearing for agriculture expansion between 2003 and 2015. The values in the table are the estimated coefficients and, in parentheses, their standard errors. Table created using stargazer v.5.2.2 (Hlavac 2018).

	Dependent variable:	
	Cleared (y/n)	Area cleared (ha)
	Logit	*Tobit*
	(1)	(2)
Cropland (2003)	−0.153 (0.171)	−0.016 (0.026)
Distance to forest	−0.013 (0.209)	−0.009 (0.027)
Household size	0.206^{**} (0.084)	0.024^{**} (0.011)
Employed off-farm	-0.287^{*} (0.157)	-0.059^{**} (0.025)
Physical Assets	-0.204^{**} (0.095)	-0.031^{**} (0.016)
Livestock	0.114 (0.100)	0.017 (0.014)
Savings	-0.504^{*} (0.280)	−0.065 (0.045)
Debt	−0.233 (0.386)	−0.030 (0.057)
JFMC	−0.951 (0.623)	−0.111 (0.089)
Kalash	0.867 (0.657)	0.125 (0.098)
Owner	0.125 (0.799)	−0.047 (0.113)
Claimant	0.360 (0.779)	0.054 (0.117)
Age of head	0.019 (0.030)	0.002 (0.005)
Settlement time	0.009 (0.021)	0.004 (0.003)
Education	−0.051 (0.048)	−0.0004 (0.007)
Slope	0.001 (0.053)	0.012 (0.007)
Elevation	−1.136 (1.135)	−0.069 (0.164)
Constant	1.459 (2.445)	−0.132 (0.376)
Observations	123	123
Log Likelihood	−63.864	−51.354
Akaike Inf. Crit.	163.729	
Wald Test		29.533^{**} (df = 17)
Note:		$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

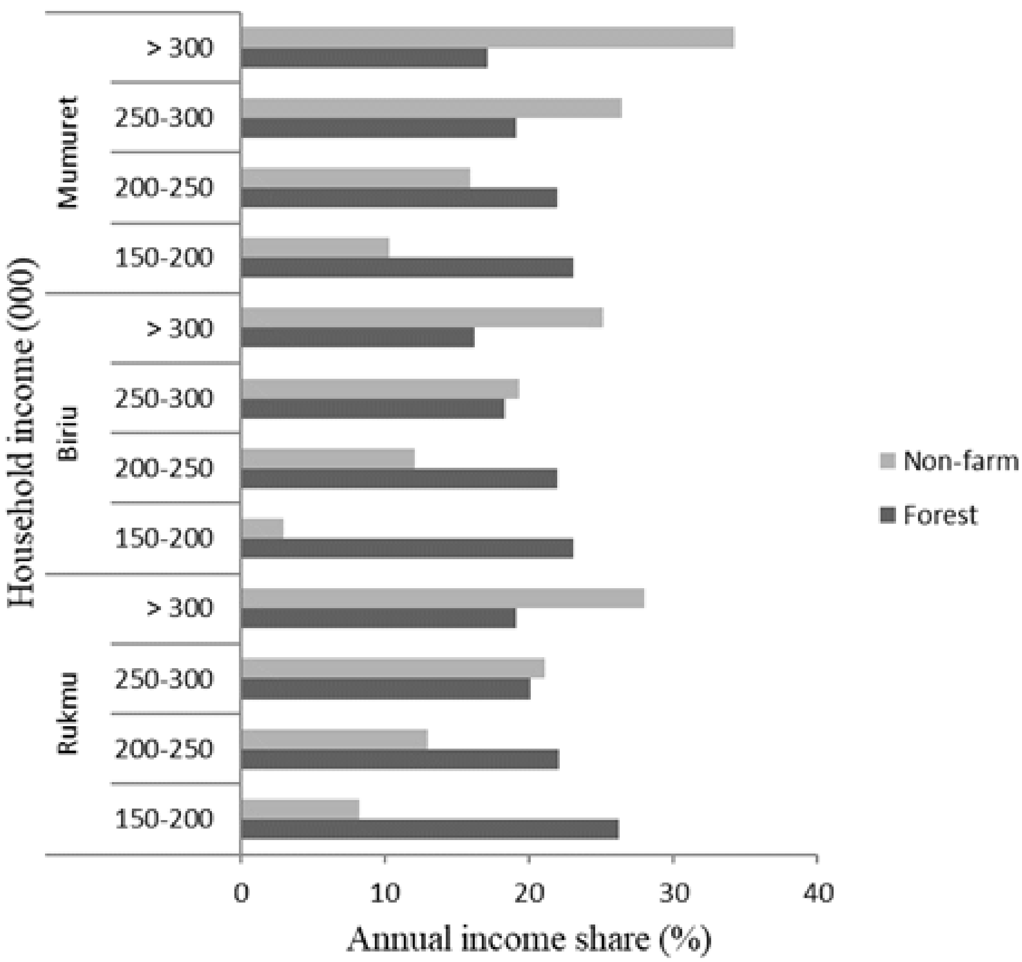

Figure 4.5: Comparison of income share from off-farm and forest

Households in the study area have limited off-farm livelihood options. Geographic isolation, extreme weather and lack of large scale government projects are the main reasons for the non-availability of alternative livelihood options. Off-farm employment opportunities in the Kalasha Valleys are limited to teaching in school, shop keeping, and small businesses run by women. For men, collecting fuel wood and timber in the nearby forested land is an important source of cash income. According to the local people, if a person does not find a job he goes to forest to collect fuel wood for sale. Fuel wood collection is sometimes more remunerative than crop production.

Researchers observed that policies aimed at stimulating off-farm employment and revenue generating activities discourages deforestation in two ways: 1) by reducing dependence on subsistence agriculture (increased incomes) thereby reducing the need to clear land; and 2) by labor competition – time spent as a wage laborer means less time is available for agriculture (Angelsen and Kaimowitz 1999; Pan et al. 2007; Walker, Moran, and Anselin 2000). In our case, the opportunity cost of labor time, since having a business or full time non-farm employment greatly reduce the time available for forest clearing. Forest clearing in the area is linked with the household income from the forest. Forest clearing is a slow process and usually considered as a byproduct of timber extraction for fuel wood and timber both for own use and sale. Generally, households first cut trees for fuel wood and timber use and then gradually encroach the cleared land for the purpose of agriculture.

4.5.4 Household's wealth and forest clearing

Previous studies on household's wealth and deforestation produced mixed results. Some studies argued that most land is deforested by the poor (Aggrey et al. 2010; Angelsen 1999; Fisher 2004; Pandit and Thapa 2003; Sapkota and

Odén 2008; Shively and Fisher 2004; Swinton and Quiroz 2003). However, others demonstrated the non-poor (Adhikari, Salvatore, and Lovett 2004; Godoy et al. 1996; Reetz, Schwarze, and Brümmer 2011) and showed the link between income and forest clearing resembles inverted U, with clearing peaking among middle income households. I did find some evidence of linking poor households with more clearing. the household data showed a negative correlation between forest clearing and value of household's wealth measured by physical assets and household savings and livestock number. The asset poorest and needy household clear more forest, where, higher assets clearing less. So, in this study area I can say that it's the needs that trigger households to clear land not the means. An obvious reason for the poor to clear more land could be Chayanovian type subsistence nature of agriculture in the region that constantly pushing them to clear more land to survive. It could also be linked to the lack of alternative employment opportunities. Poor households are natural resource dependent and use jobless members for the purpose of clearing and wood collection. One possible explanation for the rich household's small tendency toward clearing is that they might have other livelihood strategies and opportunities of acquiring high income.

Ownership and ethnicity are important social variables and play key role in forest clearing decision as observed by many studies (Chhatre and Agrawal 2009; Finley-Brook 2007; B. E. Robinson, Holland, and Naughton-Treves 2014; Vergara-Asenjo and Potvin 2014). Reason for insignificance in this particular case study could be the small sample size or small area of focus. The insignificance of ownership and ethnicity could also be linked to the current logging ban policy. 1993 the government completely banned commercial cutting and the residents 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 the policy owners mostly belong to the large ethnic group Kalash lost their interest in forest protection. Now both owners and non-owners are equally involved in forest clearing to establish legal title to the cleared land as agriculture land is considered individual property.

4.6 Conclusions and policy implications

I 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 in the Kalasha Valleys where job opportunities are limited and external inaccessibility prevents easy movement of labor for off-farm work to urban centers. Also, internal infrastructure is poor and difficult to start off-farm enterprises. As a consequence the youth, both men and women, in the valleys rely on forest extraction for income. Policymakers 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 would also be beneficial based on our analysis. Households with the largest head counts were associated with the highest probability for clearing decisions 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.

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Chapter 5

Conclusion

Prevention of forest loss is a high priority in Pakistan, where deforestation has been linked to catastrophic flooding in 1992 and 2010. Under the United Nation's REDD+ program, new incentive schemes are developed to encourage forest protection and reforestation, while implementing social safeguards for forest-dependent indigenous groups. The objective of this study is to support Pakistan's REDD+ readiness activities that affect the Kalasha, a unique indigenous people that are under enhanced protection of the UNESCO Intangible Cultural Heritage list.

This thesis comprises three papers exploring the extent and causes of deforestation and forest degradation in the Kalasha valleys of Pakistan. The valleys are located in the Chitral Tehsil (sub-division) within the Chitral District of the Khyber Pakhtunkhwa Province. The first paper (Chapter 2) examines deforestation and forest degradation at the tehsil level over two time periods (1973–1993 and 1993–2015). The year 1993 is significant as a nation-wide ban on harvesting live trees was imposed at that time. The second paper (Chapter 3) focuses on the Kalasha Valleys, which are three valleys (Rumbur, Bumberet, and Birir) within the Chitral Tehsil, inhabited by the indigenous

Kalasha people. I use GIS analysis and an actor-centred power approach to identify the extent and causes of deforestation and forest degradation in the Kalasha Valleys. The third paper (Chapter 4) presents a household-level statistical analysis relating household characteristics to the area of forest cleared for cropland between 2003 and 2015.

5.1 Chitral-level study

I contribute a long-term analysis of deforestation and forest degradation for Pakistan's Chitral Tehsil, using Landsat MSS/TM/OLI TIRS-8 images to quantify forest cover changes prior to (1973-1993) and after (1993-2015) a nation-wide logging ban was imposed in 1993. Forest cover changes were further evaluated in the context of access and enforcement measured through distances to administrative boundaries, human activities, and topography. I found that despite a complete ban on commercial green felling, deforestation continued at a high rate. Agriculture land in the study area expanded in the pre-ban period, but actually decreased by 12% post-ban. The decrease may be due to erosion of the agricultural landbase as a consequence of severe floods. Notably, the imposition of the logging ban shifted the patterns and rate of forest conversion. The analysis showed that deforestation in the pre-ban period occurred in valuable high elevation conifer forests, while during the post-ban period deforestation shifted to low elevation oak forests near human habitation. High elevation conifer forests instead suffered from forest degradation during the post-ban period, presumably due to through selective cutting of the most valuable trees.

5.2 Valleys-level study

I identify actors and power structures that have caused deforestation in the past, and recommend policy improvements that protect forests as well as the Kalasha's culture and traditional livelihoods. A remote-sensing based historical analysis showed that government actors have significant power to influence land use practices in the region, although their policy instruments may not have had the intended effects. A logging ban in 1993 caused a shift to small-scale selective cutting but could not stop forest loss. Near human habitation forest loss actually increased after the ban. Results from expert interviews reveal binary and contradictory perceptions regarding the actors responsible for forest loss. Both local residents and government officials point to the other side as primary responsible, while rationalizing their own contribution. The inhabitants of the valleys are dependent on wood for fuel and for housing. They have little cash available for purchasing alternative fuels such as LPG. Population in the area has increased at a rapid rate, and with wood as the only fuel, pressure on the forest has undoubtedly increased. Illegal logging by timber mafia is one of the sources of deforestation and degradation in the Kalasha valleys. It appears that instead of clear cutting prior to the logging ban the method of extraction appears to have shifted to selective logging, which would make illegal harvesting less obvious to the forest authorities.

5.3 Household-level study

Through a socio-economic survey of 123 households on the forest margins, and a data collected from Landsat imagery on changes in farm plot area between 2003 and 2015, I analysed the relationship between household characteristics and the amount of land cleared over the time period. I found that families with more members, more livestock, and fewer physical and financial assets were more likely to clear forested land for agricultural expansion. Families with more members employed off-farm were less likely to be involved in forest clearing. The survey also on what sources of income most contribute to the total household income showed some notable opposite associations that were consistently observed in villages across the three Kalasha valleys. The poorest households relied disporportionally on forest products for their annual income share and least on off farm income, while the opposite was true for the overall richest households Social factors such as education, ethnicity, and forest ownership were not significantly associated with clearing of forests.

5.4 Recommendations

It seems to us that deforestation and degradation will continue to be a major problem in the area unless population growth is curtailed, alternative fuels become affordable, and alternative livelihood options become available, perhaps through the development of effective forest protection plan and implantation of REDD+ schemes in the forest rich districts of the country.

I recommend forest management strategies for high-elevation conifer forests that reverse the effects of high-grading, for example reforestation activities with improved planting stock, as well as better enforcement of protection of the timber species found in these forest ecosystems. Forest management in lower elevation oak forests should focus on providing alternatives for fuelwood to relieve pressure on forest resources near human settlements.

In addition to its core objectives, this study also aims to support Pakistan's REDD+ readiness activities that affect the Kalasha. Kalasha livelihood is comparable with that of the other communities living in the forest rich districts of the country depend heavily on forest for their timber and fuelwood needs. They also depend on forest for their livelihood and ritual cultural practices. Since fuelwood production for regional consumption constitutes one of the largest sources of income for the poorest households, there is a high risk that REDD+ implementation could produce negative outcomes for the local communities. It could weaken local livelihoods and undermine their traditional practices by forcing them to follow REDD+ schemes for conserving forests. This is where REDD+ incentive schemes may play a crucial role. REDD+ could contribute to poverty alleviation in the Kalasha valleys by providing extra income from carbon credit payments, and other co-benefits such as improved tenure or carbon ownership. In addition, there is high chance that local elite will tend to capture the major share of community compensation and instead protecting the interest of the poor can in fact exacerbate social inequalities. To better represent local people, and to protect their rights JFMCs members should be elected through democratic processes. JFMCs with democratic legitimacy would be well-positioned to administer REDD+ programs and ensure that their benefits are shared with those that contribute to the protection and regeneration of forest areas. REDD+ intervention could also affect local people through restriction on fuelwood collection and timber extraction for local use.

The inhabitants of the valleys are dependent on wood for fuel and for housing. They have little cash available for purchasing alternative fuels such as LPG. Population in the area has increased at a rapid rate, and with wood as the only fuel, pressure on the forest has undoubtedly increased. The most effective intervention in this regard would be offering alternatives to the reliance on fuelwood for heating and cooking. Less than 1so there are opportunities for reducing a portion of the required fuelwood demand through programs that invest in liquefied petroleum gas (LPG) equipment and distribution. LPG may also be used for rural heating systems, but the investments required would be much higher. A much cheaper way to provide relief on the remaining forest resources would be a switch to regionally abundant coal resources for heating. While this has negative environmental impacts both in terms of pollution and carbon emissions, this will likely be partially or fully compensated by preventing further deforestation and carbon sequestration by allowing regeneration of low-elevation forests.

I also recommend maintenance of the logging ban because of small amount of remaining forest, and its rapid decline.

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Appendix A

Household survey instrument

A. Identification

1. Household code number	
2. Village name	
3. Name of forest block	
4. GPS reference point of household (UTM format)	*degree*
5. Household head forest tenure category	
a*)* User with legal ownership	
b) User with no legal ownership	
c) User with claiming ownership	
6. How long ago was this household formed	*years*
7. Was the household head born in this village?	*0/1*
8. Does the household head belong to the largest ethnic group/caste in the village?	*0/1*
9. Household head membership of forest organization	*0/1*

		1. km	*2. min*	*Mode of transportation*
10. What is the distance from the household to..?	1. district market			
	2. market to major consumption goods			
	3. market where agric. products are sold			
	4. market where forest products are sold			

B. Household composition

Who are the members of the household?

Household member code	**Relation to Household head** *Household head code=0*	**Sex** *(0=male 1=female)*	**Age** *(Years)*	**Education** *(number of years completed)*	**Present activity**
1					
2					
3					
4					
5					
6					
7					
8					

1) Codes: 1=spouse (legally married or cohabiting); 2=son/daughter; 3=son/daughter in law; 4=grandchild; 5=mother/father; 6=mother/father in law; 7=brother or sister; 8=brother/sister in law; 9=uncle/aunt; 10=nephew/niece; 11=step/foster child; 12=other family; 13=not related (e.g., servant).

C. Natural Assets

1. Please indicate the amount of land (in hectares) that you currently own and have rented in/out.

Category	1. Area *(ha)*	2. Ownership *(code-tenure)*	Main products grown/harvested in the past 12 months Max 3		
			3. Rank1	4. Rank2	5. Rank3
Forest:					
1. Natural forest					
2. Managed forests					
3. Plantations					
Agricultural land:					
4. Cropland					
5. Pasture (natural or planted)					
6. Farm trees					
7. Fallow					
8. Total land owned (1+2+3+…+8)					
9. Land rented out (**included** in 1-8)					
10. Land rented in (**not included** in 1-8)					

Use following codes for agriculture land ownership:
1 = owner; 2 = tenant; 3 = owner-cum tenant

D. Physical Assets and savings

1. Please indicate the type of house you have?

1. Do you have your own house? 1)	
2. What is the type of material of (most of) the walls? 2)	
3. What is the type of material of (most of) the roof ? 3)	
4. How many m^2 approx. is the house?	*m^2*

1) Codes: 0=no; 1=own the house on their own; 2=own the house together with other household(s); 3=renting the house alone; 4=renting the house with other household(s); 9=other, specify:

2) Codes: 1=mud/soil; 2=wooden (boards, trunks); 3=iron (or other metal) sheets; 4=bricks or concrete; 5=reeds/straw/grass/fibers/bamboo; 9=other, specify:

3) Codes: 1=thatch; 2=wooden (boards); 3=iron or other metal sheets; 4=tiles; 9=other, specify:

2. Please indicate the number and value of implements and other large household items that are owned by the household.

Note: see latest version of "PEN codes list" for a complete list of items and codes.

	1. No. of units owned	**2. Total value (current sales value of all units, not purchasing price)**
1. Car/truck		
2. Tractor		
3. Motorcycle		
4. Bicycle		
5. Handphone/phone		
6. TV		
7. Radio		
8. Cassette/CD/ VHS/VCD/DVD/ player		
9. Stove for cooking (gas or electric only)		
10. Refrigerator/freezer		
11. Fishing boat and boat engine		
12. Chainsaw		
13. Plough		
14. Scotch cart		

15. Shotgun/rifle		
16. Wooden cart or wheelbarrow		
17. Furniture		
18. Water pump		
19. Solar panel		

3. Please indicate the savings and debt the household ha

1.	How much does the household have in savings in banks, credit associations or savings clubs?	*Lc$*
2.	How much does the household have in savings in non-productive assets such as gold and jewelry?	*Lc$*
3.	How much does the household have in outstanding debt?	*Lc$*

E. Forest resource base

1.	How far is it from the house/homestead to the edge of the nearest natural or managed forest that you have access to and can use?	1. … measured in terms of distance (straight line)?	*km*
		2. … measured in terms of time (in minutes of walking)?	*min*
2.	Does your household collect firewood? *If 'no', go to 8.*		*(1-0)*
3.	**If 'yes'**: how many hours per week do the members of your household spend on collecting firewood for family use? (adult time should be reported; child time = 50 % of adult time)		*(hours)*
4.	Does your household now spend more or less time on getting firewood than you did 5 years ago? *Codes: 1=more; 2=about the same; 3=less*		
5.	How has availability of firewood changed over the past 5 years? *Codes: 1=declined; 2=about the same; 3=increased* *If code '2' or' 3', go to 7.*		
6.	**If declined** (code '1' on the question above), how has the household responded to the decline in the availability of firewood? *Please rank the most important responses, max 3.*	**Response**	**Rank 1-3**
		1. Increased collection time (e.g., from further away from house)	
		2. Planting of trees on private land	
		3. Increased use of agricultural residues as fuel	
		4. Buying (more) fuelwood and/or charcoal	
		5. Buying (more) commercial fuels (kerosene, gas or electricity)	
		6. Reduced the need for use of fuels, such as using improved stove	
		7. More conservative use of fuelwood for cooking and heating	
		8. Reduced number of cooked meals	
		10. Use of improved technology	
		11. Increased use of non-wood wild products (ex. reeds)	
		12. Restricting access/use to own forest	
		13. Conserving standing trees for future	
		14. Making charcoal	
		9. Other, specify:	

7. Has your household planted any woodlots or trees on farm over the past 5 years? *If 'no', go to next section.*		*(1-0)*
8. **If yes:** what are the main purpose(s) of the trees planted? *Please rank the most important purposes, max 3.*	**Purpose**	**Rank 1-3**
	1. Firewood for domestic use	
	2. Firewood for sale	
	3. Fodder for own use	
	4. Fodder for sale	
	5. Timber/poles for own use	
	6. Timber/poles for sale	
	7. Other domestic uses	
	8. Other products for sale	
	9. Carbon sequestration	
	10. Other environmental services	
	11. Land demarcation	
	12. To increase the value of my land	
	19. Other, specify:	

F. Forest services

1. Has the household over the past 12 months received any cash or in kind payments related to the following forest services?

Principal purpose	**1. Have received?** *(1-0)*	**2. If yes, amounts (values) received** *(Lc$)* *(if nothing, put '0')*
1. Tourism		
2. Carbon projects		
3. Water catchments projects		
4. Biodiversity conservation		
5. Others, specify:		
6. Tree planting		
7. Timber concessions		

G. Forest clearing

1. GPS reference points of household current agriculture land boundaries				
1. Did the household clear any forest since 1992 (year of forest boundary marking)?		*(1-0)*		
If YES:	2. How much forest was cleared (mean annual)?	*ha*		
	3. What was the cleared forest (land) used for? *Codes: 1=cropping; 2=tree plantation; 3=pasture; 4=non-agric uses (Rank max 3)*	1.Rank1	2.Rank2	3.Rank3
	4. If used for crops (code '1' in question above), which principal crop was grown?	1.Rank1	2.Rank2	3.Rank3
	7. What was the ownership status of the forest cleared? *(code tenure)*			
	8. How far from the house was the forest cleared located?	*km*		

Household economic activities:

A. Agriculture Production – crops

1. What are the quantities of crops that household has harvested during the past 2 seasons?

Crops *Season 1*	**Area of production** (*ha*)	**Production per ha**	**Total Production** *(tons)*	**Own use (incl. gifts)** *(tons)*	**Sold (incl.barter)** *(tons)*	**Stored** *(tons)*	**Seed** *(tons)*	**Purchase (deficit)** *(tons)*	**Price per unit**
Season 2									

2. What are the quantities and values of inputs used in crop production over the past 2 seasons? (this refers to agricultural cash expenditures)?

Crops Season 1	**Seed**		**Fertilizer** (nitrogen)		**Fertilizer** (phosphate)		**Pesticides / herbicides**		**Machinery** (tractor hours)		**Family labor** (Man-days)		**Hired labor** (Man-days)		**Land rent** (Rs)	
	qt	*p\u*	*qt*	*p\u*	*qt*	*p\u*	*qt*	*p\u*	*qt*	*p\u*	*qt*	*w\u*	*qt*	*w/u*	*qt(ha)*	*Rnt/h*
Season 2																
Total Cost																

B. Livestock production activities

1. What is the number of animals your household has now, and how many have you sold, bought, slaughtered or lost during **the past 1 year**?

Livestock	Beginning number	Livestock born (net died)	Sold (incl. barter), live)	Slaughtered for own use(or gift given)	Bought or gift received	End number (now)	Price per adult animal	Total end value
Cows								
Heifers								
Oxen								
Bull								
Sheep ewe								
Sheep rams								
Goat doe								
Goat buck								
M Calf								
F Calf								
M Lamb								
F Lamb								
M kid								
F kid								

2. What are the quantities and values of animal products mainly milk produced during **the past one year**?

Milking livestock	Number	**Milk Production** *(per animal/ day)*	**Length of lactation period** *(days)*	**Total production** *(kg)*	**Home consumption** *(kg)*	**Milk sold** *(Kg)*	**Price** *(per kg)*	**Total value**
1. Cows								
3. Sheep								
4. Goat								

3. What percentage of your livestock feed is obtained from following sources?

Livestock	Number	Dry matter requirement *(tons per animal)*	Total DM requirement *(tons)*	Crop residues *(% age)*	Home grown forages *(% age)*	Market purchase *(% age)*	Forest grazing *(% age)*	Pasture grazing *(% age)*
Cows								
Heifers								
Oxen								
Bull								
Sheep ewe								
Sheep rams								
Goat doe								
Goat buck								
M Calf								
F Calf								
M Lamb								
F Lamb								
M kid								

4. What types of your family livestock use forest for grazing?

Livestock	Forest grazing *(number)*	Ownership	Pasture grazing *(number)*	Ownership
Cows				
Heifers				
Oxen				
Bull				
Sheep ewe				
Sheep rams				
Goat doe				
Goat buck				
M Calf				
F Calf				
M Lamb				
F Lamb				
M kid				
Cows				

5. What are the quantities and values of inputs used in livestock production during **the past one year** (cash expenditures)? *Note: The key is to get total costs, rather than input units.*

Livestock	**Dry matter req** *(tons/per year)*	**Labor req** (Man-days/animal)	**Labor use** (Man-days)		**Veterinary cost** *(Rs/animal)*	**Concentrate cost** (Rs/animal)	**Dry matter purchase** (Rs/animal)
			Family labor	Hired labor			
Cows							
Heifers							
Oxen							
Bull							
Sheep ewe							
Sheep rams							
Goat doe							
Goat buck							
M Calf							
F Calf							
M Lamb							
F Lamb							
M kid							

C. Forest extraction activities

1. What percentage of your fuelwood and timber requirements is obtained from following sources?

B.

Extracts	**Total requirement** *(tons)*	***Forest*** *(% age)*	**Farm trees** *(% age)*	**Market purchase** *(% age)*	***LPG (Fuelwood only)*** (% age)
Fuelwood					
Timber					
Tree loops					

2. What are the quantities and values of forest products the members of your household collected for both own use and sale over **the past month**?

Forest product	**Collected where?**		**Quantity collec-ted (7+8)**	**Labor use**	**Own use (incl. gifts)**	**Sold (incl. barter)**	**Price per unit**	**Type of market**	**Gross value (5*9)**	**Tran-sport/ marketing costs (total)**	**Purch. inputs & hired labour**	**Net income (11-12-13)**
	Land type *(code-land)*	**Ownership** *(code-tenure)*										

1) Codes: 1=only/mainly by wife and adult female household members; 2=both adult males and adult females participate about equally; 3=only/mainly by the husband and adult male household members; 4=only/mainly by girls (<15 years); 5=only/mainly by boys (<15 years); 6=only/mainly by children (<15 years), and boys and girls participate about equally; 7=all members of household participate equally; 8=none of the above alternatives; 9=person employed by and living with the household.

D. Farm trees

Area(ha)	**Biomass** (apprx)	**Yield**(m3)/y		**Consume**(m3)		**Sold**(m3)		**Price** /unit	**Income**	**Cost planting**	**othercost**
		Fuel wood	timber	Fuel wood	timber	Fuel wood	timber				

E. off-farm labor activities

1. Has any member of the household had paid work over **the past month**?

Note: One person can be listed more than once for different jobs.

1. Household member (PID)	**2. Type of work** *(code-work)*	**3. Days worked past month**	**4. Daily wage rate**	**5. Total wage income (3*4)**

Appendix B

Expert interview questions

Name ______________

Department ______________

Designation _____________

Date ______________

1. Do you know what Green Felling Ban is?
   i. Yes
   ii. No
2. In your opinion which is/was better suited to your condition?
   i. Green Felling Ban
   ii. No Green Felling Ban
3. What is your attitude regarding Green Filling Ban and management activities?
   i. Supportive
   ii. Non- Supportive
      a. Why________________
4. What is the attitude of people regarding Green Felling Ban and management activities?
   i. Supportive
   ii. Non-supportive
      a. Why ________________
5. Despite of ban deforestation still continue in the area what are the important causes?

   (please rank in order of importance)

1) 2) 3) 4)