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PhD Dissertation

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EVALUATING COMMUNITY FORESTRY PROCESSES AND OUTCOMES: EVIDENCES FROM MID-HILL COMMUNITY FORESTS OF NEPAL

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Preface

I have been involved in the forestry sector of Nepal since 1989. Over three decades, I have worked with researchers, policy makers, planners and local users on different aspects of forestry in Nepal. With the Government of Nepal's recognition of community forestry as a strategy for forest conservation and rural development in the late 1980s, much has been written on various dimensions of the community forestry programme. Based on my personal experiences and discussions with colleagues, I worked on this research in order to solicit information about the outcomes of the community forestry programme, taking examples of 10 community forest user groups in Tanahun, a mid-hill district of western Nepal.

This dissertation has been submitted in partial fulfilment of the requirements for the Doctor of Philosophy (PhD) degree at the Global Development Unit, Department of Food and Resource Economics, Faculty of Science, University of Copenhagen, Denmark. I hereby declare that the work contained in this dissertation is my own original work and that it has not been submitted to any other university for a degree. The research was conducted from 2009 to 2012. The fieldwork was carried out in 10 community forests of Tanahun district of western Nepal and qualitative as well as quantitative approaches were applied. The research assessed the extent of forest condition change of selected community forests over two time periods viz. 1972-1998 (before community forestry) and 1998-2009 (after community forestry), studying the relative economic importance of forest income to the total household economy under different tenure arrangements, analyzing determinant factors influencing people's participation in community forestry activities, analyzing the diversity of farm trees and determinants of tree growing practices on farm land, and investigating the effects of management activities on vegetation diversity, dispersion patterns and stand structure of community-managed forests. The work has resulted in five papers with the following titles:

1. Oli, B. N. and Treue, T. 2015. Conservation by utilization; a temporal analysis of community-managed forests in Nepal (in review at *World Development*)
2. Oli, B. N.; Treue, T. and Smith-Hall, C. 2015. The relative importance of community forests, government forests, and private forests for household-level incomes in the Middle Hills of Nepal (in review at *Forest Policy and Economics*)
3. Oli, B. N.; Treue, T. and Larsen, H. O. 2015. Socio-economic determinants of growing trees on farms in the middle hills of Nepal (published in *Agroforestry Systems*). DOI: 10.1007/s10457-015-9810-1
4. Oli, B. N. and Treue, T. 2015. Determinants of participation in community forestry in Nepal (accepted by *International Forestry Review*)
5. Oli, B. N. and Subedi, M. R. 2015. Effects of management activities on vegetation diversity, dispersion pattern and stand structure of community-managed forest (*Shorea robusta*) in Nepal (published in *International Journal of Biodiversity Science, Ecosystem Services and Management*). DOI: http://dx.doi.org/10.1080/21513732.2014.984334

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My sincere gratitude goes to the former Director General of Department of Forest Research and Survey Mr. Sahas Man Shrestha for his support in developing the PhD research proposal. I benefited a lot from the support received from Mr. Lila Puri, Research Officer of the ComForM project. I also greatly appreciate the academic and moral support received from Dr. Bir Bahadur Khanal Chhetri and Dr. Santosh Rayamajhi both in Denmark and Nepal. My special thanks go to Mr. Kapil Khanal, Dr. Maheshwar Dhakal, Dr. Rajendra KC, Dr. Hemant Ojha, Dr.Manohara Khadka, Mr. Deepak Kharal, Mr. Sindhu Dhungana, Dr. Indra Sapkota, Mr. Resham Dangi, Mr. Ramu Subedi for their valuable inputs on my research work. I appreciate the support of Mr. Brian Peniston in language editing. Mr. Bhim Bahadur Thapa from the Department of Forest Research and Survey deserves special thanks for providing aerial photographs of 1992 required for the study. I also express my sincere thanks to the anonymous reviewers of the papers.

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My deepest thanks go to my wife Apsara and son Abhas for their patience, sacrifice and understanding while I was away for the study in Denmark. I also appreciate the encouragement and inspiration from my parents Toya Nath Oli and Kamala Oli, and my brothers and sisters.

Summary

With the overall objective to evaluate outcomes of decentralized forest governance in Nepal, particularly focussing on assessing forest conditions as well as the role of community forestry in household economies, this research was carried out in 10 community forests of Tanahun district of western Nepal. The fieldwork consisted of five components: forest measurement including boundary survey, household survey of 304 households, key informant interviews, counting and identification of farm trees, and focus group discussions. Different types of airborne analogue aerial photographs, satellite imageries (high resolution), digital topographic data (spatial data) and GPS data were also used for the study. Data were analyzed using ArcGIS 9.2, SPSS 16 and STATA 11 software.

It was observed that, after decentralization, all forests were actively as well as sustainably harvested by local communities, supporting the general 'conservation through economically rational utilization' predictions of common pool resource management theory. Assisted by a general positive economic development, indefinite, exclusive and enforceable proprietor rights to valuable forests seemed to be the explanatory factors. The study further revealed that total forest income contributed about 5.8% to total household income, ranging from 3.8 to 17.4% for the richest and poorest, respectively. Community forestry income constituted about 49.7% of the total forest income, followed by 27.5% from government-managed forests, and 22.8% from private forests/trees. Analyses on poverty indices and decomposed Gini coefficients showed that incorporating forest incomes in total household income reduced measured rural poverty substantially, and income inequality to some extent. Out of 10 explanatory variables used in an OLS regression model, four in community forest regimes were significant; (i) low caste households generated higher forest incomes than higher caste households, (ii) households with the lowest land holdings generated more forest incomes than other households, (iii) households with high livestock holdings generated higher forest incomes than other households, and (iv) households that received higher remittances generated less forest incomes than other households. For private forest/tree regimes three variables turned out to be significant; (i) households with high land holdings generated higher incomes from private forests/trees than others, (ii) those with high livestock holdings derived higher incomes from private forests/trees than other households, and (iii) those who were close to markets generated higher incomes from private forests/trees than others. In government-managed forest only two variables were significant (i) those receiving high remittances also generated higher forest incomes and (ii) households who were far from markets generated less forest income than the other households.

On-farm trees were found to be very important in terms of supplying firewood and especially fodder for the rural households. Land holdings, livestock holdings, firewood consumption, and education level were positively related to the number of

trees on a household's farm land while distance to the forest and the use of alternative energy sources were negatively related. One conclusion drawn is that tree products are vital to the most prevalent rural livelihood strategies and it is reasonable to believe that rural differentiation does not show itself in this aspect, but rather in assets that require more capital.

Furthermore the results suggest that, overall moderate participation in community forestry activities is by far most common for rural households in the Nepalese mid-hills. Yet, there are several determinant factors which influence the level of participation. Of the 12 variables included in an analytical model, the following associations stood out as significant; male-headed households participated more than female-headed households, higher caste households participated more than lower caste households, households with high livestock holdings participated more than other households, households involved in many networks participate more than other households, and households that consume high amounts of firewood participated more than other households. Wealth class did, however, not seem related to the level of households' participation. Nor did the amount of produce extracted from the community forests.

Using the example of one community forest, the study showed that community defined and enforced access rules do not necessarily maintain forest species diversity or regulate the forest stand structure, because species with high economic potential tended to be over-harvested. A multitude of anthropogenic, socio-economic, and environmental factors, either alone or jointly, affected the forest structural, functional, and compositional aspects at varying scales and intensities, which play crucial roles in conservation, maintenance, and degradation of forest biodiversity in Sal (*Shorea robusta*) forests of Nepal.

Dansk Resumé

Denne afhandlings overordnede formål er at undersøge resultaterne af decentraliseret skovforvaltning i Nepal, specielt med fokus på hvordan omlægningen til denne forvaltningsform har påvirket skovtilstanden samt økonomien i berørte rurale husholdninger. Feltarbejdet inkluderede 10 'community forests' i Tanahun distrikt i det vestlige Nepal og indeholdt fem hovedkomponenter: skovtaksation inklusiv identifikation af de lokale skovgrænser, en spørgeskemaundersøgelse inkluderende 304 stratificeret tilfældigt udvalgte hushold, en opgørelse samt identifikation af private træer på landbrugsjord og fokusgruppediskussioner. En række analoge flyfotos, satellitbilleder, digitaliserede topografiske kort samt indsamlet GPS data blev også anvendt i arbejdet. Data blev analyseret via forskelligt software inkluderende ArcGIS 9.2, SPSS 16 og STATA 11.

Som et hovedresultat kunne det konstateres, at de undersøgte skove efter decentraliseringen blev aktivt, men bæredygtigt, udnyttet, hvilket understøtter hypotesen om "beskyttelse via benyttelse" inden for teorien om fælles forvaltning af fælles ressourcer (common pool ressource management). Resultaterne peger på, at den udslagsgivende faktor var, at lokale brugergrupper (community forest user-groups) med baggrund i Skovloven af 1993 fik overdraget tidsubegrænsede og eksklusive brugs- og forvaltningsrettigheder til geografisk specificerede skovressourcer, herunder fuldt ejerskab til skovprodukter samt til indtægterne i det omfang produkterne sælges internt i brugergruppen eller på det generelle marked. Dette er dog også med stor sandsynlighed fremmet af at det lokale behov for især brænde og andre skovprodukter er mindsket i takt med en generel positiv økonomisk udvikling i området. Studiet afdækkede endvidere at skovindtægter i gennemsnit udgjorde 5,8% af husstandsindtægterne, hvilket varierede fra 3,5% for den mest velstillede fjerdedel til 17,4% for den fattigste fjerdedel af de 304 husstande. De fælles forvaltede fælledskove (community forests) var ophav til 49,7% af folks samlede skovindtægter, fulgt af 27,5% fra statsejet skov og 22,8% fra private træer. Analyser af fattigdomsindikatorer samt en dekomposition af Gini-koefficienter for indtægtskilder viste, at når indtægter fra skov og private træer medregnes i husstandsindkomsterne (hvilket endnu ikke er gængs standard), så reduceres antallet af husholdninger der falder under fattigdomsgrænsen betragteligt og uligheden i indkomstfordelingen falder. En OLS (ordinary least square) regressionsanalyse for indtægterne fra fællesskove viste at lavkaste hushold får mere end højkaste hushold, hushold med store jordtilliggender får mindre end hushold med mindre jordtilliggender, og hushold som får de største rimesser fra familiemedlemmer får mindre end øvrige hushold. Dog viste analysen også at de hushold som har mange husdyr får forholdsmæssigt større indtægter fra fællesskovene end de fattigste hushold. Fællesforvaltede skove medvirker m.a.o. til at mindske den rurale fattigdom samt i nogen grad til at udjævne indkomstfordelingen.

Træer på landbrugsjord viste sig at være meget vigtige kilder til brænde og især husdyrfoder. Ejendomsstørrelsen, antallet af husdyr, forbruget af brænde og graden af uddannelse som overhovedet i de undersøgte husstande besad, var positivt relateret til antallet af private træer, mens afstanden til skov samt brugen af andre energikilder end brænde (biogas og elektricitet) var negativt relateret. Det konkluderes derfor, at private træer udgør en vigtig komponent i de fleste rurale husstandsøkonomier, samt at forskelle mellem husstande med få og mange private træer mest af alt afspejler forskelle i forholdsvist kapitaltunge aktiver.

Angående de enkelte husstandes involvering i driften af fællesskove viser studiet, at 'moderat deltagelse' var langt det mest almindelige. Dog influerede en række faktorer på graden af deltagelse. Modelberegninger viste at: husstande med mandlige overhoveder deltog betydeligt mere end husstande med kvindelige overhoveder, husstande af højere kaste deltog mere end lavkastehusstande, husstande med mange husdyr deltog mere end de øvrige husstande, husstande med mange netværksforbindelser deltog mere end andre, og husstande med et højt brændeforbrug deltog mere end andre. Husstandsindtægten og mængden af produkter en husstand høster i fællesskoven viste sig derimod ikke at være korreleret med graden af deltagelse.

Detaillerede botaniske studier af en af de 10 fællesskove viste, at de lokalt definerede samt håndhævede regler om medlemmernes adgang til at fælde og ekstrahere træer ikke nødvendigvis bevarer skovstrukturen, fordi visse arter er mere efterstræbte end andre, og derfor tenderer til at blive overudnyttede. En hel række antropogene, socioøkonomiske og miljømæssige faktorer, enten alene eller i vekselvirkning, influerer artssammensætningen samt øvrige biologisk strukturelle og funktionelle aspekter af skoven. I tilgift foregår dette på forskellige skalaer og med varierende intensitet, hvilket spiller en afgørende rolle i forhold til hvorvidt biodiversiteten bevares eller degraderes i naturlig Sal (*Shorea robusta)* skov i Nepal.

1. Introduction

1.1 Background and rationale

Driven by economic rationales of political elites and later on to some degree justified by Hardin's (1968) "Tragedy of the Commons", forest management in many developing countries have been converted from some form of common pool resource management system or semi-open access to centralized management. Yet, in most cases this governance regime has been largely unsuccessful in regulating access to and control over forest resources (Gibson *et al*., 2000 cited in Andersson, 2006). This failure of management could be attributed to a lack of collective action, or lack of a joint pursuit of a common goal (Olson, 1965). The main reasons behind the inability of centralized forest bureaucracies to fulfil their official objectives include the vast size of the forest areas, limited financial resources as well as inadequate administrative, technological and enforcement capacities. Corruption, insufficient information concerning forest ecosystems, and the failure to recognize customary rights to land are also contributing factors (Baland and Plateau, 1996).

As a response to centralized bureaucracies' inability or unwillingness to incorporate the needs of local people into official management objectives for the national forest estate, efforts have in recent years been made to transfer ownership and/or management authority from the state to the local communities (Meinzen-Dick *et al*., 1999; Conroy *et al*., 2002). Nepal has a history of common pool land, pasture, and forest resource management arrangements in areas located at the periphy of the then central state's area of control. This included the general upland talkudar pasture and forest management system which worked during the period 1911-1996 (Fisher 1989, Basnet 2006) and the even older kipat system in North Eastern Nepal that was in function during the period 1774-1994 and according to which local people, not the state or king of Nepal, owned their land communally and paid taxes as subjects not based on land holdings to the King (Forbes 1996, 1999). British colonial rule continued or reinvented decentralization in natural resource management by vesting local authorities with powers to collect revenues and manage resources under their jurisdiction (Agrawal, 2001). Globally, decentralization of forestry policies began in the mid to late 1980s and had become a prominent feature of forest governance by the mid-1990s (Ribot *et al*., 2006). In order to address the problem of deforestation and degradation of state-owned forests, nations across the world have thus been promoting decentralization of natural resource management (Bray *et al*., 2005; Larson, 2005). By 2008, around 10-12% of the world's natural forests were under decentralized governance and at least 35 developing countries were officially engaged in promoting this form of forest management (Sunderlin *et al*., 2008). As a result of effective decentralization, local actors can gain control and decision-making powers in three arenas: 1) use, 2) management, and 3) ownership (Agrawal and Ostrom, 2008). Decentralized forest governance has the twin objective of conserving forests and improving local people's livelihoods (Capistrano and Colfer, 2005; Ribot, 2004;

Agrawal and Ostrom, 2001; Hobley, 1996), and Nepal is one of the leading countries in introducing this form of forest management programmes (Agrawal and Ostrom, 2001; Gautam *et al.*, 2004; Gilmour and Fisher, 1991).

Drawing on common pool resource theory, it is assumed that forests can be better managed with the active involvement of users than through centralized management alone (Ostrom, 1999). Consistent with this approach, there is empirical evidence that community-level management regimes can lead to ecological and social benefits (Gautam *et al.*, 2004; Jackson *et al.*, 1998; Nagendra and Gokhale, 2008; Gautam, 2007; Pokharel *et al.*, 2007; Branney and Yadav, 1998; Fox, 1993; Tachibana and Adhikari, 2009; Chakraborty, 2001; Saigal *et al*., 2005; Ravindranath *et al*., 2004; Blomley *et al*., 2008; Lund and Treue, 2008; Kassa *et al*., 2009). However, others have also argued that there is little evidence that forest sector decentralization has benefited forests and the people who depend on them (Kaimowitz *et al.*, 1998). Similarly, a number of researchers claim that challenges still remain to provide conclusive evidence, which demonstrates a link between community forestry and broader environmental outcomes (Gautam *et al*., 2004; Pokharel *et al*., 2007). Despite the growing body of literature on the positive conservation outcomes of decentralized forest management (Gautam *et al*., 2004; Jackson *et al*., 1998; Nagendra and Gokhale, 2008; Gautam, 2007; Pokharel *et al*., 2007; Branney and Yadav, 1998; Tachibana and Adhikari, 2009; Chakraborty, 2001), there remains a paucity of studies that elucidate the effects of community involvement on forest condition with quantitative rather than perception-based evidence (Lund *et al*., 2010). Bardhan (2002) argues that even though decentralization experiments are going on in many developing countries, hard quantitative evidence on their impact remains scarce. In this context, evidence and analysis from this research can potentially provide a knowledge base for the scientific community on biophysical outcomes of community forest management, especially changes in forest conditions as well as the underlying causes of such changes.

Despite the positive outcomes brought about by decentralized forest management (Larson and Ribot, 2004; Capistrano and Colfer, 2005), relatively little has been documented regarding the effects of decentralization on local governance systems and livelihood opportunities of local communities (Andersson, 2003; Nygren, 2005; Larson *et al.*, 2007; Tacconi, 2007). However, the general roles of forest resources in reducing income disparities and contributions to rural development have recently received considerable academic attention. Studies have shown that forests offer vast potential for poverty alleviation and reduction of income inequality among forest dependent communities (Das, 2010; Babulo *et al*., 2009; Fisher, 2004; Cavendish, 2000; Jodha, 1986; LóPez-Feldman *et al*., 2007; Mamo *et al*., 2007 Reddy and Chakravarty, 1999). Furthermore, global empirical evidences now confirm that forest income has a significant role in total household incomes (Vedeld *et al*., 2007; Cavendish, 2000; Fisher, 2004; Mamo *et al*., 2007; Godoy *et al*., 2002; Illukpitiya and Yanagida, 2008; Babulo *et al*., 2009; Angelsen *et al*., 2014).

A gap, however, remains in our knowledge regarding the relative economic importance to rural households of forests under different tenure arrangements. Using a global dataset prepared by the Poverty Environment Network, Jagger *et al*. (2014) found that state-owned forests generated higher forest incomes than community forests and private forests when reported per hectare and per household, and also as a portion of cash and subsistence incomes. They did, however, not investigate how these patterns vary across income groups, nor did they examine the relative importance of forest product groups. Against this backdrop, the current study aims to improve our understanding of the relative economic importance at household-level of income from forests under different tenure arrangements. This includes how the relative importance varies with total household income and why, as well as individual contributions of product groups. It also highlights the determinant factors associated with average household environmental income in the studied households.

Farmers maintain and plant trees in farming landscapes that enhance food, fuel, fodder, and medical security, especially for low-income rural populations and during hungry periods, thereby diversifying income, lowering production risk and optimizing the management of their resources (Arnold and Dewees, 1995), and assisting to establish sustainable productive systems (Mohiuddin *et al*., 1997). Yet, a number of biophysical and socio-economic factors determine, whether farmers will grow trees on their land (Garforth *et al*., 1999; Dewees, 1995; Webb and Dhakal, 2010). A plethora of literature is available on the characteristics and role of farm trees in sustaining livelihoods in Nepal (Kanel, 1995; Das and Oli, 2001; Neupane *et al*., 2002; Munishi *et al*., 2008; Kharal and Oli, 2008; Regmi and Garforth, 2010). There remains, however, a knowledge gap on how trees on farmland contribute towards household consumption of forest products compared to other management regimes viz. community forests and government-managed forests; and factors associated with tree growing in mid-hills. In this context, the study enhances our understanding of the extent of farm trees, providing explanatory factors associated with tree growing in Nepalese mid-hills, and analyzing the share that farm trees play in total household consumption of forest products.

The Nepalese community forestry programme, a form of decentralized forest management and a national priority programme, engages more than 11 million people in about 18,300 Community Forest User Groups in Nepal (DoF, 2014). Socio-economic development, participation of local people in decision-making and local collaboration can be seen as determinants in ensuring sustainable forest management objectives, multiple forest functions and services (Bizikova *et al*., 2012). Formalized local participation in forest governance via decentralization is often viewed as a key mechanism for providing incentives to local communities to use forests sustainably through enhanced local knowledge, stronger accountability, and perceived legitimacy of forest rules (Larson and Soto, 2008; Agrawal *et al*., 2008). Forest systems are more likely to have sustainable outcomes when local forest users participate in forest rulemaking (Persha *et al*., 2011). However, it is argued that the community forestry programme in Nepal is still not successful in achieving people's effective participation in the governance and management of forests (Agrawal and Gupta, 2005; Buchy and Subba, 2003). Recognizing the importance of people's participation in community-based forest management, this study attempts to analyze the factors influencing participation in community forestry processes in the Nepalese mid-hills.

Understanding the effects of forest management on species composition and diversity is important to develop ecologically sustainable forest management practices (Opdam *et al*., 2002). As per the provisions mentioned in operational plans, Community Forest User Groups (CFUGs) carry out tending operations; mostly thinning, pruning, and shrub clearing. This type of stand management could, however, result in changes in vegetation and species diversity. Knowledge on stand structure and dynamics provides managers with opportunities to harness forest products in a sustainable manner. The underlying objective of handing over national forests to local communities is to fulfil basic forest products need of the local people in a sustainable way (HMGN/ADB/FINNIDA, 1989). Moreover, striking a balance between increasing forest productivity and conserving biodiversity has also been a crucial issue in community forestry of Nepal. Therefore, the study aims at investigating the effects of management activities on structure, diversity and richness, and dispersion pattern in acommunity forest of western Nepal.

1.2 Objectives

The overall objective of the study is to evaluate the outcomes of decentralized forest management in Nepal with particular focus on assessing forest conditions and the role of forests in the household economy. The specific objectives were to:

1. assess the effect of forest decentralization on the state of the forest through documenting the development of crown coverage in 10 selected community forests of Tanahun district of western Nepal over two time periods viz. 1972-1998 (before decentralization) and 1998-2009 (after decentralization),
2. document and assess the relative importance of income from forest under different tenure arrangements to rural households,
3. analyze the diversity of farm trees and determinants of tree growing practices on farm land,
4. analyze determinants of people's participation in community forestry activities, and
5. investigate the effects of management activities on vegetation diversity, dispersion patterns and stand structure of community-managed forests

1.3 Research questions and hypotheses

Research questions, hypotheses, methods of data collection and data analysis for each of the objectives are presented in Table 1.

Table 1: Research questions, hypotheses, methods of data collection and data analysis

Research questions	Hypotheses	Methods of data collection	Data analysis
1a. Has forest decentralization resulted in forest conservation?	Decentralized forest management has contributed towards improved resource condition (e. g. Nagendra and Gokhale, 2008; Gautam, 2007; Tachibana and Adhikari, 2009).	Acquisition of aerial photographs from 1972 and 1998 as well as satellite images from 2009 Household survey and focus group discussion for perception assessment and history revealing. CFUG record, Operational plan review	Stand structure change maps over two-time periods; 1972-1998 (before decentralization) and 1998-2009 (after decentralization) through image interpretation. Descriptive statistics
1b. What are the underlying socio-economic and political drivers of forest condition change in the studied community forests?	Political as well as socio-economic variables play an important role in bringing change in forest condition.	Household survey Focus group discussion	Descriptive statistics Historical trend analysis Interpretation of local people's narratives
2a. What is the absolute and relative size of forest income in total household economy across different income quartiles?	Environmental income has a great role in household total income and the reliance on environmental income decreases with increasing total household income (e.g. Cavendish, 2000; Vedeld *et al*., 2004).	Household survey Focus group discussion	Descriptive statistics ANOVA test
2b. What factors determine the average per adult equivalent unit (aeu) forest income across tenure types?	A number of biophysical and socio-economic factors determine the average per aeu forest income	Household survey Focus group discussion	Descriptive statistics OLS regression
3a. What characterizes the composition, diversity and uses of farm trees in mid-hill region of Nepal?	Farmers have maintained tree diversity on their farm land to fulfil their needs for forest products.	Household survey Field observation including species identification Focus group discussion	Diversity indices Descriptive statistics
3b. What explanatory factors	A number of biophysical and socio-economic factors	Household survey Focus group discussion	Descriptive statistics

are associated with tree growing on farm land?	determine whether farmers will grow trees on their land (Garforth *et al*. 1999; Dewees 1995; Montambault and Alavalapati, 2005)		OLS regression
4a.What factors determine the level of participation in community forestry activities?	Participation in forest management varies with socio-economic and demographic variables (Lise, 2000; Torgler*et al*., 2011).	Household survey Focus group discussion	Descriptive statistics Ordered probit regression
4b. What are the marginal effects of the degree of participation in community forestry activities?	The marginal effects explain the probability of users participating in community forestry activities.	Household survey Focus group discussion	Descriptive statistics
5a. What is the relationship between crown cover and stand structure of the species occurring in natural Sal (*Shorea robusta*) forests?	Spatial distribution pattern of woody species follow a random pattern with respect to habitat.	Forest inventory Image interpretation Household survey	Descriptive statistics
5b. What is the effect of crown cover in species richness, diversity and composition?	The manipulation of crown cover through human activities or natural disturbances causes changes in structure and composition of species.	Forest inventory Household survey	Descriptive statistics Diversity and dispersion indices Regression equation

2. Analytical framework

The thesis empirically investigates the outcomes of decentralized forest management against the predictions of democratic decentralization theory. This suggests that if local communities with democratically accountable and responsive leaders, within a framework of central/higher-level government monitored minimum environmental standards, are authorized to manage local renewable natural resources, and if these communities perceive the benefits of acquiring the associated bundle of rights to resources and revenues to outweigh the costs, then positive environmental and economic outcomes will materialize (Ribot, 2002, 2004). Whether community-level economic net benefits from such decentralized resource management are equitably shared within the community is, however, not guaranteed. By definition the poorest and weakest form minorities. In the absence of enforceable minority rights their interests are, therefore, are at risk of being 'democratically steamrolled' through a 'tyranny of the majority'. Yet, groups with shared legitimate interests, e.g. women and low caste people, who are not necessarily minorities at community-level, might become marginalized as well, or suffer the costs of elite-capture, if they are unaware of or for cultural reasons unable to make practical use of their formal democratic rights.

In addition to the expected local-level environmental and economic outcomes of democratically decentralized resource management another aspect of decentralization is to reduce costs at the central level and for the central level to, indirectly and implicitly, gain more control over and be able to influence what happens at the periphery (Hobley, 1996; Manor, 1999; Agrawal, 2005). Securing a steady flow of environmental products and services to society at large generally justifies the central government's interest in promoting the conservation of renewable natural resources through decentralization. However, these biophysical objectives sometimes conflict with the often less clearly articulated objectives of the state and its centralized bureaucracies, such as departments of forests, to generate official and unofficial revenues from the harvesting and trade in environmental products[1]and services (timber, firewood, charcoal, medicinal and aromatic plants, wild meat as well as fees for trophy hunting, trekking, national park entry, etc.). The incentives and practices of the state and centralized bureaucracies in relation to decentralization of natural resources including forests, however, falls outside the scope of this thesis, which focuses on the local-level biophysical and socio-economic effects and outcomes of community forestry in Nepal.

In order to operationalize the effects of community forestry on forest conservation and rural livelihoods, the thesis draws on an array of theoretical frameworks and methodological approaches. Five different papers were produced and a brief

[1]Products that are the result of natural processes rather than a cultivation effort.

description as well as a summary of their analytical approach and frameworks is presented below:

Paper 1 evaluates the outcomes of decentralized forest management on forest conservation in the Nepalese mid-hills. Through multiple case studies, the paper focuses on assessing the extent of forest condition change of 10 selected community forests in Tanahun district of western Nepal. This is done over two time periods; 1972-1998, before forest management was decentralized, and 1998-2009, after decentralization. Furthermore, the paper attempts to identify the underlying political and socio-economic drivers of the observed forest cover change. As crown cover is known to be highly correlated with other measures of the forest stock, such as bole volume, total above ground biomass, and basal area (Tiwari and Singh, 1987), and to also provide evaluative information descriptive of the condition of the forest (Niccolai *et al*., 2010), it is used as the indicator of forest condition. Forests with less than 40% crown cover are considered as poorly-stocked forests, taking reference both from Nepal (HMGN/ADB/FINNIDA, 1989) and India (Prabhakar *et al*., 2006). Historical events with respect to forest policy and actual forest use are considered in analyzing the underlying drivers of forest condition change. Developments in local households' main income sources (agriculture vs. remittances and other income sources), main energy source (fuelwood vs. other sources), and the number of CFUG members were used to capture the key socio-economic determinants of forest product extraction. Accordingly, this paper applies a mixed methods approach where bio-physical changes are quantified through ocular analysis of aerial photographs and satellite images of the concerned forest areas (see below) and related to national and local-level political as well as socio-economic changes that were identified through archival studies and through interview data.

Paper 2 investigates the importance of forest income in household economies and in reducing poverty and inequality. This is done through income accounting, standard economic poverty measurements, standard inequality measurements, and an ordinary least square (OLS) regression analysis that identifies the likely determinant factors of forest income. Household total annual income is defined as the sum of all gross incomes minus the costs of intermediate inputs and capital costs, i.e. value added net income where the households' own labour input is not calculated as a cost (Sjaastad *et al*., 2005). The income of the sample households was categorized into three major sources: farm, forest, and other. Income per adult equivalent unit (aeu) was used as the common denominator to allow comparisons across households. Income from forests was disaggregated across three different tenure types (government forests, community forests and private forests/trees). Different types of poverty indices have been suggested to measure poverty (Sen, 1976; Thon, 1983; Foster *et al*., 1984). We employed the Foster-Greer-Thorbecke (FGT index) index to measure the prevalence, depth and severity of poverty both when including and excluding forest incomes from the calculations. Equality of income distribution was assessed using the Gini coefficient decomposition approach developed by Lerman and Yitzaki (1985).

Paper 3 documents information on the diversity and local uses of farmland tree resources and also analyzes determinants of tree growing practices on farm land. Trees outside forests include all trees found outside forests and outside other wooded lands: stands smaller than 0.5 ha; tree cover on agricultural land, e.g. agroforestry systems, home gardens, orchards; trees in urban environments; along roads and scattered in the landscape (FAO, 2006). In this paper, we consider all the woody plants including tree and shrub species grown on farm land. Of the total 304 sampled households, the 267 who grew trees were considered in this paper. Data were collected for species composition, species richness, diversity, and socio-economic determinants of tree growing on farm land. Howland and Howland's (1984) criteria was used to rank the use of trees, and an OLS regression was applied to investigate the determinant factors of tree growing.

Paper 4 analyzes determinant factors influencing people's participation in community forestry activities. In this paper, participation refers to the user's involvement in meetings/assemblies of community forest user groups, involvement in community forestry activities (formulation and revision of operation plans, silvicultural operations), and involvement in forest patrolling. Participation in collective management typically occurs in the form of labour contributions, monetary contributions, or both (Naidu, 2011). In this case, the contribution of labour time was the only form of participation. An ordered probit model was used to identify determinant factors that shape the level of participation in community forestry activities. The marginal effects of socio-economic factors on the activity level of participation were also estimated.

Paper 5 has two main objectives: (1) to describe the relationship between crown cover, and stand structure of the species occurring in natural Sal (*Shorea robusta*) forests with the hypothesis that the spatial distribution of woody species follows a random pattern with respect to habitat, and (2) to examine the effect of crown cover in species richness, diversity and composition. Vegetation description was done through stratified random sampling based on crown cover.

In sum, the thesis generally takes a positivist (quantitative) and neo-classical economic (homo economics) analytical approach to uncover or suggest likely cause-effect relations among data collected and observations made. Other more qualitative approaches would emphasize other aspects of community forestry, i.e. how other objectives than maximizing (long-term) community and individual material and economic benefits from community forest conservation and utilization influence the way in which local people use local forests, together as groups and as individuals, thereby shaping the quantitatively observable condition of the concerned forests. Such 'other objectives' could be pride of ownership, love of nature, religious beliefs etc. Accordingly, the generated knowledge on the outcomes of community forestry in Nepal is limited and to some extent defined by the theoretical framework. While this is bound to leave out important aspects of community forestry, my general professional experience tells me that most people in rural Nepal are very aware of the cost-benefit ratio of alternative activities and for reasons of poverty as well as basic needs they cannot afford to engage extensively in undertakings that yield few or very uncertain material benefits. Furthermore, and for better or worse, the political, legal, and economic discourse on community forestry in Nepal as well as globally generally calls for quantitative and socio-economic 'evidence' about the extent to which this form of forest governance results in forest conservation, economic net benefits for the involved communities, and equitable distribution of such gains among community members. In this light I believe that the thesis makes a useful contribution to the continuation and further refinement of community forestry in Nepal. Moreover, the thesis contributes to the on-going global debate over the effects and usefulness of forest decentralization.

3. Study area

3.1 Country background

Nepal is a small mountainous country surrounded by China to the north and India to the south, east and west. The country is located at 80^0 04' to 88^0 12' E longitude and 26^0 22' to 30^0 27' N latitude and covers a total area of 147,181 km^2. In altitude, it ranges from 70 m above sea level in the south-eastern Terai, to 8,848 m at the summit of Mount Everest, the highest point on the surface of the earth (CBS, 2012). With its varied topography and elevation, Nepal experiences a wide range of climates, ranging from sub-tropical in the lowlands to the arctic climate in the high mountains. The average annual rainfall ranges from 250 to 4,500 mm (HMG/ADB/FINNIDA, 1989). The total population is 26.49 million, which grows annually with 1.35%, and the population density is 180 persons/km^2 (CBS, 2012). The national average household size has decreased from 5.44 in 2001 to 4.88 in 2011. About 86% of the total population lives in the rural areas. Nearly 64% of all households use firewood as the major source of fuel for cooking (CBS, 2012). The per capita GNP of the country in 1997 and 2013 was US $ 476 (CBS, 2002) and US $ 703, respectively (MoF, 2014). The overall literacy rate (for the population aged 5 years and above) has increased from 54.1 percent in 2001 to 65.9 percent in 2011 (CBS, 2012). About one fourth of the population (25.16%) lives below the poverty line and the Gini-Coefficient, which indicates inequality in income distribution, is 0.328 (CBS, 2011a).

Forest and shrub together cover about 5.83 million ha which is 39.6% of the total land area of the country (DFRS, 1999). The per capita forest area is 0.27 ha. Agricultural land (both irrigated and non-irrigated) covers about 27.9% of the country's total land area (CBS, 2013). Although remittances have become significant and increasingly important over the past 10 years, agriculture is still the mainstay of the economy, which, combined with forestry, contributes 33.1% of the national income (MoF, 2014). Administratively, the country is divided into 5 development regions, 14 zones, 75 districts, 130 municipalities and 3,633 village development committees (VDCs)[2]. However, following the Constituent Assembly election in 2013, yet to be completed, a state restructuring process is going on in the country.

3.2 Community forestry in Nepal

Prior to the mid-1950s, traditional and indigenous practices of forest management were prevalent in the Nepalese hills (Messerschmidt, 1987; Thapa and Weber, 1995). Following the nationalization of private forests in 1957 and the collapse of the feudal *Rana* regime in the early 1950s, these traditional land and forest holding systems were officially abolished and all the privately-owned forests brought under government ownership (Regmi, 1978). With the state control over forest resources, local people felt lack of ownership over forests (Bajracharya, 1983; FAO/World Bank, 1979). As a

[2]The smallest official administrative unit in Nepal.

result, it became increasingly clear that the government could not manage forests effectively without local people being involved (Mahat *et al*., 1986). Furthermore, a treatise of hill deforestation concern instigated by Eckholm (1976) and later explained as a 'Theory of Himalayan Environmental Degradation' by Ives and Messerli (1989) played a pivotal role to raise a strong political concern over the management of forest resources of Nepal. Though the National Forestry Plan of 1976 provided a policy base for initiating forestry development activities in the hills (Gilmour and Fisher, 1991), the model of involving local people in forest management as community forests was officially enshrined only in 1989 with the promulgation of the Master Plan for the Forestry Sector (HMGN/ADB/FINNIDA, 1989). As per this policy guidance, the Forest Act of 1993 and the Forest Regulations of 1995 established the legal foundation for officially handing over areas of state-owned forest to self-forming community forest user groups (CFUGs) who, subject to a forest management plan (operational plan) endorsed by the local District Forest Officer, get indefinite and exclusive proprietor rights to specified forest areas, called community forests (CF), and full ownership to the products extracted from their CFs (HMG/N, 1995).

As of July 2014, about 1.7 million hectares of forest land have been handed over to more than 18,300 CFUGs throughout the country (DoF, 2014). A number of policy and legislative measures have been developed since the advent of the CF programme. Most CFUGs have become viable institutions and have demonstrated their capacity to manage forests and generate small, in some cases large, funds for rural development (Gilmour and Nurse, 1991; Branney *et al.*, 1994; Malla, 1998; Dev *et al.*, 2003; Kanel and Niraula, 2004; Dev and Adhikari, 2007; Pokharel *et al.*, 2007).

3.3 Studied community forests

Ten (10) CFUGs of Tanahun district in western Nepal were selected for this study (Figure 1). Tanahun is a mid-hill district is situated in the western development region of Nepal (27^0 74’ to 28^0 13’ N and 83^0 94’ to 84^0 56’ E). The district covers an area of 1,546 square kilometer, with a population density of 209 persons/km^2. There are 41 Village Development Committees and three Municipalities in the district (DFO, 2014). The altitudinal range of the district varies from 200 to 2,325 masl andthe average annual rainfall is 1,761 mm. The mean maximum and minimum temperatures are 38-48^0C and 5-6^0C, respectively. The total population of the district is 323,288, with 55.6% female and 44.4% male (CBS, 2012). The average household size and literacy rates are 4.13 and 85%, respectively (CBS, 2012). A total of 80 caste/ethnic groups are found in Tanahun district. The majority of the population depends on agriculture for their sustenance, with an average landholding per household of 0.92 ha. The ratio of forest to cultivated land in the district is 1.22 (CBS, 2009). The CFUGs are characterized by diverse community structures and various land use and market access types. The community is diverse particularly in terms of ethnic groups, time of settlement, economic level and occupation. The CFUGs have natural forests mainly dominated by *Shorea robusta* and *Schima castanopsis* forests.

Tanahun District is traversed by the main road from Kathmandu to Pokhara and is representative of good access mid-hill districts in western Nepal. A map of the studied CFUGs is presented in Figure 1.

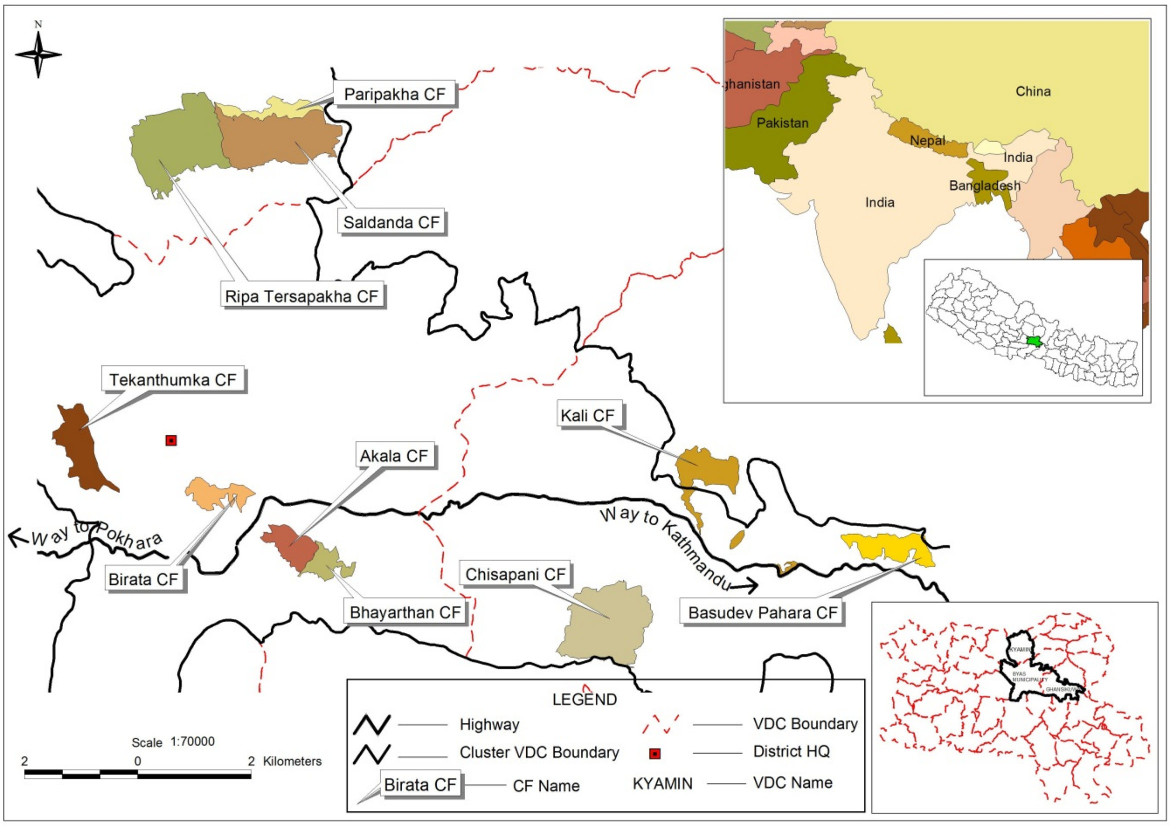

Figure 1: Location of the study site and sampled community forests

Table 2: Details of studied community forests

SN	CFUG Name	Date of Handover	No. of HH in CFUG	Population	Male/ Female ratio	Forest Area (ha)	Forest Type	CF Area (ha/HH)
1	Akala	Sep 1993	317	1,617	7/6	42.92	Natural/Sal pole dominant	0.14
2	Basudev Pahara	Apr 1995	147	867	7/4	56.40	Natural/Sal pole dominant	0.38
3	Bhayarthan	Sep 1993	107	559	6/5	30.61	Natural /Sal Pole dominant	0.29
4	Birata	Jul 1998	129	613	7/4	42.00	Natural/Sal pole dominant	0.33
5	Chisapani	Jun 1996	184	853	7/6	171.29	Natural Sal	0.93
6	Kali	Sep 1993	228	1,234	7/6	94.05	Natural Sal	0.41
7	Paripakha	Jun 1997	63	367	6/5	34.40	Natural/Sal pole dominant	0.55
8	Ripa Tersapakha	Nov 1994	192	1,074	14/1	183.68	Sal+Chilaune/Katus Mixed	0.96
9	Saldanda	Sep 1995	236	1,334	12/3	139.24	Sal Pole to mature	0.59
10	Tekanthumka	Jun 1997	282	1,527	6/3	71.24	Sal Pole to mature	0.25

Sources: Operational Plan of CFs, Field Survey

Species: Sal (*Shorea robusta*); Chilaune (*Schima wallichii*); Katus (*Castanopsis spp*)

4. Research design, methodology and data analysis

4.1 Research/survey design

Questionnaires and other data collection instruments as well as methods were developed with reference to the above mentioned theories on decentralization, community-based natural resource management, and poverty. The research employs a case study strategy where both qualitative and quantitative methods were used for data collection. Data were collected at three levels: household, community, and community forest. Tanahun district was selected as a broadly representative mid-hill district in terms of population density, forest to agricultural land ratio, and income level. I, then, retrieved information on the characteristics of all the community forests in Tanahun districts, e.g. date of hand over, forest area, size of the CFUGs, location, income and expenditure of the CFUGs. A total of 10 CFUGs from this district were then selected based on the following criteria:

- CF more than 10 ha in area
- More than 10 years old
- Having more than 50 member households
- The existence of good quality time series spatial data (aerial photos from 1972, orthophotos from 1998 and GeoEye satellite images from 2009) for two time series (i) before CF (approximately) and (ii) after CF

4.2 Methods of data collection

Different types of airborne analogue aerial photographs, satellite imageries (high resolution), digital topographic data (spatial data) and GPS data were used for the study. Black and white panchromatic aerial photographs of 1972 were obtained from the archives of the Department of Forest Research and Survey, Nepal. These were at a nominal scale of 1: 20,000, and taken at an average height of 3,300-4,500 masl on 09 December 1972 using a RC 10-883 lens camera. A flatbed scanner was used to scan these aerial photographs in 1200 dpi (dot per inch) resolution and spatial resolution of geo-reference was maintained at 0.5 meter for analysis. The 1998 orthophotos were obtained from the Survey Department of Nepal. These were generated from 1:15,000 scale aerial photographs, which were taken during 1998 for urban planning purposes. These orthophotos were in 1:5,000 and 1:10,000 scales, respectively with 0.5 meter in spatial resolution. The GeoEye image (multi spectral 2 metre spatial resolution and panchromatic band, 0.5 metre spatial resolution) of February/March 2009 (Path 98, Row 50) of the studied community forests was procured through an authorized supplier in Kathmandu. An almost cloud-free image on a date that was close to the summer solstice was obtained. This was done so as to get an image with a sun elevation that was as high as possible (74°) in order to minimize the shadowing effect. All the data/products of GeoEye image were in Universal Transverse Mercator (UTM) 45 N Zone with WGS 84 datum projection parameter.

Digital topographic data of 1996/97 with 1: 25,000 scale of the studied area was also procured from the Survey Department of Nepal. The data set has different layers i.e. land-cover, administrative boundaries, hydrograph, transportation network, drainage network, buildings, designated area, topography etc. The orthophotos of 1998 have adopted the same projection parameters. Position format in GPS was calibrated according to projection parameter adopted by the Survey Department of Nepal for overall compatibility in GIS related tasks. Field-based GPS data (spatial) was collected for delineation of CF boundaries. GPS boundary data are compatible with the topographic digital data and orthophotos. The CF boundary survey was carried out by Handheld Garmin GPS (e-trex H and e-trex vista H) with high sensitivity feature. During forest boundary delineation, below 5 metre accuracy (EPE- Estimated Positional Error) was maintained in open places and <10 metre accuracy was maintained in forested areas to obtain quality data. GPS Utility 4.98 version software was used to handle GPS related data. Local forest users and executive committee members accompanied us during the GPS-aided boundary survey to prevent conflicts between adjoining CFs and to differentiate cultivated land from forest land. CF boundary data was taken as a unit for further analysis of forest cover as well as forest structure, composition, status and condition.

The fieldwork was carried out during January-July, 2010, consisting of five components: 1) forest measurements including boundary surveys, 2) household survey, 3) key informant interviews, 4) counting and species identification of farm trees and 5) focus group discussions. Forest measurement of Chisapani CF was carried out following the community forest inventory guidelines 2004 prepared by the Department of Forests. A formal household survey of 304 households was conducted (Table 2). First, the list of households was obtained from the individual CFUGs' offices. Users were then disaggregated on the basis of wealth ranking using Participatory Rural Appraisal (PRA) tools and at least 30 households from each CFUG were randomly selected with proportionate representation from each wealth category. Based on the per aeu annual income, all households were then categorised into quartiles; lowest, second, third, and top 25% for analytical purposes. A total of 16% households from all the 10 CFUGs were selected for this purpose. The household survey comprising both structured and open-ended questions captured a profile of the household, and a range of variables including family size, land holding, income source, livestock holding, time of settlement, distance to forests and energy use pattern (see Appendix). Information on households' participation in community forestry activities and benefits accrued from the community forests was also obtained from the household survey. Field observations were done simultaneously to assess the distribution of tree species on farmland. During the field observation of each sampled household's farm, all woody plants including tree and shrub species were botanically identified and their numbers counted regardless of their age. Key informant interviews were carried out with knowledgeable persons including CFUG executive committee members, local leaders, teachers, and development workers. Group discussions were also conducted at the local level to crosscheck and validate the information obtained from household surveys. The forest product consumption patterns, availability of resources, problems and constraints associated with tree growing in the area, suggestions, and recommendations for the future improvement were taken during the group discussions.

Secondary data were gathered through CFUG offices, Village Development Committee Offices, the District Forest Office, the Central Bureau of Statistics, other concerned offices, and from various literature sources. Operational plans of all the 10 CFs were also reviewed.

4.3 Data analysis

Paper 1

The GeoEye satellite image was in Standard Geometrically Corrected processing level. Image processing was done through the ERDAS IMAGINE 9.1 software package and the modified Intensity Hue Saturation (IHS) resolution merge method was used for spatial enhancement of the image. The panchromatic image (0.5 meter) was chosen as the high resolution input band file whereas the 4-band multi spectral image (2 meter) was chosen as the multispectral input file to create a pan-sharpened image adopting a bilinear interpolation re-sampling technique. Orthophotos of 1998 were used as the base image for geo-referencing for both scanned aerial photographs of 1972 and pan-sharpened image. Permanent features such as crossroads, school buildings and terraces were used as Ground Control Points (GCPs). A total of 6 to 11 GCPs were selected very precisely for accurate co-registration and validation in both aerial photographs of 1972 and the GeoEye image of 2009. For geo-referencing, a root mean square error (RMSE) of less than 14 pixels (<7 m) was accepted for further analysis.

CF polygon maps were produced with the help of GPS data taken from the field. On-screen digitization based on visual interpretation of aerial photographs of 1972, orthophotos of 1998 and the GeoEye image of 2009 was done for each CF. Different theme/layers were produced on the basis of visual interpretation. Overlay/cross operation was performed in ArcGIS 9.2 software for change analysis based on visual interpretation of all two-time period data. The composite maps thus obtained show the forest stand structure in the corresponding years. Socio-economic information was analyzed to relate this with observed forest cover change in the studied CFs. The process followed in spatial data analysis is presented in Figure 2.

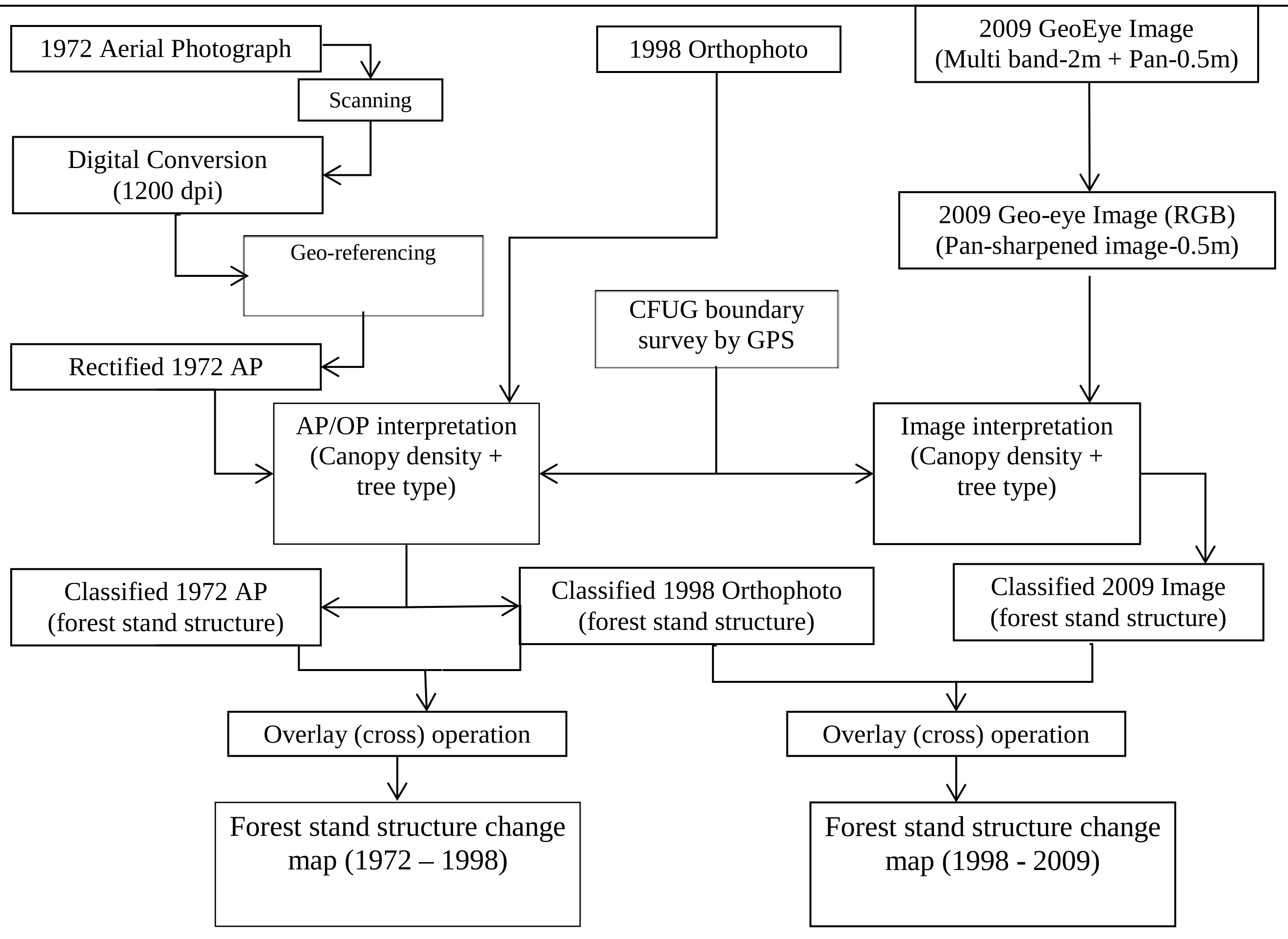

Figure 2: Flow chart showing steps in assessing forest condition

Paper 2

Data analysis was focused on income accounting, poverty measurement, inequality measurement and determinant factors of forest income across three tenure types. The income of the sample households was categorized into three major sources: farm, forest, and non-farm/non-forest. Farm income covers income from crops and livestock whereas non-farm/non-forest income includes income from business, service, remittances, and other non-farm non-forest sources. Descriptive statistics, ANOVA testing for differences across income quartiles, and Ordinary Least Squares regressions, where the dependent variable is mean per adult equivalent unit (aeu) forest income across tenure types (government, community, private), were applied. To further investigate differences across tenure types, the Foster-Greer-Thorbecke (FGT) poverty indices (Ravallion, 1992) with and without forest income, are reported, and income inequality is analysed using the Gini coefficient decomposition approach (Lerman and Yitzaki, 1985), by tenure regime.

Paper 3

Data were analyzed using SPSS 16 and STATA 11 software. Trees on farms were analyzed in terms of diversity and dominance using the Shannon-Wiener Diversity Index and the Simpson's Dominance Index. Ranking of tree species followed Howland and Howland (1984). The Shannon-Wiener Index is the most commonly used diversity indicator in plant communities. It takes a value of zero when there is only one species in a community, and a maximum value when all species are present in equal abundance (Mohan *et al*., 2007); values higher than 2 are considered medium to high diversity (Barbour *et al*., 1987). The Shannon-Wiener Diversity Index was computed as:

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

where H is the index of diversity, p_i is the importance value of a species as a proportion of all species.

The Simpson's Dominance Index represents the probability that any two species encountered at random would be different (Munishi *et al*., 2008). It was computed as:

$$D = \sum p_i^2$$

where D is the index number and p_i is the importance value of a species as a proportion of all species.

Household demographics, asset and income variables were investigated regarding their association with tree growing using Chi^2 and Spearman's correlation. An OLS regression model was subsequently built with the explanatory factors.

Paper 4

Descriptive analysis was used to present household characteristics and information regarding member household's participation and costs and benefits of participation in community forestry activities. An ordered probit model was used to identify determinant factors that shape the level of participation in community forestry activities. Marginal effects of socio-economic factors at active level of participation were also estimated. The dependent variable, participation, measures the household level participation in community forestry activities. The independent variables were chosen on the basis of reviewing similar studies and on the basis of field observations in the 10 sites. Considering the ordinal nature of the dependent variable, an ordered probit model was used in the analysis.

Paper 5

Diversity is calculated based on abundance data and measured in effective number of species (Hill, 1973), to make the dataset follow the replication principle. Equation 1 was used to define the diversity of species

$$^{q}\mathrm{D} = \frac{1}{\sqrt[q-1]{\sum_{i=1}^{R} p_i \, p_i^{\,q-1}}} \qquad (1)$$

Where, ^{q}D is a diversity of order q, p_i is the proportional abundance of species i in the dataset. Species diversity ^{q}D (hereafter denoted as D) equals the inverse of mean p_i, and it is the effective number of species. When q=1, each individual has the same probability of being chosen, and hence the probability that the chosen individual represents species i equals p_i . When q=0, each species has the same probability of being chosen irrespective of its proportional abundance. When q=2 the basic sum (sum of the term inside the root) represent the Simpson index (Simpson, 1949; Hill, 1973; Jost, 2006) and hence the equation is the inverse of the Simpson index, which represent the true diversity of order 2.

Morisita's Index of Dispersion (I_δ) (Equation 3) was used to discern the dispersion pattern of species (Krebs, 1999). Uniform index value [(M_u)] (Equation 4) and Aggregation index value [(M_c)] (Equation 5) were calculated as follows:

$$I_\partial = n\left[\frac{\sum x^2 - \sum x}{(\sum x)^2 - \sum x}\right] \qquad (2)$$

$$M_u = \left[\frac{x^2{}_{0.975} - n + \sum x}{(\sum x) - 1}\right] \qquad (3)$$

$$M_c = \left[\frac{x^2{}_{0.025} - n + \sum x}{(\sum x) - 1}\right] \qquad (4)$$

Where n is the sample size, x is the number of individuals, $x^2{}_{0.025}$,$x^2{}_{0.975}$ are the right tailed chi-squared value at 2.5% and 97.5% with n-1 degree of freedom. Based on equations 2-4 values standard Morisita Indexes (I_p) were calculated following four different conditions, which are:

1) When, $I_\partial \geq M_c > 1$, then $I_p = 0.5 + 0.5\left[\frac{I_\partial - M_c}{n - M_c}\right]$ (5),

2) When,$M_c > I_\partial \geq 1$, then $I_p = 0.5\left[\frac{I_\partial - 1}{M_c - 1}\right]$ (6),

3) When, $1 > I_\partial > M_u$, then $I_p = -0.5\left[\frac{I_\partial - 1}{M_u - 1}\right]$ (7), and

4) When, $1 > M_u > I_\partial$, then $I_p = -0.5 + 0.5\left[\frac{I_\partial - 1}{M_u - 1}\right]$ (8)

Where a negative value of I_p indicates a uniform pattern, zero indicates a random pattern and a positive value indicates the degree of aggregation (clumped) pattern.

Additionally, following Jobidon *et al*. (2004), the Total Basal Area of species (TBA) and basal area of major associated species of Sal (ABA) was also calculated at plot level. The ABA to TBA ratio at plot level is used to represent the proportion of Sal associated species. A value of proportion (1:0) represents pure associates' species cover, while the reverse proportion (0:1) represents pure Sal cover. To quantify the effect of associate tree species on plant diversity and associated species' productivity, the linear relationships for species Richness versus ABA/TBA ratio and the D versus ABA/TBA ratio were established. Similarly, examining the effect of ABA/TBA ratio on plant diversity, regression equations were fitted for 1) Species Richness versus canopy cover, and 2) D versus canopy cover. Due to the nature of data (ratio), and to examine the trade-offs between dependent and independent variables the regression equation was used.

4.4 Limitations

The results presented in paper 2 are based on income data derived during a single year and this is likely to fluctuate from year to year. Hence, a more in-depth study that captures data over several years is recommended to generalize the findings. While undertaking interview, respondents might not have solicited income and expenditure figures entirely accurately as these are somewhat sensitive and some income sources were also complex to report.

Though digital classification of land-cover types is widely accepted because of its statistical validation and automatic processing, precision and accuracy is difficult to achieve in tropical environments where landscape heterogeneity is common and ground-truthing is difficult as well as resource demanding. Hence, visual interpretation was employed in generating change detection maps through image analysis.

5. Main results and conclusion

5.1 Forest condition change

From the analysis of 10 community forest in western Nepal, we found that community involvement in forest management (1998-2009) has brought about positive changes in forest condition. Our results confirmed that the period 1998-2009 was generally characterized by an increase in the area of mature crown density stands and a decreased area of lower density stands, except for the <10% crown density class. During the period 1972-1998, where the forests were under centralized management authority, we found a negative change in the area of mature (>70% crown cover) stands in six and a positive change in four CFs. Those showing negative changes in the mature stand structure were all located near the *Prithvi* Highway, which connects Pokhara and Kathmandu, and near urban centres. Furthermore, in these six forests it was external actors (timber contractors) rather than local people who had cut and removed the big size trees.

The quantitative evidence from remote sensing including GIS analyses and information obtained from qualitative tools verified such changes in the studied community forests. Using >70% crown density of mature stands as a proxy for well-conserved forest (c.f. Thadani and Ashton, 1995; Baland *et al*., 2010), it is seen that from 1972 to 1998, the total area of mature forest decreased by 10% corresponding to an average annual change of -0.43% per annum. For the period 1998-2009, we found an overall average positive change of 14% or 1.23% per annum. Transferring responsibility and authority of managing forests to local communities, therefore, appears successful in improving the forest condition. Collective action in forest management, which the 1993 Forest Act provided the official legal basis for, and the associated ownership feeling among the user-group members clearly played a major role in this development. Yet, changing energy use patterns away from firewood, trees grown on farm land, and a decreasing trend of household dependency on agriculture also helped to bring about positive changes in forest condition. It was, further, observed that, after decentralization, all forests were actively harvested by the local communities, thus supporting the general 'conservation through economically rational utilization' predictions of common pool resource management theory (e.g. Ostrom, 2009).

5.2 Relative importance of forest income

Our research focused on the importance of forest resources in reducing poverty and generating income in the Nepalese mid-hills. We found that the poorest households, those in the bottom 25% income quartile, derived 33.3% of their annual cash and subsistence income from farms (cropping and livestock rearing), 17.4% from forests, and 49.3% from non-farm, non-forest sources. The income sources for households in the top quartile were farming (34.0%), forests (3.8%) and non-farm, non-forest (62.2%). On average, forest income contributed 5.8% to total household income across all wealth categories. In absolute terms, however, the best off 25% derived significantly higher incomes from forests than any of the other three wealth categories. The results thus confirm that forest dependence measured as the share of forest income was higher among poorer than among the richer households, which nevertheless derived significantly higher forest incomes. Inferences from poverty indices and Gini index decomposition revealed that incorporating forest incomes in total household income significantly reduces measured rural poverty and income inequality. Community forestry income constituted about 49.7% of forest incomes, followed by 27.5% from government-managed forest, and 22.8% from private forests/trees on farmland. Community forestry income, however, contributed more than other sources of forest income to income inequality, thus indicating elite capture. Out of 10 explanatory variables used in an OLS regression model, four in community forest regimes were significant; (i) low caste households generated higher forest incomes than higher caste households, (ii) households with the lowest land holdings generated more forest incomes than other households, (iii) households with high livestock holdings generated higher forest incomes than other households, and (iv) households that got high remittances generated less forest incomes than other households. For private forest/tree regimes, three variables turned out to be significant; (i) households with high land holdings also generated higher incomes from private forests/trees than others, (ii) those with high livestock holdings derived higher incomes from private forests/trees than other households, and (iii) those who were close to markets generated higher incomes from private forests/trees than others. In government-managed forest regimes only two variables were significant (i) those receiving high remittances also generated higher forest incomes and (ii) households who were far from markets generated less forest income than the other households. We, therefore, conclude that, although community forest incomes generally contribute positively to alleviate poverty, their full income equalizing potential could be realized if the poorest households get preferential access to harvest community forest products.

5.3 Extent and determinants of tree growing

About 88% of the total sampled households were involved in tree growing on their farm land. It is interesting to note that the average per household landholding is about half a hectare, while the average number of trees per household and per ha of agriculture land is 65 and 158, respectively. We observed medium to high on-farm tree species richness and diversity in the studied 10 community forests, which were instrumental in fulfilling forest product needs of local people. The majority of these trees were planted while some were retained during land clearing for agriculture.

The present study confirms the importance of tree products for rural Nepalese households and shows that on-farm trees are very important in terms of supplying firewood and fodder. Among the determinants for on-farm tree growing, land holdings, livestock holdings, firewood consumption, and education were positively related to the number of trees on a household’s farm land while distance to the forest and the use of alternative energy sources were negatively related. The sex of the household head, income, ethnicity, and networks did not contribute significantly to explain difference in on-farm tree growing. One conclusion drawn is that tree products are vital to the most prevalent rural livelihood strategies and it is reasonable to believe that rural differentiation does not show itself in this aspect, but rather in assets that require more capital.

5.4 Determinants of participation

Our results suggest that, overall moderate participation in community forestry activities is by far the most common for rural households. Yet, there are several determinant factors, which influence the level of participation. Of the 12 variables included in the model gender, caste, household size, livestock holding, network, and amount of firewood extraction are found to be statistically significant. Males participate more than females in community forestry activities. The logic behind this rests with the fact that male individuals participate more in extra-household activities in a patriarchal society like that of Nepal. Our results further show that the higher the caste status, the higher the households' level of participation. Household size also had a positive effect on participation in community forestry activities but only at the 10% confidence level. Users having more livestock participate more in community forestry activities and households that have high levels of affiliation with different social groups/networks also tend to participate more in community forestry activities. Firewood consumption is statistically significant, which confirms that users consuming high amounts of firewood from the forests participate relatively more in community forestry activities. In all wealth categories, moderate levels of participation were dominant in our study. The significantly lower participation of female headed and lower caste households in community forestry activities documents that there is room for "equity improvement".

5.5 Diversity, dispersion pattern and stand structure

Using the example of Chisapani CF in western Nepal, we found the mean species density of the forest to be 192 trees ha^{-1} and the average basal area to be 16.2 m^2 ha^{-1}. True species diversity and species richness increased with crown density. Tukey's Post-hoc test showed significant differences in species richness between open and dense crown classes. Except *Woodfordia fruticosa*, all other species exhibited a patchy distribution. The study revealed that the number of stems per hectare and basal area per hectare did not vary significantly across three crown densities. In all the three crown densities, Sal (*Shorea robusta*) was found dominant throughout the forest.

This study shows that regulation of access through CF does not necessarily maintain species diversity or regulate the forest stand structure, because people preferred and were allowed to harvest species with high economic potential and value. A multitude of anthropogenic, socio-economic, and environmental factors, either alone or jointly, affects the forest structural, functional, and compositional aspects at varying scales and intensities, which plays a crucial role in conservation, maintenance, and degradation of forest biodiversity in Sal (*Shorea robusta*) forests of Nepal. Therefore, a strategy aiming to protect biodiversity, increase stand structural diversity, and maximize natural Sal mixed forests' productivity by means of thinning and pruning, without compromising local needs, is required.

6. Recommendations

The methodology used in this research may be applied to monitor forest cover changes in other community forests of similar topographic and socioeconomic conditions. With the availability of satellite imagery and other spatial data, similar analyses could be done in all forest management regimes (government-managed, community, or private forests) to determine which governance regimes have worked to conserve forest resources, in which locations and, thus help to uncover the causal relations.

The policy message from this research is that if forest incomes can be directed more towards the poorest households (away from the richest households), then the income equalizing potential of forests could be fully realized. This should in theory be possible as it is a minority of the total population that benefits disproportionally, but it requires that the poorest households discover the mechanisms of inequity and form coalitions with other household categories to change the local-level distribution of forest benefits. This recommendation is not entirely new so the obvious challenge is how such transformations of community forestry institutions might be promoted in practice. By adding to the body of empirical documentation of inequity in community forestry this thesis contributes to the justification of future research into community forest user group decision-making arrangements including the role of the forest bureaucracy and the surrounding society in general.

The observed increase of areas covered by big trees and thus the likely accumulation of woody biomass within community forests appear to be caused by the transfer of forest authority from the centre to forest user groups which is further promoted by a positive general economic development in the study area. However, all households use products from trees and on average 23% of the studied households' forest/tree-based incomes stem from trees on farmland in the form of firewood and particularly in the form of fodder. Accordingly, trees on farmland seem to be a result of effective felling control within community forests as well as a reason why such felling controls can be made effective. In the study area, the average number of trees per household and per ha of agriculture land is significantly higher than the Tanahun district and national average. This suggests that that promotion of tree growing on farm land, e.g. through a supply of preferred species, will help minimize pressure on nearby forests, especially if these are under the authority of local forest user groups.

The significantly lower participation of female headed and lower caste households in community forestry activities documents that there is considerable room for "equity improvement". In practice this could be promoted through increased inclusion of these groups into community forestry activities or, in the case of women's participation, through the formation of women's forest user groups either within existing or as new forest user groups. These options have, however, been available since the 1993 Forest Act was enacted. Accordingly, the relatively low inclusion of women in community forestry is likely to be but one aspect of how a hierarchical and patriarchial society operates. Therefore, an increased inclusion of women and traditionally marginalized groups in community forestry may well depend on a wider social and cultural transformation of Nepalese society rather than the other way round.

To conclude, a multitude of anthropogenic, socio-economic, and environmental factors, either alone or jointly, affect the forest structural, functional, and compositional aspects at varying scales and intensities. This plays crucial roles in the conservation, maintenance, or degradation of forest biodiversity in community forests of Nepal. While forest conservation appears an overall effect of forest decentralization, this study also finds that the resulting silvicultural regime will not necessarily maintain the biodiversity in natural Sal (*Shorea robusta*) forests. Therefore, a strategy aiming to protect biodiversity, increase stand structural diversity, and maximize natural Sal mixed forests' productivity by means of thinning and pruning, without affecting local needs, is required. However, further studies are needed to quantify thresholds (standards) in community managed natural mixed Sal forest to maximize their species diversity.

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Research Papers

Paper 1

Conservation by Utilization; a Temporal Analysis of Community-managed Forests in Nepal

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SUMMARY
The effect of decentralization on forest conservation is investigated through remote sensing images of ten forests before (1972-1998) and after (1998-2009) decentralization. Likely drivers of observed forest cover changes are examined through 304 household interviews, key informant interviews and literature. We found pre-decentralization degradation by ‘outsiders’ of forests with good market access. After decentralization, all forests were actively utilized and all except one had improved. Assisted by a positive economic development, indefinite, exclusive and enforceable proprietor rights to valuable forests seemed the explanatory factors. Methodologically, our approach could hold significant potential in monitoring conservation outcomes of different forest governance regimes.

Key words **-** Decentralized forest management, forest conservation, remote sensing, causal relations, monitoring.

INTRODUCTION

Decentralization may be defined as the transfer of control over resources and revenues from central to local governments (Andersson, 2003; Kaimowitz et al., 1998), and/or from the state to lower hierarchical levels of governance including local communities (Ribot, 2002, 2004). To address the problem of deforestation and degradation of state-owned and centrally managed forests, nations across the developing world have in different ways promoted forest decentralization (Bray et al., 2005; Larson, 2005, Agrawal et al. 2008, Persha et al. 2011). Today, 10-12% of the world’s natural forests are under some form of decentralized management and at least 35 developing countries are officially engaged in promoting forest decentralization (Sunderlin et al., 2008). However, forest conservation through decentralization should be economically worthwhile at the local-level to win the voluntary and dedicated participation of decentralized managers -be they local governments or communities. Accordingly, decentralized forest governance generally has the dual objective of forest conservation and improved local livelihoods (Hobley, 1996; Capistrano & Colfer, 2005; Ribot, 2004; Agrawal & Ostrom, 2001). Whether forest conservation is economically attractive or indeed feasible at the local level depends on (i) the duration and bundle of enforceable rights to make and enforce rules on forest resources as well as revenues that is transferred from the 'centre' to the chosen local-level institution, (ii) the productivity and thus sustainable harvesting potential of local forest resources, (iii) the costs of harvesting and transporting forest products to the market and/or local places of consumption, (iv) the number and dependence of local households on forest products, (v) the market for forest products and services, and (vi) the conditions under which products and services from decentralized forests can be marketed (Hobley, 1996; Ribot, 2004; Ostrom, 2009; Lindsay, 1998, Agrawal et al., 2008). Forest conservation is, however, not guaranteed just because it is economically feasible or attractive and the profitability of alternative land-uses, fluctuating prices on forest products or forest product substitutes as well as growth or recession in the local-level economy will in any case influence the profitability of forest conservation at any given point in time. Forest decentralization is, thus, as a general rule, associated with a 'conservation clause' that authorizes re-centralization in case decentralized forests are degraded or cleared (Hobley, 1996; Lund & Treue, 2008; Ribot et al., 2010).

While local-level institutionalized rules about and individually felt reasons why it is important to conserve local forests go well beyond rationales of economic profitability and fear of losing officially sanctioned forest authority (c.f. Agrawal, 2005) this element of decentralization is nevertheless under most direct control of the central state in the sense that outright deforestation as well as massive degradation is very difficult if not impossible for the decentralized managers to hide. Although a common denominator for forest decentralization is the failure of centralized management regimes to conserve national forest resources, the state may still legitimize making decentralization contingent on demonstrated forest conservation because forest conservation is closely associated with the production of environmental services like biodiversity conservation and watershed protection, which are of often great value to society a large but generally provided as public goods rather than through market transactions.

Despite a growing body of literature on the positive conservation outcomes of decentralized forest management (e.g. Gautam et al., 2004; Jackson et al., 1998; Nagendra & Gokhale, 2008; Nagendra et al., 2005; Gautam, 2007; Pokharel et al., 2007; Branney & Yadav, 1998; Fox, 1993; Tachibana & Adhikari, 2009; Chakraborty, 2001), these are often perception-based and thus of questionable validity (Lund et al., 2010). Although forest decentralization is going on in many developing countries, quantitative evidence on the forest conservation impact is rather scarce and with notable exceptions there is still paucity of studies that elucidate the effects of community involvement on forest condition with solid quantitative evidence, presumably because such evidence is costly and time consuming to produce. In a multiple case-study of forests in Tanzania, Treue et al. (2014) combined household surveys, key informant interviews and bio-physical measurements of forest growth, the growing and removed stock (measuring both live trees and stumps) and found that growth exceeded or compensated the harvest of wood in all decentralized forests where ‘outsiders’ could be effectively excluded. Using tree species richness in relation to that of comparable forests as a proxy for forest conservation on a dataset including 84 forests in East Africa and South Asia, Persha et al. (2011) found positive, negative and trade-off effects of decentralization (defined as whether forest users participated in rule-making or not) on forest users’ livelihoods and forest conservation. However, through regression analyses, their data suggest a clear positive effect of forest users’ involvement in rule-making on forest conservation. Similarly, but based on local users’, forest guards’ and monitoring agents’, and forestry specialists’ perceptions of whether the study’s 152 forests had degraded, remained stable or regenerated over a five year period Chhatre & Agrawal (2008), find that local-level enforcement of forest rules had strong positive, yet complex, relations with the probability of forest regeneration. In a study of 45 forests managed by local communities (Van Panchayats), relative to comparable state protected and open access forests in the Indian state of Uttaranchal, Baland et al. (2010) found, through bio-physical on-the-ground measurements that Van Panchayats were significantly less lopped for fodder that the two other forest types but they found no significant differences in growing stock and basal areas.

Resource strained national forestry services can, however, not be expected to monitor the bio-physical outcomes of forest decentralization through detailed and repetitive forest inventories. Canopy closure and tree size rather than species diversity are more likely to be the parameters that national forestry services can in practice monitor. Moreover, a high degree of tree species diversity could, in fact, reflect degraded forest as light demanding pioneers as well as shade tolerant species would be present while the latter would dominate in forests that have been conserved over a longer period and thus developed a more closed canopy. Persha et al. (2011) also conclude that more research is needed to better understand the causal relations between conservation and livelihood outcomes of forest decentralization so as to inform forest decentralization policies. As indicated, the incentive structures created by the bundle of forest rights that are transferred from central to decentralized management institutions as well as the ability of people to enforce locally devised rules are likely to be pivotal.

In this respect, Community Forestry (CF) in Nepal should offer useful insights as this form of forest decentralization was among the first in the world to be officialised and includes a transfer of substantial rights to local communities. Prior to the mid-1950s, traditional and indigenous practices of forest management were prevalent in the Nepal hills (Messerschmidt, 1987; Thapa & Weber, 1995). Following the nationalization of private forests in 1957 and the collapse of the feudal *Rana* regime in the early 1950s, these traditional land and forest holding systems were officially abolished and all privately-owned forests nationalized (Regmi, 1978). This sweeping centralization of forest authority eroded local people's feeling of ownership to local forests (Bajracharya, 1983; FAO/World Bank, 1979), and gradually it became clear that the government could not manage and conserve forests effectively without local people being involved (Mahat et al., 1986). Furthermore, a treatise of hill deforestation concern instigated by Eckholm (1976) and later explained as a 'Theory of Himalayan Environmental Degradation' by Ives and Messerli (1989) promoted a strong political interest in bringing Nepal's forest resources under sustainable management. Although the National Forestry Plan of 1976 provided a policy base for initiating forestry development activities in the hills (Gilmour & Fisher, 1991), the involvement of local people was not officially enshrined until 1988 with the promulgation of Master Plan for the Forestry Sector (HMGN/ADB/FINNIDA, 1989). As per this policy guidance, the Forest Act of 1993 and the Forest Regulation of 1995 officially recognized forest users as forest managers and provided the legal basis for this to be effectuated as well as detailed practical directions on how state-forest areas can be handed-over as community forests to self-formed community forest user groups (CFUGs) who thus acquire proprietor rights (c.f. Schlager & Ostrom, 1992), i.e. exclusive forest management authority and full ownership to CF products (but not the land area) in perpetuity (HMG/N, 1995). As of July 2014, about 1.70 million hectares of forest land had been handed over to more than 18,300 CFUGs (DoF, 2014). Most CFUGs have become viable institutions and have demonstrated their capacity to manage forests and generate mostly small but occasionally substantial funds. Yet, whether CF has resulted in forest conservation remains debated and poorly documented (Gilmour & Nurse, 1991; Branney et al., 1994; Malla, 1998; Dev et al., 2003; Kanel & Niraula, 2004; Pokharel et al., 2007; Meilby et al., 2014).

Accordingly, the study aims to (i) assess the extent of forest condition change in ten selected community forests in Tanahun district of Western Nepal over two time periods viz. 1972-1998 (before CF) and 1998-2009 (after CF) and (ii) identify and analyze the likely underlying reasons for the observed changes in forest condition. In light of the above mentioned challenge for central forest authorities to monitor bio-physical outcomes of forest decentralization and of the emerging policy agenda on Reduced Emissions from Deforestation and Forest Degradation (REDD+), which requires verifiable changes in forest cover and growing stock, this study also holds methodological potential.

ANALYTICAL FRAMEWORK

Our analysis focuses on outcomes of decentralized forest management in terms of changes in forest resource condition as well as the likely underlying governance and socio-economic drivers of these changes. The forest cover changes presented here are not solely the outcomes of forest decentralization but rather an array of factors that are influenced by overall and site-specific socio-economic developments as well as the way forest decentralization has, in practice, been implemented in each site.

Researchers in the past have used various methods for assessing forest condition, depending on individual preferences, research objective and data availability (Gautam, 2007). Here, we assess forest condition in terms of four identifiable degrees of crown cover and tree sizes. Following Baland et al. (2010), crown density (CD), or crown cover, is the projected area of tree crowns on the land area in percent. The categories used in this study were:Scrubland & new regeneration to pole size stands with <10% CD; Pole Stage + Immature stands with 10-40% CD; Pole Stage + Small size timber stands with >40-70% CD; and Mature tree stands with >70% CD, which have been used in Nepal since the late 1980s (HMGN/ADB/FINNIDA, 1989). Crown size and cover is highly correlated with other forest stock measures such as bole volume, total above ground biomass, and basal area (Tiwari & Singh; 1987, Vanclay 1994). In a forested ecosystem, tree crowns provide evaluative descriptive information about the condition of the forest (Niccolai et al., 2010). Forests with less than 40% crown cover are considered poorly-stocked both in Nepal (HMGN/ADB/FINNIDA, 1989) and in India (Prabhakar et al., 2006). Several studies have used fine resolution satellite data to map tree crowns in order to estimate tree cover in dense forested areas (Carleer et al., 2005; Wang et al., 2004; Warner & Steinmaus, 2005). Furthermore, we draw on Leckie et al. (2003) who concluded that such remote sensing techniques have the potential to provide crown measurement data at low cost and with greater coverage than field data collection.

To assess the apparent outcome of CF on forest conservation, we used remote sensing images to assess the forest cover changes in 10 forests over a time period before and after implementation of CF (approximately). On this basis, two-date change maps (1972-1998, 1998-2009) as well as transition matrices were generated for the studied CFs (further details are provided below).

Remote sensing provide useful spatial information to assess forest cover changes, but an analysis of the social processes influencing land-use decisions is also necessary to understand the factors leading to different conservation outcomes (e.g. Mascia et al., 2003). Hence, we employed a case study approach to obtain socio-economic information. Multiple sources of evidence were collected during the field work in order to increase the validity and reliability of our analyses (Yin, 2003: 97). Data was collected at two levels: household and community. As the study aims to assess the extent of forest cover change and investigate the underlying governance and socio-economic drivers of the observed change, both qualitative and quantitative methods were used. Household surveys and informal discussions with knowledgeable individuals were carried out in order to understand the historical dynamics of forest use and management in the ten sites.

METHODOLOGY

Study Sites

Tanahun district was purposively selected as representative of CF in the mid-hills of Nepal. The district is situated in the Western Development Region (27^0 03' to 28^0 05' N and 83^0 75' to 84^0 34' E). It covers an area of 1,546 km^2 with an altitudinal range from 197 to 2,358 masl. The average annual rainfall is 1,691 mm and the mean maximum and minimum temperatures are 29.5^0C and 17.4^0C respectively. The population density of the district is 209/km^2 (323,288 in total, with 55.6% female and 44.4% male). The average household size and literacy rate is 4.13 and 74.8%, respectively. Agriculture is the main livelihood activity for the majority of the population, and the average landholding per household of 0.92 ha (CBS, 2012a). The ratio of forest to cultivated land in the district is 1.22, and the size of CFs varies from 0.9 to 686 ha with an average of 64.8 ha (DFO, 2009; DoF, 2014). In sum, the population density in Tanahun is moderate and the forest resource fragmented and surrounded by cultivated land, which resembles the situation of mid-hill districts in Nepal (DoF, 2014; CBS, 2012a and 2012b).

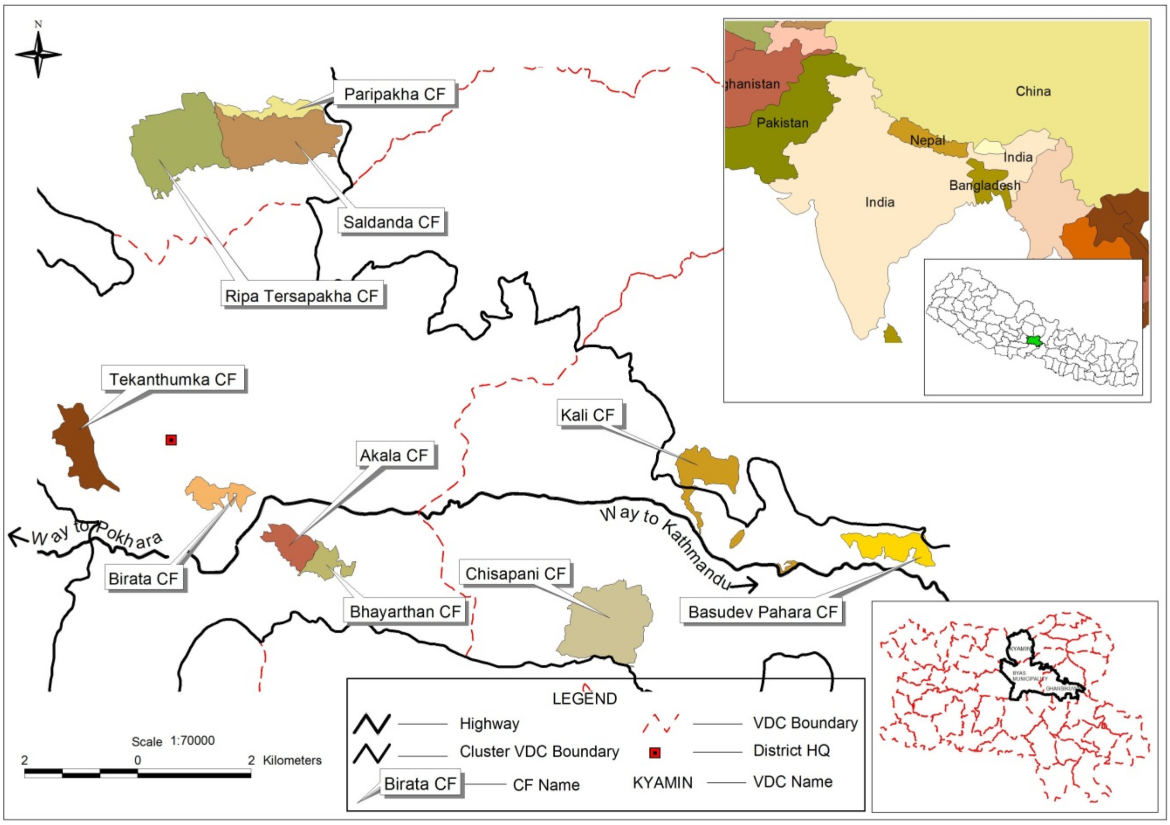

Figure 1: Map of the study area and selected CFs/CFUGs

The selected ten CFUGs are characterized by a diverse community structure, various land use types and some variation in market access. In terms of ethnic composition, time of settlement, economic level and occupation, the communities are diverse while the CFs are quite similar in the sense that they natural forests mainly dominated by

Sal (*Shorea robusta)*. The *Prithvi* highway passes through the district and allows fairly easily access to the city of Pokhara and the capital of Kathmandu. The CFs/CFUGs (Figure 1) were selected on the following criteria:

- Size more than 10 ha such that the cash and subsistence value of products extracted were likely to matter economically for the CFUG households.
- More than 10 years old to allow for a substantial 'after CF' time period in our analyses.
- Having more than 50 member households to enhance the likelihood of heterogeneousness among members.
- Having access to road and market to allow for commercial utilization.
- The existence of good quality time series spatial data (aerial photos from 1972, orthophotos from 1998 and GeoEye satellite images from 2009) for two time series (i) before CF (approximately) and (ii) after CF

Table 1: Details of studied community forests

CFUG Name	Date of Handover	Total HH	Total Population	Executive Committee Male/ Female ratio	Forest Area (ha)	Forest Type	CF Area/ HH (ha)
Akala	Sep 1993	317	1,617	7/6	42.92	Natural/Sal pole dominant	0.14
Basudev Pahara	Apr 1995	147	867	7/4	56.40	Natural/Sal pole dominant	0.38
Bhayarthan	Sep 1993	107	559	6/5	30.61	Natural /Sal Pole dominant	0.29
Birata	Jul 1998	129	613	7/4	42.00	Natural/Sal pole dominant	0.33
Chisapani	Jun 1996	184	853	7/6	171.29	Natural Sal	0.93
Kali	Sep 1993	228	1,234	7/6	94.05	Natural Sal	0.41
Paripakha	Jun 1997	63	367	6/5	34.40	Natural/Sal pole dominant	0.55
Ripa Tersapakha	Nov 1994	192	1,074	14/1	183.68	Sal+Chilaune/Katus Mixed	0.96
Saldanda	Sep 1995	236	1,334	12/3	139.24	Sal Pole to mature	0.59
Tekanthumka	Jun 1997	282	1,527	6/3	71.24	Sal Pole to mature	0.25

Sources: Operational Plans of CFs, Field Survey

Species: Sal (*Shorea robusta*); Chilaune (*Schima wallichii*); Katus (*Castanopsis spp.*)

Methods of data collection

Spatial data

Different types of airborne analogue aerial photographs, satellite imageries (high resolution), digital topographic data (spatial data) and GPS data were used for the study. Spatial data were collected in three consecutive time periods, i.e. aerial photographs of 1972, orthophotos of 1998 and GeoEye satellite images of Feb/March, 2009.

Black and white panchromatic aerial photographs of 1972 were obtained from the archives of the Department of Forest Research and Survey, Nepal. These were at a nominal scale of 1: 20,000, and taken at 3,300-4,500 masl on 09 December 1972 using an RC 10-883 lens camera. A flat-bed scanner was used to scan these aerial photographs in 1200 dpi (dot per inch) resolution and spatial resolution of geo-reference was maintained at 0.5 meter for analysis.

The 1998 orthophotos were obtained from the Survey Department of Nepal. These were generated from 1:15000 scale aerial photographs, which were taken during 1998 for urban planning purposes. These orthophotos were in 1:5000 and 1:10000 scale respectively with 0.5 meter in spatial resolution for analysis.

The GeoEye image (multi spectral 2 metre spatial resolution and panchromatic band, 0.5 metre spatial resolution) of February/March 2009 (Path 98, Row 50) of the studied community forests was procured through a local authorised supplier in Kathmandu. We obtained an almost cloud-free image on a date that was close to the summer solstice. This was done so as to get an image with a sun elevation as high as possible (74°) in order to minimize the shadowing effect. All the data/products of GeoEye image were in Universal Transverse Mercator (UTM) 45 N Zone with WGS 84 datum projection parameter.

Digital topographic 1: 25,000 scale data from 1996/97 of the studied area was also procured from the Survey Department of Nepal. This dataset has different layers i.e. land-cover, administrative boundary, hydrograph, transportation network, drainage network, building, designated area, topography etc. The orthophotos of 1998 used the same projection parameter. The position format in GPS was calibrated according to projection parameters adopted by the Survey Department of Nepal for overall compatibility in GIS related tasks.

Field-based detailed GPS data (spatial) was collected for delineation of CF boundaries. GPS boundary data are compatible to topographic digital data and orthophotos. CF boundary surveys were carried out by handheld Garmin GPS (e-trex H and e-trex vista H) with high sensitivity feature. During forest boundary delineation, below 5 metre accuracy (EPE- Estimated Positional Error) was maintained in open places and below 10 metre accuracy was maintained in forested areas to get quality data. GPS Utility 4.98 version software was used to handle GPS related data. Local forest users and executive committee members accompanied the enumerators during the GPS-aided boundary survey to prevent conflicts between adjoining CFs and also to differentiate cultivated from CF land. Observations during the CF boundary walks were used during interpretation of the GeoEye images in terms of forest cover as well as forest structure, composition, and condition.

Household and key informant data

Perceptions and recollection about forest product use, rule enforcement, forest management practices, policy changes etc. over time were obtained from household surveys. Past historical information regarding the forest condition of each CF and underlying causes of forest structure change was collected through informal discussion with key informants and previous CFUG executive committee members during the field survey. The nature of data and major temporal events are summarized in Table 2.

Table 2: Nature of data and major temporal events

Year	1972	1998	2009
Remote Sensing Data	Aerial Photographs of scale 1:20,000	Orthophotos of scale 1:15,000	GeoEye image of 2x2m resolution
Political Era	Absolute Monarchy	Constitutional Monarchy	Democratic Republic
Major Policy Interventions	Cadastral Survey (delineation of cultivated and forest land). Centralized forest management system	Master Plan for the Forestry Sector 1989 (promote CF strategy in the country). Forest Act 1993 and Regulation 1995 Community involvement in forest management	Interim Constitution 2007. The ban on cutting trees grown on farm land e.g. *Acacia catechu, Bombax ceiba* lifted. Community involvement in forest management
Forest Property Regime	State	Common	Common
Local Events	Construction of the Prithvi highway. Building of houses in emerging towns along the highway. Cadastral survey	The handing-over of CF to locally formed CFUGs gained momentum.	The national community forestry programme gradually promote the implementation of community development and poverty-focused activities among CFUGs

Image processing

The GeoEye satellite image was in Standard Geometrically Corrected processing level. Image processing was carried out using the ERDAS IMAGINE 9.1 software package. Spatial enhancement of the GeoEye image was carried out using the modified Intensity Hue Saturation (IHS) resolution merge method. Pan image (0.5 meter) was chosen as the high resolution input band file and 4-band multi spectral image (2 meter) was chosen as the multispectral input file to create a pan sharpened image adopting a bilinear interpolation re-sampling technique. Orthophotos of 1998 were taken as a base image for geo-referencing for both scanned aerial photographs of 1972 and the pan sharpened GeoEye image. Permanent features such as cross roads, school building and terraces were used as Ground Control Points (GCPs). A total of 6 to 11 GCPs were selected very precisely for accurate co-registration and validation in both aerial photographs of 1972 and GeoEye image of 2009. For geo-referencing, we accepted a root mean square error (RMSE) of less than 14 pixels (<7 m) for further analysis.

Image classification

Digital classification of land-cover types is widely accepted among the scientific community because of its statistical validation and automatic processing. However, precision and accuracy is difficult to achieve in tropical environments where landscape heterogeneity is common and ground-truthing is impossible (for historical images) or difficult as well as resource demanding (for recent images). Accordingly, visual interpretation was considered the only viable/possible option to interpret forest status, condition and composition in our case. As human experience and knowledge is important during visual interpretation (Lu et al., 2004), and because data was analyzed by an experienced research team who also visited the field sites we thus relied on skilled individuals in visual interpretation techniques as the, in practice best possible approach (c.f. Edwards, 1990; Ulbricht & Heckendorff, 1998; Puig et al. 2002; Desclee et al., 2006).

Change detection

Drawing on Singh (1989), Hayes & Sader (2001) and Jensen et al. (1995), change was detected for each forest by ocular identification and manual delineation of areas with stands in the above mentioned four categories for 1972, 1998 and 2009, respectively. Overlaying these ‘forest stand’ maps in ArcGIS allowed the construction of forest cover change maps and change matrices for the periods 1972-1998 and 1998-2009, respectively (see below).

Socio-economic data

Household survey: The lists of households (HHs) from the ten CFUG offices were used. A total of 304 HHs were randomly selected taking at least 30 households from each CFUG. Socio-economic and demographic information along with the households’ knowledge on CF processes, historical context of forest management, perception on forest condition, energy use pattern, tree growing on farm land, forest development activities, forest products distribution and utilization, and rule enforcement was explored.

*Key informant interviews:*Key informants representing *dalits* (lowest caste), women, ethnic/caste groups, CFUG committee members, government officials, development activists, teachers, and local political leaders were interviewed to solicit information regarding the historical development of forest resources, utilization patterns, underlying causes of forest cover changes, and problems they were/had been facing in managing the forests.

Focus group discussion: At least two focus group discussions were conducted in each CFUG. These focussed on understanding the historical dynamics of forest management and socio-economics drivers of forest condition change.

Literature sources: Secondary data sources including literature, research reports, documents, meeting minutes, archives and decisions of the CFUG executive committees, policy, and legislative documents were also obtained.

Data analysis

CF polygon maps were produced with the help of GPS data taken from the field. On-screen digitization based on visual interpretation of aerial photographs of 1972, orthophotos of 1998 and GeoEye image of 2009 was done for each CF based on which different theme/layers were produced. Overlay/cross operation was performed in ArcGIS 9.2 software for change analysis interpretation of all two-time period data. The composite maps thus obtained show the forest stand structure in the corresponding years. To allow comparison across the ten CFs, all observed area changes in the four crown density classes were, for each CF, converted to their corresponding annual change in ha. Socio-economic and governance related information was qualitatively analyzed in relation to the observed forest cover change in the studied CFs.

RESULTS

Tables 3 and 4 summarize the development of stand structure across the studied CFs for 1972-1998 (before CF) and 1998-2009 (after CF), respectively. Similarly, an overview of the per annum change of the four stand structures (<10%, 10-40%, >40-70% and >70% crown density) in the two-time periods are presented in Figures 2 and 3.

The period before CF (1972-1998)

Table 3 shows that the area of mature trees in stands with more than 70% crown density had decreased from 517.75 ha in 1972 to 463.45 ha in 1998. During this period 72% (374.30 ha) remained in the same crown density class while an additional 88.72 ha (70.48 + 18.24) had grown into this class from lower tree size and crown density categories. The areas of >40-70%, 10-40% and <10% crown cover had all increased during the period 1972-1998, but mostly that of 10-40%, which indicates an overall degradation (further details below).

Table 3: Forest stand structure change in ha (1972-1998) of all studied CFs

Category → ↓			1998 Orthophoto			
			Mature Trees (>70% CD)	**Pole Stage +Small size Timber (>40-70% CD)**	**Pole Stage +Immature (10-40% CD)**	**Scrubland & new regeneration to pole size (<10% CD)**
		Total CF Area 861.17	463.45	248.98	137.99	10.74
1972 Aerial Photo	**Mature Tree (>70% CD)**	517.75	***374.30***	100.73	41.10	1.66
	Pole Stage+Small size Timber (>40-70% CD)	223.37	70.48	***114.23***	33.55	5.04
	Pole Stage+Immature (10-40% CD)	110.20	18.24	32.92	***58.09***	1.56
	Scrubland & new regeneration to pole size (<10% CD)	9.87	0.00	1.54	5.45	***2.48***

Notes:

- Figures in bold italics in the diagonal cells show no change in respective crown density categories.
- Due to rounding off errors, row and column sums vary slightly from those stated in the table.

During the period 1972-1998 (Figure 2), we found a negative change in the area of mature (>70% crown cover) stands in six and a positive change in four CFs. Those showing negative changes in the mature stand structure were all located nearby the *Prithvi* Highway and near urban centres (see Figures 1 and 2). The household survey and focus group discussions revealed that improved road access, migration of rural people towards urban centres, economic incentives of supplying timber to other major cities were the main reasons for clearing out mature trees during this period. In all but one of these six CFs (Kali) it was only the area with the biggest trees (>70% crown density) that had decreased while the area with >40-70% crown coverage had increased or remained stable. Accordingly, the biggest trees, i.e. those suitable for timber production, were targeted while the second biggest were allowed to remain and, during the 26-year period, some of these grew into the mature stands >70% crown density class, thereby offsetting some of the degradation. This is most pronounced in Saldanda CF where the big areas of mature forest was more than replaced by the next class of >40-70% crown density while the area of the lowest two classes decreased. By contrast the, four CFs, which were relatively inaccessible at that time (Chisapani, Paripakha, Ripa Tersapakha and Tekanthumka) had increasing areas of mature stands. It is noticeable for these four CFs that the area of crown density classes >40-70% and 10-40% decreased meaning that some these stands grew into maturity during the period. In all these four forests, the area with less than 10% crown density was zero or very small and had remained stable.

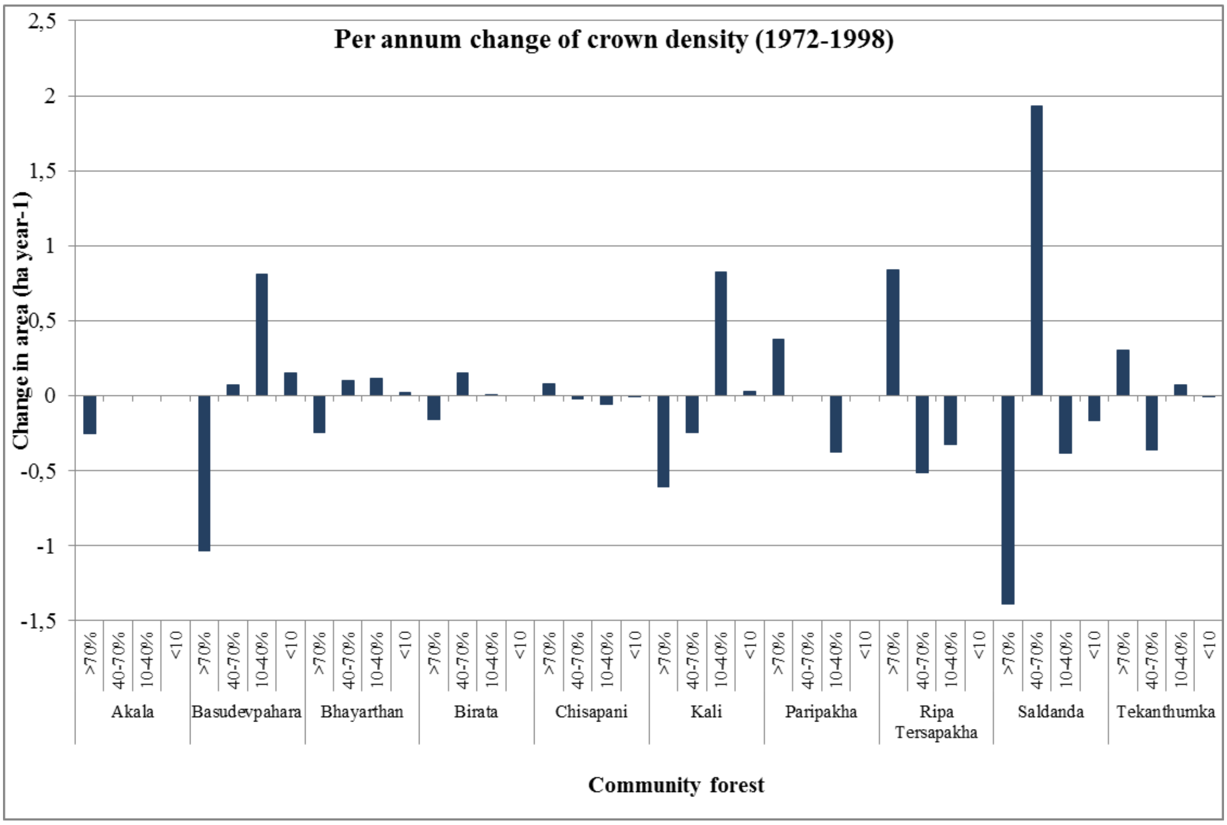

Figure 2: Per annum change of four different stand structures during 1972-1998

The period after CF (1998-2009)

Table 4 summarizes the forest structure change of all ten forests from 1998 to 2009, i.e. the period after CF and covers some degree of variation. The area of mature stands had increased by more than 14% from 463.45 ha in 1998 to 530.28 ha in 2009. In addition, the areas of 10-40% and >40-70% crown density stands had decreased. However, the area of scrubland and new regeneration (<10% crown density) had increased as well. Accordingly, the period 1998-2009 was generally characterized by an increase in the area of mature crown density stands and a decreased area of lower density stands except for <10% crown density class. The area of 40% crown density or higher had increased by 3.5% from 712.43 ha in 1998 to 737.51 ha in 2009, thus indicating a general biomass accumulation.

Table 4: Forest stand structure change in ha (1998-2009) of all studied CFs

Category → ↓			2009 GeoEye Image			
			Mature Tree (>70% CD)	**Pole Stage+Small size Timber (>40-70% CD)**	**Pole Stage+ Immature (10-40% CD)**	**Scrubland & new regeneration to pole size (<10% CD)**
		Total CF Area 861.17	530.28	207.23	108.85	14.82
1998 Orthophoto	**Mature Tree (>70% CD)**	463.45	***433.74***	20.14	8.46	1.01
	Pole Stage+Small size Timber (>40-70% CD)	248.98	79.79	***140.49***	26.95	1.82
	Pole Stage+Immature (10-40% CD)	137.99	16.64	45.94	***67.95***	7.39
	Scrubland & new regeneration to pole size (<10% CD)	10.74	0.10	0.64	5.44	***4.57***

Notes:

- Figures in bold italics in the diagonal cells show no change in respective crown density categories.
- Due to rounding off errors, row and column sums vary slightly from those stated in the table.

Of the ten studied CFs, seven showed positive, two remained the same and one (Chisapani, see below) showed negative change in the area of mature stands during the period 1998-2009 (Figure 3). Among the above mentioned six CFs, which experienced a decrease in areas with mature stands during the pre-CF period, four (Akala, Bhyarthan, Birata and Saldanda) experienced similar developments of stands with >40-70% crown density growing into the mature class of >70% crown density. Of the remaining two, we found only pole to mature size stands during the field survey as well as when analysing the images in Basudev Pahara. Here, all mature trees were extracted during the previous period (see above incl. Figure 2) and no other stands in the forest had sufficient time to grow into the >70% crown density class. However, there was substantial ingrowth from stands with 10-40% crown density to stands with >40-70% crown density. The other, Kali CF, experienced a small increase in the areas >70% and 40-70% crown cover at the expense of the area with lower crown density. In Paripakha and Basudev Pahara CFs, we did not observe any changes in mature crown density. The underlying reason appeared to be that there was little demand-pressure on Paripakha CF since local people had considerably more trees on their farmland (309/ha) in comparison to the other sites where the number of trees per ha varied between 96 and 181 (see Oli et al. 2015a for details). In the case of Basudev Pahara CF, the area of >40-70% crown density had more than doubled and almost exclusively at the expense of the area with 10-40% crown density. The decrease of stands >70% crown density in Chisapani CF was modest (from 130.33 to 128.33 ha) while the area of 10-40% crown cover had increased from 8.38 to 13.52 ha and that of >40-70% crown cover had decreased from 31.98 to 26.92 ha. The underlying reason was that the users wanted to get connected to the national electricity grid which required substantial co-financing by the village and the only obvious source of funding was selling timber from their CF where harvesting of mature trees that would soon face decay and defects as a result of old age was silviculturally sound and economically rational.

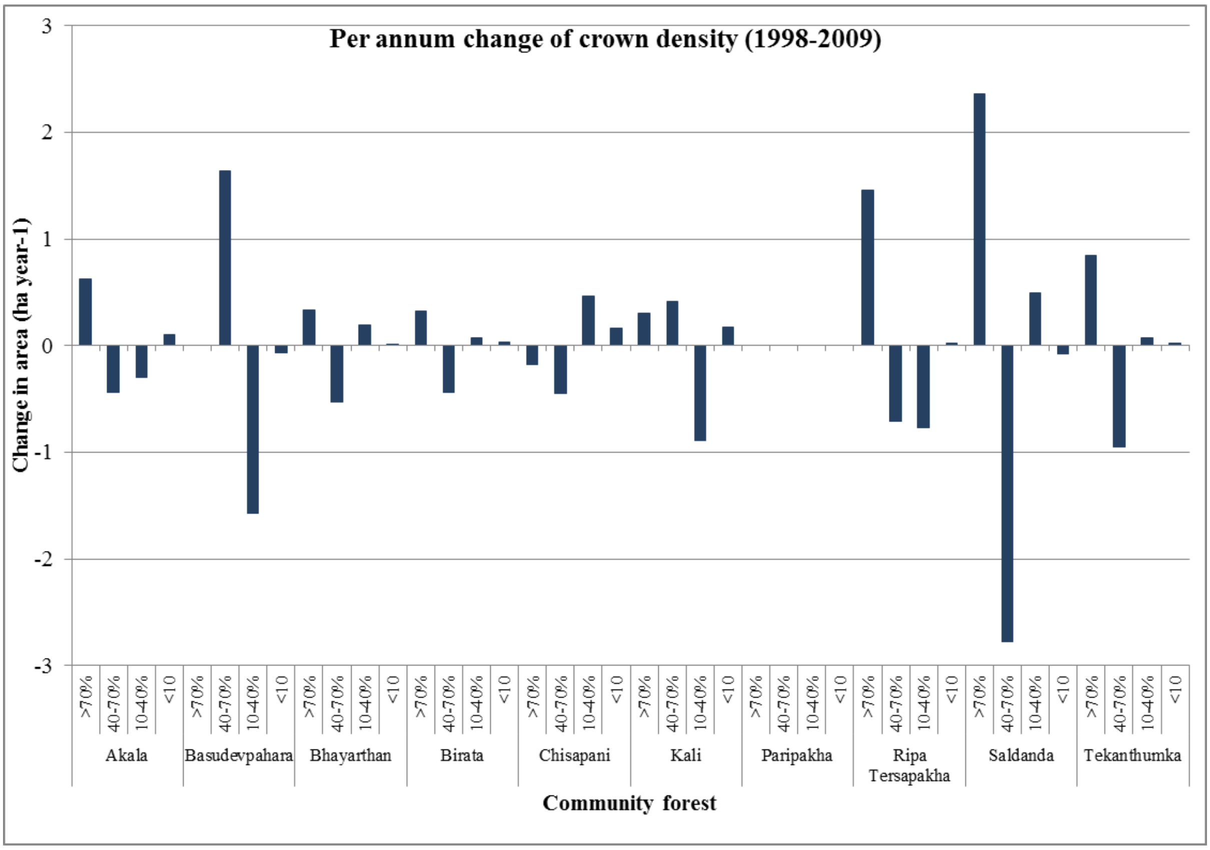

Figure 3: Per annum change of four different stand structures during 1998-2009

Comparison of the before and after CF periods

The observed total and calculated annual rate of change in mature stands of each studied CF is presented in Table 5. Using >70% crown density of mature stands as a proxy for well-conserved forest (c.f. Thadani & Ashton, 1995; Baland et al., 2010), it is seen that from 1972 to 1998, the total area of mature forest decreased by 10% corresponding to an average per annum change of -0.43%, but with considerable variation among the sites as explained above. For the period 1998-2009, we found an average positive change of 14% or 1.23% per annum and only one site (Chisapani) exhibited a negative change, which was very limited.

Table 5: Change of mature stands

Name of CF	Area	Area >70% crown density			Change in area >70% crown density			
		1972	1998	2009	1972-1998		1998-2009	
	(ha)	(ha) [%]	(ha) [%]	(ha) [%]	(%)	(%/year)	(%)	(%/year)
Akala	42.92	36.58 [85]	30.01 [70]	36.90 [86]	-18	-0.76	23	1.90
Basudev Pahara	56.40	26.86 [48]	0.00 [0]	0.00 [0]	-100	NA	NA	NA
Bhayarthan	30.61	23.16 [76]	16.79 [55]	20.50 [67]	-28	-1.23	22	1.83
Birata	42.00	36.54 [87]	32.38 [77]	35.98 [86]	-11	-0.46	9	0.96
Chisapani	171.29	128.3 [75]	130.33 [76]	128.33 [75]	2	0.06	-2	-0.14
Kali	94.05	67.19 [71]	51.37 [55]	54.66 [58]	-24	-1.03	6	0.57
Paripakha	34.40	24.70 [72]	34.41 [100]	34.41 [100]	39	1.28	0	0.00
Ripa Tersapakha	183.68	28.84 [16]	50.72 [28]	66.76 [36]	76	2.20	31	2.53
Saldanda	139.24	113.88 [82]	77.84 [56]	103.78 [75]	-32	-1.45	33	2.65
Tekanthumka	71.24	31.69 [44]	39.59 [56]	48.95 [69]	25	0.86	24	1.95
Total	**861.17**	**517.75 [60]**	**463.45 [54]**	**530.28 [61]**	**-10**	**-0.43**	**14**	**1.23**

The general enhancement or stabilization of the area with >70% crown density over the period 1998-2009 conceals an important feature; in all CFs, except Parikakha, some areas have gone from higher to lower crown density. This shows that these forests have been utilized but in ways that have allowed a stabilization or, more frequently, an expansion of areas with mature trees and thus in all likelihood a net accumulation of woody biomass. Interestingly this general pattern is also found for all CFs except Parikakha during the period 1972-1998, but in the six, which suffered a substantial decrease in area with >70% crown density, ingrowth from lower crown density areas could only partially compensate this loss. As mentioned, Parikakha CF stands out because it did not suffer much degradation during the period 1972-1998 (it is on the other side of a ridge that separates it from Saldanda CF, which has much better road access) and local people there considerably more trees on their farmland than in the other sites (see Oli et al., 2015a).

Socioeconomic and governance drivers of forest structure change

Policy changes

In 1978, the government of Nepal initiated its community forestry programme in the country's mid-hills and high mountains. Since then, the management responsibilities of many forest areas in the mid-hills and high mountains were transferred to the local communities as Panchayat protected forests during the Panchayat regime (1960-1990) (Bhattarai, 2008). With the Forest Act of 1993 and Forest Regulation of 1995, the model of community forestry was also extended to the lower lands of Nepal known as the Terai. During the referendum in 1980, the pro-democracy revolution in 1990, and the people's movement in 2007, natural resources, especially forests, were under heavy pressure and rampant felling was observed in government-managed forests across the country because of poor control and rule enforcement (Bhattarai, 2008). Community forests, on the other hand, were less disturbed -even during these political upheavals (Gilmour & Fisher, 1991; Varughese, 2000). Accordingly, CF in Nepal appears a robust management system through which local people exercise their exclusive forest rights (Rasul et al., 2011). Table 6 summarizes the most important historical events' impact on forests the studied ten sites.

Table 6: Historical events related to forest loss/use in Tanahun

Period	Events	Impacts
1967	Construction of the *Prithvi* Highway	Migration of people to areas around the highway. The demand for timber went high and ultimately there was massive pressure on nearby forests. In addition, outsiders came to buy timber for markets in major cities (Pokhara and Kathmandu).
1969	Establishment of District Headquarter at Damauli	Migration of people to the Headquarter. The demand for construction timber went high which put massive pressure on nearby forests.
1978	Promulgation of *Panchayat* Forest and *Panchayat* Protected Forest Rule	Opened avenues for people's participation in forest management. Laid the foundation for legal community involvement in forest management in Nepal.
1978-79	Referendum	Supporters of the then rulers were granted impunity to commercial logging and to claim densely forested lands especially in the lower elevations in the south, hoping that the party-less *Panchayat* system would draw maximum public support. Tanahun district was not an exception in this period. Outsiders and locally influential leaders extracted timber resources for sale to major urban centres in the country.
1989	Promulgation of Master Plan for the Forestry Sector (MPFS) Restoration of Democracy	The government promulgated a 21-year Master Plan for the Forestry Sector. One of the key programmes of the plan was promoting community forestry in the mid-hill region of Nepal. It established the policy foundation for enacting the Forest Act of 1993 and the 1995 Forest Regulation. With the policy provisions, the handing over process of CFs in Nepal and particularly in Tanahun to local communities was initiated.
1990-91		The pro-democracy movement of 1990-91 converted Nepal from Absolute Monarchy to a Constitutional Monarchy. During the pro-democracy movement, many areas were deforested, largely because the higher level battle for democracy called existing government institutions' legitimacy into question which, in the case of district forest offices, undermined their ability to control timber harvesting. Our studied CFs were also under pressure during that time.
1993	Enactment of Forest Act	In line with the MPFS policy, the government enacted the 1993Forest Act. This Act provided ample opportunity and legal basis for local forest user groups to gain exclusive and perpetual rights to parts of government owned forests (making up the vast majority of all forest in Nepal) as well as full ownership to the products from CFs. With the provisions of the Act, the handing over process of CFs in Tanahun and many other mid-hill districts gained momentum.
1995	Enactment of the Forest Regulation	The Forest Regulation was enacted to support the provisions mentioned in the Forest Act. The number of CFs in Tanahun went high and local people developed a feeling of ownership toward their CFs.

1993-98	Establishment of CFs of the studied sites	The local forest users got exclusive legal rights to conserve, manage and utilize their CFs.
2007-15	Political movement	After a decade long conflict between Maoists and the then government, this political movement was a milestone to bring peace and stability in the country. The political parties abolished the existing constitution and an interim constitution was drafted to run the country. Until the new constitution was formed in early 2015, the country was in a state of transition that weakened government offices' ability to control timber smuggling especially from high-value forests in the low land region. Community forests in our study sites were not affected by this state transition.

Sources: Key informant's interviews focus group discussions, CF Operational Plans and archives

Changing economic activities

Of the 304 surveyed households, 45% had remittances (almost exclusively originating from relatives working overseas) as their single most dominant source of income. Remittances accounted for 12.5% of the total annual income (cash and subsistence) for the 25% poorest householdswhile the second, third, and top quartiles got 36.3, 40.7, and 34.0 %, respectively (see Oli et al., 2015b for further details). However, five years back, the number of households having remittances as their major source of income was only 20%. The number of households having agriculture as their major source of income at present and five years ago were 14% and 36%, respectively. Table 7 shows the average forest product consumption by households who currently have agriculture and remittances as their major sources of income. It is apparent that households having remittances and other sources as their major incomes consume considerably less forest products than households with agriculture as their major income source. While only 14% of the households currently have agriculture as their main income source, their per capita consumption of firewood and fodder is almost twice of what the other households consume. On the other hand, there was no significant difference in timber consumption between the household categories (see Table 7).

Table 7: Average annual per capita forest product consumption by households with different major income sources

Forest Products	Main Sources of Income		
	Agriculture (n=42)	**Remittance (n=137)**	**Other (n=125)**
Firewood (Kg)	234[a]	126[bc]	147[c]
Fodder (Kg)	1571[a]	663[bc]	885[c]
Timber (cft)	0.47[a]	0.41[a]	0.34[a]
F-Value	7.772	8.322	0.128
Significance	0.001***	0.000***	0,879

****significant at 1% level*

Different superscript letters in rows signify differences at the 95% level

Changing energy use pattern

Like in other developing countries, biomass is the major source of energy in Nepal where fuelwood contributes about 71% of the total energy consumption (WECS, 2013). However, our data show that today, only 40% of the studied households had firewood as a single dominant energy source. Nearly 59% depend on a combination of firewood and other energy sources like biogas, electricity, kerosene, and Liquefied Petroleum Gas. The average annual per capita firewood consumption in our study sites was 149.55 kg, which is 75% lower than the national average of 605 kg (WECS, 2013). In total, 35% of the 304 surveyed households had over the past ten years installed biogas plants to fulfil their energy requirements. Further, in three CFUGs, CF revenue had been used to promote installation of biogas plants in members' houses. Here the CF funds were used to hire tractors to carry sand and boulders while other inputs like cement, and wage for a mason was provided by the municipality. Users were, however, not provided loans for biogas plants from the CF funds. In sum, the evidence suggests that a reduced dependence on firewood, which in turn seems linked to many households' economic diversification away from agriculture and livestock keeping, has contributed to the observed general improvement of the forest condition during the period with CF.

Use of farm trees and government forest

While timber, poles, and charcoal was extracted exclusively from CFs by the interviewed households, private trees and government forests also contributed to fulfilling local users' needs for forest products. Of the total extracted firewood, 64.0% originated from CFs, 22.6% from private trees, and only 13.4% from government forests. Of the total fodder extraction, 41.5% came from CFs, 25.2% from private trees, and 33.3% from government forests (see Oli et al., 2015b for details). Nearly 88% of the surveyed households grew trees on their farm land and we found 158 trees per ha of cultivated land and 65 trees per household (Oli et al., 2015a), which is substantially higher than the national average of 39 and 21, respectively (CBS, 2012b). Farmers have planted trees on farmland not only for diversifying income, but also in response to the effective rules of access and withdrawal that the CFUGs have implemented for their CFs.

Population

The total population in the studied CFUGs in 2009/10 and at the time of hand-over is presented in Table 8. In six CFUGs, the population had increased by 33% from a total of 4,891 to 6,518 while in three CFs; Paripakha, Ripa Tersapakha and Tekanthumka, the population had gone down by a modest 7% from 3,195 to 2,968, mainly as a result of migration to nearby urban centres. In the case of Bhayarthan CF, population data at the time of hand over were not available. Accordingly, the observed stable or improving condition of the ten forest during the period 1998-2009 (see above) seem unrelated to the development in population even in sites where the population increase has been substantial (Akala, Basudev Pahara, Birata and Saldanda).

Table 8: Population in the studied community forests at present and at the time of hand over

CFUG Name	Time of Handover	Total Population		Change	
		At handover	2009/10	(%)	(%/year)
Akala	September 1993	909	1,617	78	3.45
Basudev Pahara	April 1995	668	867	30	1.75
Bhayarthan	September 1993	NA	559	NA	NA
Birata	July 1998	406	613	51	3.49
Chisapani	June 1996	831	853	3	0.19
Kali	September 1993	1,076	1,234	15	0.81
Paripakha	June 1997	450	367	-18	-1.56
Ripa Tersapakha	November 1994	1,112	1,074	-3	-0.22
Saldanda	September 1995	1,001	1,334	33	1.93
Tekanthumka	June 1997	1,633	1,527	-6	-0.51

Source: CF Operational Plans; Note: NA: Not Available

DISCUSSION

Across the ten studied forests we found a general 'pre-CF' degradation (1972-1998) and a general 'post-CF' improvement (1998-2009). Very importantly, however, outsiders' extraction of timber for commercial purposes rather than local people's harvesting activities seemed to be the reason why six of the ten studied forests suffered degradation during the pre-CF period. In the post-CF period, only one community had slightly reduced the area with mature trees, from 130 to 128 ha, but this made good economic and silvicultural sense and while approximately 10 ha of mature trees with a crown density >70% was affected (degraded) by the users' harvest of timber to finance connection of their village to the national electricity grid, more than 8 ha grew from the class of >40-70% crown density into that of >70% thus offsetting most of the impact within this 12 year period. Except for one forest, which was hardly used for wood extraction in any of the two time periods, *all* forests were characterized by some areas going from higher to lower size and crown density classes. This happened both before and after-CF. Together with interview data from the ten sites this indicates that local use-patterns continued after-CF. More importantly, it strongly suggests that when outsiders, as a result of CF and a general restoration of law and order in forestry (c.f. Table 6), could be effectively excluded, this local use was kept within the regenerative capacity of the forests. During focus group discussions, the authors asked members of the executive committees in the six CFUGs who's CFs were regenerating after the pre-CF degradation, what they would do if outsiders were again granted rights to harvest timber in their CFs and the answer was in all cases "we will protect our forest -even with our lives, if needed". This result resonates with Treue et al. (2014), who found that forests under participatory management in Tanzania were generally utilized within their regenerative capacity when 'outsiders' could effectively be excluded. Hence, our results challenge the common narrative of forests under centralized governance being deforested and degraded by local people (peasants) because they lack incentives to conserve these forests (e.g. Hobley, 1996). Rather, it seems more important that decentralized forest managers acquire *enforceable* exclusive rights to forest they are granted authority over (c.f. Lindsay, 1998; Schlager & Ostrom, 1992; Ostrom, 2009) -at least when the regenerative capacity of such forests in combination with other sources like trees on farmland, can meet the local demand (see below) for forest products.

Proximate and underlying causes of deforestation are the subject of a plethora of literature. In India, for example, Karia et al. (2001) conclude that the underlying reasons for forest loss are heavy grazing pressure and land encroachments by villagers for their overwhelming needs. In addition, authors from various regions of the world argue that increasing population density is a significant underlying factor of deforestation (e.g. Basu & Nayak, 2011; Cropper et al., 1999; Mena et al., 2006; Pahari & Murai, 1999; Uusivuori et al., 2002). However, the causal relations are unclear and e.g. Leach & Fairhead (2000) find that in some areas and under certain conditions, population growth seems to have has resulted in an expansion of forests. In our cases, we found improvement in forest condition in the majority of the studied community forests during 1998-2009, irrespective of a sometimes substantial population increase. This resonates with Fox (1993) who found that, despite an annual population growth rate of 2.5% in Central Nepal forests were in much better condition in 1990 than they were in 1980.

Economic development and thus a reduced dependency on forests for firewood and fodder in our ten sites have in all likelihood contributed to the observed enhancement of mature stands with >70% crown density and a likely general accumulation of woody biomass. Whether these factors have been decisive is, however, not certain. Moreover, forest stands that are managed mainly for firewood and fodder production generally have higher annual average stand increments than otherwise similar forests where the stands are allowed to reach maturity sizes because they are harvested at their maximum growth rate (at the exponential part of their logistic S-shaped growth curve) rather than after they have gone through the period of slowing-off growth that leads up to their maximum growing volume (when the logistic S-curve curve flattens out), which is when most species are suitable for timber and thus attain the highest price to volume ratio (Vanclay, 1994: 106-7; Ryan et al., 1997; Weiner & Thomas, 2001). Had the CFUGs needed more firewood and fodder, this might well have been extracted from the forests without compromising their productivity, per se, but the trade-off would be a reduction of areas with timber size trees. In two follow-on studies of Basudev Pahara, Bhayarthan, Chisapani and Saldanda CFs, Toft (2013) , who studied the role of officially sanctioned forest management plans (Operational Plans), found that certain areas near streams and local roads in all four CFs were never allowed to grow into timber size trees and Adeyeye (2014), who studied processes of, de facto, silvicultural management, found that the local CF managers' decisions were well rationalized and carefully balancing site-specific local knowledge about their forests' regenerative capacity with the members' requests for timber, fodder and firewood as expressed during general assemblies in the respective CFUGs. Private trees clearly also serve to allow an accumulation of timber size stock in the CFs. Interview data, however, suggest that the relatively high number of private trees across the ten sites is an effect rather than a course of forest conserving governance that CF has promoted.

Overall, our study speaks to the international debate on whether and how forest decentralization will result in/promote forest conservation (e.g. Hobely, 1996; Ostrom & Nagendra, 2006; Agrawal, 2005; Agrawal et al., 2008; Agrawal & Chhatre, 2006; Chhatre & Agrawal, 2008 & 2009; Persha et al., 2011; Ribot et al., 2010; Lund & Treue, 2008; Treue et al., 2014; Blomley et al., 2008; Meilby et al., 2014; Rutt et al., 2014). In this respect it is important to specify that the studied ten sites in Nepal represent examples where local people are not desperately poor and where the forests had existed and supported local livelihoods for more than two decades prior to their present official status as CFs. Under these conditions, assisted by but hardly entirely dependent on a favourable economic development, we can say that the evidence strongly suggests that CF has indeed promoted forest conservation and that this has been achieved through sustainable utilization –not through radical preservation. Furthermore,given the mentioned context, the overriding causal relation seems to be that, through CF, local communities got indefinite and enforceable exclusive rights to products from their CFs. In other words, the limiting factor on forest conservation before CF was local people's inability to exclude 'outsiders' from local forests. It was not their inability to meet basic needs for forest products while conserving forest resources or their inability to estimate the growth rates of 'their' forests and device as well as implement matching harvesting regimes.

Ideally, this study should have attempted to document the development of tree cover in areas surrounding the ten CFs to test for 'leakage' effects, i.e. whether the apparent control of harvest within CFs has been associated with forest degradation/deforestation elsewhere (c.f. Baland et al., 2010). Resource constraints prevented this, but the documented high amount of trees on farmland and the fact that government forests only supplied 13.4 and 33.3%, of firewood and fodder extraction, respectively, c.f. above, does not indicate alarming rates of leakage. This is especially so because fodder includes grasses, herbs and lopped tree branches the collection of which is thus rarely associated with felling or damaging trees beyond their natural recovery capacity. Besides, almost all forests in the area are in the process of being or have already been handed-over as CFs to local communities, so there is little or no open-access forest available around most settlements. This touches upon another side of the forest decentralization debate, namely how much forest to decentralize and how much to keep under centralized management. In a fairly densely populated agricultural landscape like the Mid-hills in Nepal, where forest resources are patchy and largely confined to marginal agricultural lands (steep slopes, rocky areas and hill tops) –and where the rule enforcement capacity of the central-level forest authority is very limited, it seems relevant to decentralize all forest management because this will enhance the ability of the official right-holders to actually exclude 'outsiders'.

While ours and other scholar's results strongly indicate that forest decentralization promotes forest conservation, there is no guarantee that local communities will actually do this (c.f. Agrawal & Gibson, 1999). The simple reason being that forestry is often financially inferior in comparison to alternative land-uses and/or open to local or more distant actors' short-term gains through harvesting and marketing of old growth trees (c.f. above). However, since the state and ultimately the nation's population hold legitimate interestsin ensuring thatdecentralization leads to forest conservation,at least over the long-term. Accordingly, by law, decentralized forests may generally be re-centralized, if they are cleared or degraded. This also applies to CF in Nepal where the 1993 Forest Act and the 1995 Forest Rules specify the processes for re-centralizing CFs (see e.g. Rutt et al. (2014) for further details). Yet, how should resource strained central forest administrations monitor the condition of an ever increasing number of CFs? The decreasing prices and increasing quality of satellite images suggests that this study's approach of establishing GIS polygons, which is generally a one-off investment, and monitor the forest condition within these would be worthwhile to pilot test. This is especially so, if a first round identification of apparent negative changes in crown coverage might be done electronically and subsequently confirmed manually before costly on-the-ground verification is undertaken in forest where such changes appear alarming. Future improvements of hard and software might also allow for cost efficient monitoring of developments in tree size classes and thus the growing stock. This scenario potentially offers central authorities a panoptic view of the forest condition in all CFs and could significantly increase the efficiency while reducing the costs of monitoring CFs. If polygons of government-managed forests were also included and all data made publicly available, this would also offer society an informed basis on which to discuss conservation outcomes of alternative forest tenure and governance regimes (see e.g. Ostrom & Nagendra 2006). In terms of direct payments for REDD+ to CFUGs, a concept that is already being piloted in Nepal (see e.g. Rutt & Lund, 2014 and Saito-Jensen et al., 2014), this methodology might also hold significant potential.

CONCLUSION

This paper focused on outcomes of decentralized forest management in terms of forest resource condition as well as the underlying policy and socio-economic drivers that are likely to have caused the observable changes. This was done through time series analyses of tree size and crown cover densities observable on aerial photos and satellite images during a 26 year period before forest decentralization (1972-1998) and a 12 year period after decentralization (1998-2009) in ten representative mid-hill community forests in western Nepal. Furthermore, 304 randomly chosen households (about 30 in each site) were interviewed to elicit information about local forest product use and economic development. Key informants and forestry officials were also interviewed about the forest history of the area in general and in the specific sites. In addition, major historical events and legislation of particular relevance for the forestry sector was reviewed.

The analyses showed that, before decentralization, six forests, all of which suffered timber extraction by non-locals, were degraded while the areas with mature trees and high crown cover densities in the then more remote (in terms of market access) four sites remained stable or increased. During the period after decentralization, all except one forest exhibited general regeneration and enhancement of areas dominated by mature trees. In the CF with a slightly negative development, the harvesting was, however, silviculturally sound and economically rational (removal of old trees to generate village funds and to make space for regeneration) and the timber harvest was largely compensated for by ingrowth from lower sizes into the timber size class over the observed 12 years. Very importantly, it was observed that, after decentralization, all forests were actively harvested by the local communities, thus supporting the general 'conservation through economically rational utilization' predictions of common pool resource management theory (e.g. Ostrom, 2009). Demographic developments in the ten sites seemed unrelated to the observed conservation outcomes and although all ten sites had experienced a favourable economic development, not least through remittances from relatives working overseas, during the period after decentralization, it seems that the decisive causal relation between forest decentralization and forest conservation was that the community forest user groups got long-term (indefinite) and *enforceable* exclusive rights to their community forests including ownership to all products from these.

Due to resource constraints the study could not document the development of tree cover outside the investigated forests to examine possible negative spill-over effects of improved community forest conservation. However, the respondents had considerably more private trees on their farmland than the national average and extracted far more 'forest products' from their community forests and private trees than from government managed forests. Furthermore, forests in this area are relatively small and scattered in a landscape dominated by agriculture –and most are already under or in the process of being decentralized meaning that few semi-open access forest resources are, in fact, available. Accordingly, and in agreement with Ostrom's (2009) design principles for robust property rights institutions, the policy conclusion is that decentralization is likely to promote forest conservation in areas where (i) the population density is relatively high, (ii) people are not desperately poor, (iii) the forests are sufficiently large to be economically important to local people while being small enough to allow effective exclusion of 'outsiders', and (iv) local people get long-term and secure rights to forest resources and associated revenues. Moreover, the study's approach to observe detailed changes in forest structure through high resolution images appear to hold significant potential in terms of addressing central forest administrations' legitimate interest in monitoring the conservation effect of forest decentralization, which they are often incapable of doing through classical methods of repetitive forest inventories because these are prohibitively expensive and prone to technical errors and manipulation. If such panoptic data on forest cover developments was made publicly available and included forests under alternative regimes (central government or private management), then future policy and scholarly discussions over the effect of different governance regimes on forest conservation, would be greatly informed and thus help to uncover causal relations.

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Paper 2

The relative importance of community forests, government forests, and private forests for household-level incomes in the Middle Hills of Nepal

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ABSTRACT

This study estimates the household-level economic importance of income from forests under different tenure arrangements, including the poverty and inequality reduction capacity of forests across tenure types, using data from 304 households in Tanahun District of Western Nepal. We observed that forest income contributes 5.8% to total household income, ranging from 17.4% in the lowest income quartile to 3.8% in the top quartile. Analyses of poverty indices and Gini decomposition showed that incorporating forest incomes in total household income reduces measured rural poverty and income inequality. Community forestry income constituted about 49.7% of forest income, followed by 27.5% from government-managed forest, and 22.8% from private forests. Community forestry income, however, contributed more than other sources of forest income to income inequality, indicating elite capture. We argue that the poverty reduction and income equalizing potential of community forestry required modification of rules that govern forest extraction and pricing at community forest user group level.

Key words: Forest income, tenure, livelihoods, poverty, inequality, South Asia

1. Introduction

There have been substantial recent advances in our understanding of the importance of environmental incomes (defined below) to rural households in developing countries. The methodological break-through came with the seminal work of Cavendish (2000, 2002) subsequently used by the Poverty Environment Network (PEN) to develop a standardized approach to design and implement household and village surveys aimed at collecting quantitative data on environmental incomes and rural livelihoods (Angelsen et al., 2011). Empirical findings from PEN, covering around 8,000 households in 24 developing countries, indicated a high degree of environmental reliance among rural households: 28% of total household income was derived from environmental resources, with 81% coming from forests (Angelsen et al., 2014). There is, however, a gap in our knowledge regarding the relative economic importance of forests under different tenure arrangements to rural household incomes. Using the PEN data set, Jagger et al. (2014) found that state-owned forests generated higher forest income than community forests and private forests, both when reported per hectare and per household, and for cash as well as subsistence incomes. They did, however, not investigate how these patterns vary across income groups, nor did they look into the relative importance of forest product groups.

The aim of our study is to improve the understanding of the relative economic importance at household-level of income from forests under different tenure arrangements. This includes how the relative importance varies with total household income and why, as well as the individual contributions of product groups. Empirical data from the Middle Hills of Nepal are used for the analyses. This study location is a particularly relevant as (i) the mixed agricultural system makes households reliant on inputs from forests and trees across a range of tenure systems (e.g. Olsen, 1996); (ii) the long history of community forestry makes the presence of different tenure systems likely within short distances; and (iii) the existing literature on the household-level economic importance of environmental resources in the country allows a broader discussion of our findings. In addition, with 25% of the population in the country living below the official poverty line of USD 0.72/capita/yr (CBS, 2011), an improved understanding of rural incomes may contribute to poverty prevention and reduction.

Meilby et al. (2014), using an environmentally augmented panel data set from three sites in Nepal, reported relative environmental incomes from 9.1-12.7% of total household income. They do not report variations across households but this is at the lower boundary of the global PEN data set (Angelsen et al., 2014). Reported key product groups in the Middle Hills are firewood and wild fruits. Previous studies from Nepal have also reported low average environmental income shares – the figures are, however, not directly comparable, due to differences in applied methods and definitions, but nevertheless illustrate the tendency: average forest income share of 5-8% (Adhikari, 2005), 4-23% (Chhetri, 2005), 6-22% (Aryal and Angelsen, 2007), and 12-31% (Rayamajhi et al., 2012). Yet, none of these studies report on the relative importance of income derived from forests under different tenure arrangements although the policy importance of who extracts what products from which forests and non-forest areas is rather obvious.

2. Methods

2.1. Study area

Tanahun District in the Western Development Region of Nepal ($27^{0}74'$ - $28^{0}13'$ N and $83^{0}94'$ - $84^{0}56'$ E, Fig. 1) covers an area of 1,546 km^2, ranging from 200 to 2,325 masl (DFO, 2009). Average annual rainfall is 1,761 mm, with mean maximum and minimum temperatures of 38-48^{0}C and 5-6^{0}C. The total population is 323,288 with 55.6% female and 44.4% male; average household size and literacy rate are 4.13 and 85% (CBS, 2012). There are 41 Village Development Committees (VDCs, the lowest administrative unit) and three Municipalities. Tanahun District is traversed by the main road from Kathmandu to Pokhara and representative of good access Middle Hill districts in Western Nepal. Most households are engaged in mixed farming, linking forests, animals and crop production: animal manure and forest litter is composted and used as fertilizer in the production of staples. Average landholding per household in the district is 0.92 ha, with a ratio of forest to cultivated land of 1.22 (DFO, 2013). About 82% of the total population has access to piped drinking water and 55% of households have electricity. In Tanahun District, about 14.8% of the population lives below the poverty line with a minimum of 4.0% in Dulegaunda VDC to maximum of 38.5% in Chhimkeshwari and Deurali VDCs. In our study sites, 6.4%, 14.1% and 11.5% of people live below the poverty line in Byas Municipality, Ghansikuwa and Kyamin VDCs, respectively (CBS, 2013). The average per capita income in Tanahun in 2011 ranges from US $ 344 to 748 (CBS, 2013) up fromUS $ 233 in 2001 (CBS, 2002).

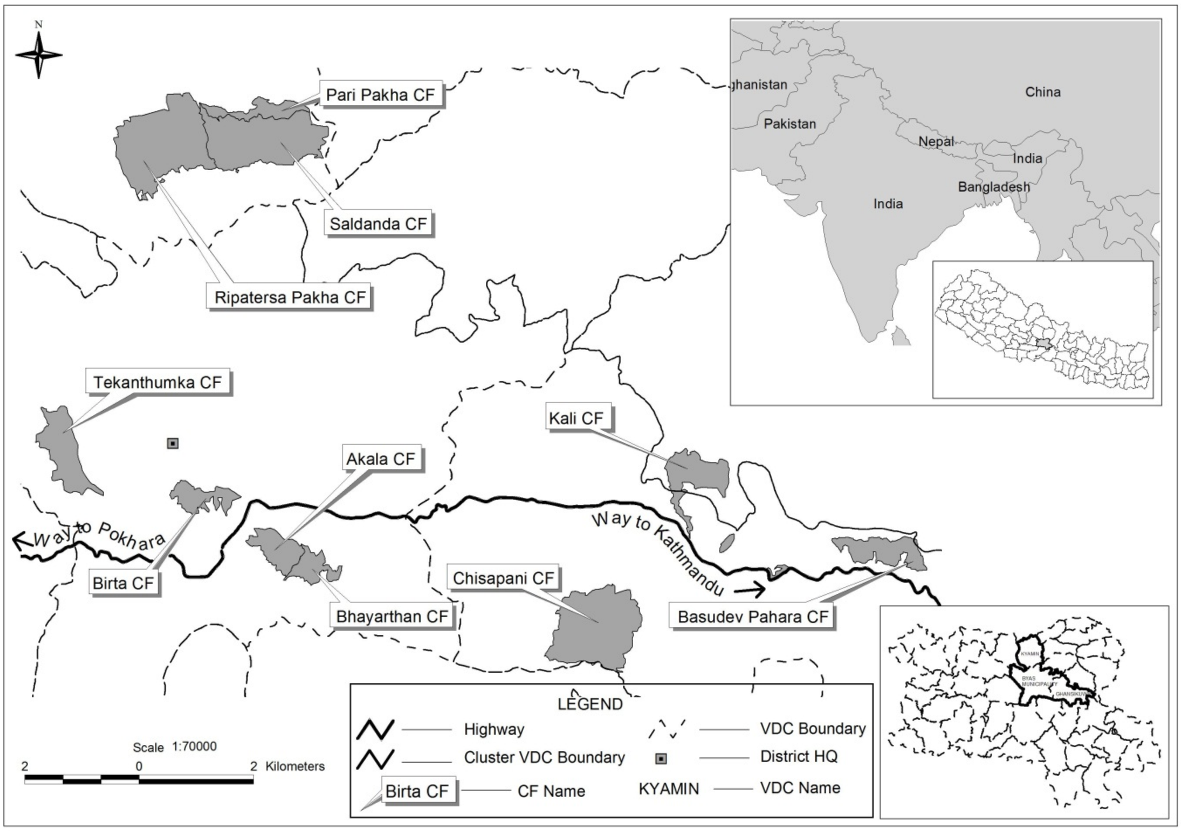

Figure 1. Location of the study site and the sampled community forests

2.2 Data collection

The present study is part of a larger project on community forestry in Nepal. Hence data collection took point of departure in Community Forest User Groups (CFUGs), self-governing local institutions responsible for managing handed-over national forests. We retrieved information on key variables (e.g. date of establishment, area, no. of members, and location) of all community forests in Tanahun District and categorized them as close to or far from the nearest market centre. In a sub-set of three local administrative units (Byas Municipality and Kyamin and Ghansikuwa VDCs), accessible and located next to each other for logistical reasons, ten community forests were then purposely selected to ensure variation in establishment date, forest area, performance of the CFUGs on social and forest development activities, and access to facilities (Table 1). The four CFUGs in the municipality are considered market close and the six in the VDCs market far. The CFUG forests are either dominated by *Shorea robusta* and/or *Schima-castanopsis*. In comparison, the 4,571 CFUGs registered in the 11 districts of the Western Mid-hills, have an average size of 50.6 ha, equivalent to 0.49 ha/hh (CBS, 2012; DoF, 2014).

Table 1
Profile of 10 study CFUGs, Tanahun District, Nepal

CFUG name	Estab.	Near/far market	No. of hh in CFUG	Population	Forest Type[1]	Area (ha)	Area (ha/hh)
Akala	Sep 1993	Near	317	1,617	Sal, pole dominant	42.9	0.14
Bhayarthan	Sep 1993	Near	107	559	Sal, pole dominant	30.6	0.29
Birata	Jul 1998	Near	129	613	Sal, pole dominant	42.0	0.33
Tekanthumka	Jun 1997	Near	282	1,527	Sal, pole to mature	71.2	0.25
Basudev Pahara	Apr 1995	Far	147	867	Sal, pole dominant	56.4	0.38
Chisapani	Jun 1996	Far	184	853	Sal	171.3	0.93
Kali	Sep 1993	Far	228	1,234	Sal, pole dominant	94.1	0.41
Paripakha	Jun 1997	Far	63	367	Sal. pole dominant	34.4	0.55
Ripa Tersapakha	Nov 1994	Far	192	1,074	Sal, Chilaune, Katus	183.7	0.96
Saldanda	Sep 1995	Far	236	1,334	Sal, pole/mature	139.2	0.59

Sources: Operational Plans of CFs, Field Survey
[1]Species: Sal (*Shorea robusta*); Chilaune (*Schima wallichii*); Katus (*Castanopsis* spp.)

A large number of households (n = 304) were randomly sampled using lists of households in each CFUG obtained from the CFUG offices; approximately 30 households were selected in each CFUG. The household survey, comprising both structured and open-ended questions, captured demographic and socio-economic characteristics, income sources and types, assets, expenditures, information related to the household's interaction with the community and with forests, time of settlement, distance to forest, and energy use patterns. The questionnaires were translated into Nepali language and pre-tested outside the frame. The applied recall period was one year and the first author, together with trained enumerators, undertook data collection from December 2009 to August 2010. Secondary data was gathered through CFUG offices, VDC Offices, the District Forest Office, and the Central Bureau of Statistics.

2.3 Applied definitions

Total annual household income is the sum of all gross subsistence and cash incomes minus the costs of intermediate inputs and capital costs, i.e. value added net income (Sjaastad et al., 2005). Net income is inclusive of households' own labour input. Total income is aggregated by income in three sectors. *Environmental income* is the value of products extractedfrom forests and non-forest habitats, processing of such products, and relevant wages such as from community forestry work. The sub-component forest income is the sum of income from community forests, government forests and trees on private land, including from firewood, fodder, timber, poles, and wild fruits. Forests include both natural forests and plantations; and private forest income includes income from all private trees (the average no. of trees per ha of cultivated land is 158). *Farm income* is the economic value of crop and livestock production including wages for on-farm work. Crop income consists of agricultural crop production, both annual and perennial crops, and income from crop by-products. The values of inputs (fertilizers, ploughing services, seeds, and hired labour) are deducted from the gross crop income for each household to obtain the net crop income. Livestock income is realized from sales of products and services. Incremental stock value changes are not included. *Non-farm income* is income from other sources including self-owned businesses, remittances, pensions, and non-farm salaries and wages. Whenever possible, product values were estimated based on local market prices; otherwise substitute prices were estimated. Imputed values are used for livestock services (ploughing).

2.4 Data analysis

Sector-wise household income per aeu(adult equivalent unit (OECD, 2005); assigns a value of 1 to the first household member, 0.7 to each additional adult and 0.5 to each member below 15 years of age) was calculated in each CFUG, including total annual mean environmental income per aeu per forest product group. Income is reported by quartile, source and product group. Statistical analyses are descriptive statistics, ANOVA testing for differences across income quartiles, and Ordinary Least Squares regressions where the dependent variable is mean per aeuforest income across tenure types (government, community, private). An overview of explanatory variables and expected relationships, identified from the contextually relevant regional body of mainly qualitative and quasi-quantitative literature on household–forest income relationships, is presented in the Appendix. To further investigate differences across tenure types, we also report the Foster-Greer-Thorbecke (FGT) poverty indices (Ravallion, 1992) with and without forest income, and analyse income inequality, using the Gini coefficient decomposition approach (Lerman and Yitzaki, 1985), by tenure regime.

3. Results

3.1 Household characteristics

Household characteristics are presented in Table 2. The average household size was 5.37, slightly higher than the district average; the average land ownership was 2.04 ha per household; and the average community forest area per household was 0.49 ha.

Table 2
Household (n=304) characteristics across income quartiles, Tanahun District, Nepal

Attributes	Income quartiles				Sample mean (SD) N=304	Min-max value
	Lowest 25%(n=76)	Second (n=76)	Third (n=76)	Top 25% (n=76)		
Age of hh head (yrs)	47.2	46.9	44.7	48.5	46.8 (14.0)	17-80
Education (hh head, yrs)	5.00	5.36	5.95	6.78	5.77 (2.43)	0-12.5
Caste (1=Dalit)	0.12	0.20	0.08	0.21	0.15 (0.36)	0-1
Agr land owned (ha)	1.41	1.98	2.13	2.65	2.04 (1.70)	0.02-9.75
Livestock owned (LSU)[2]	0.33	0.46	0.42	0.59	0.45 (0.37)	0-3
CF area (ha/hh)	0.44	0.51	0.52	0.48	0.49 (0.27)	0.14-0.96
HH size (head count)	5.71	5.41	5.36	5.01	5.37 (2.20)	1-13
Children < 7 yrs	0.54	0.41	0.45	0.38	0.44 (0.72)	0-4
Remittances (1=yes)	0.37	0.49	0.71	0.61	0.54 (0.50)	0-1
Location (1=near market)	0.40	0.29	0.41	0.50	0.40 (0.49)	0-1

[2]LSU = Adult female buffalo is considered as 1, adult male buffalo as 0.76, adult cow as 0.69, adult ox as 0.89, adult male sheep/goat as 0.23 and adult female sheep/goat as 0.20.

Patterns are as expected, e.g. with more education and more agricultural land with rising incomes. The only exception is with regard to the caste attribute, with a relative high share of *dalits* (low caste) in the highest income quartile.

3.2 Aggregate household income by sources and quartile

The mean annual household absolute and relative income (per aeu) by income sources and quartiles for all surveyed households is given in Table 3. The poorest households, in the lowest quartile, are reliant on incomes from crops (30%), other income (28%), and forests (17%). The dominant income sources for more well-off households are remittances, crops and services (such as pension income), e.g. 34, 29, and 28% in the top quartile. Forest income decreases as average household income increases, from 17.4% in the lowest quartile to 3.8% in the highest, with an average share of total mean annual household income of 5.8%. In absolute terms, however, the top quartile's forest income is almost 48% higher than the lowest quartile. Hence, while poorer households depend most on forests, well-off households derived significantly higher absolute forest incomes. The lowest quartile also stands out for having low levels of remittances and service incomes.

Table 3
Mean annual total household (n=304) absolute (NRs) and relative (%) income per aeu by source and quartile, Tanahun District, Nepal

Sources of income	Income quartiles										F-value	Sig
	Lowest		Second		Third		Top		Average			
	Abs.	Rel.	Abs.	Rel.	Abs.	Rel.	Abs.	Rel.	Abs.	Rel.		
Farm												
Crop	3394[a]	29.9	5551[a]	25.3	8087[b]	23.1	21912[c]	28.8	9736	25.3	98.3	***
Livestock	391[a]	3.5	733[ab]	3.3	1259[b]	3.6	3957[c]	5.2	1579	4.1	53.6	***
Sub-total	3786[a]	33.4	6284[ab]	28.7	9347[b]	26.8	25870[c]	34.0	11315	29.4	71.5	***
Forest	1968[a]	17.4	2150[a]	9.8	1978[a]	5.6	2905[b]	3.8	2247	5.8	16.6	***
Non-farm												
Remittances	1416[a]	12.5	7960[b]	36.3	14206[c]	40.7	25870[d]	34.0	12352	32.0	69.5	***
Service	965[a]	8.5	5539[b]	25.3	9423[c]	27.0	21505[d]	28.2	9358	24.3	373.7	***
Other	3206[a]	28.3	3005[a]	13.7	3225[a]	9.2	3638[a]	4.8	3271	8.5	0.497	n.s.
Sub-total	5588[a]	49.3	13499[b]	61.5	23629[c]	67.6	47375[c]	62.2	24981	64.8	75.3	***
Total	**11342[a]**	**100**	**21934[b]**	**100**	**34942[c]**	**100**	**76149[d]**	**100**	**38543**	**100**	**119.1**	*******

*Note: US $ 1 equals to NRs 73;   *** = Significant at 1% level*
Bonferroni's test: Relative share followed by a common superscripted letter imply the difference between them is not significant at the 5% level

Total mean annual per aeu absolute forest incomes by management regime, products, and income quartiles are presented in Table 4. Across the three management regimes,the best-off quartile obtains significantly higher income than the other quartiles (grand total row). This is particularly due to higher fodder incomes from community forests and private forests/trees on farmland (as noted in Table 2, the highest income quartile have larger livestock holdings). Interestingly fodder accounts for 76-77% of total forest incomes for all four household categories while firewood accounts for 16% of the lowest and second quartiles' and 14% of the two highest quartiles' forest incomes, respectively. Timber accounts for 7% of the lowest and second lowest income quartiles', 8% of the second highest and 9% of the highest quartiles' forest incomes. Accordingly, these three products dominate and contribute almost equal shares to each quartile's forest incomes. Statistically, all household categories collect timber and firewood in similar per aeu quantities within each of the three management regimes although the data indicates that the best-off quartile households derive more firewood from private trees than the other household categories, which appears logical. Fodder from government-managed forests is collected in equal quantities by all four household categories although the tendency seems to be that the poorest collect more than the richest. This is reversed in community forests where the best-off households collect almost twice the amount of the poorest and significantly more than the other three categories. Less surprisingly fodder from private trees follow a similar pattern.

Table 4
Total mean annual per aeu absolute household (n=304) income (NRs) by management regime, products and quartiles, Tanahun District, Nepal

Management regime (Sources)	**Products**	**Income quartiles**					**F-value**
		Lowest (0-25%)	**Second (26-50%)**	**Third (51-75%)**	**Top (76-100%)**	**Average**	
Government-managed forest	Firewood	50[a]	50[a]	35[a]	45[a]	45	0.213
	Fodder	643[a]	639[a]	443[b]	575[a]	574	2.376*
	Sub-total	**693[a]**	**689[a]**	**478[b]**	**620[a]**	**619**	**3.013****
	[%]	*[35]*	*[32]*	*[24]*	*[21]*	*[27]*	
Community Forests	Firewood	210[a]	234[a]	165[b]	253[a]	215	2.393*
	Fodder	541[a]	623[a]	678[ab]	1032[b]	717	4.025***
	Timber	134[a]	154[a]	168[a]	256[a]	178	0.223
	Pole	1[a]	1[a]	1[a]	1[a]	1	0.085
	Charcoal	3[a]	4[a]	4[a]	6[a]	5	0.172
	Sub-total	**889[a]**	**1016[a]**	**1016[a]**	**1548[b]**	**1116**	**4.651*****
	[%]	*[45]*	*[47]*	*[51]*	*[54]*	*[50]*	
Private/trees on farmland	Firewood	57[a]	66[a]	72[a]	109[b]	76	3.398**
	Fodder	328[a]	378[a]	411[a]	626[b]	435	4.997***
	Bedding material	1[a]	1[a]	1[a]	2[a]	1	0.206
	Sub-total	**386[a]**	**445[a]**	**484[a]**	**736[b]**	**512**	**6.194*****
	[%]	*[20]*	*[21]*	*[25]*	*[25]*	*[23]*	
	Grand Total	**1968[a]**	**2150[a]**	**1978[a]**	**2905[b]**	**2247**	**6.861*****
	[%]	*[100]*	*[100]*	*[100]*	*[100]*	*[100]*	

*Note: US $ 1 equals to NRs 73; *** = Significant at 1% level*
Bonferroni's test: Relative share followed by a common superscripted letter imply the difference between them is not significant at the 5% level

3.3 The effect of forest income on poverty and inequality

Using the FGT poverty index formula, we estimated the total poverty index for the surveyed households with and without forest income in general and across tenure types. We found 5.9% of the sampled households to live below the specified poverty line (α = 0; Table 5) which is much lower than the national figure of 25.1% (CBS, 2011) reflecting our use of a regional poverty line and the relatively affluence of the district located along major national infrastructure. The depth of extreme poverty (α = 1) is 1.3%, while the severity (α = 2) is 0.4%. These figures are also much lower than the national estimates of 5.4 and 1.8 (CBS, 2011). If forest income is excluded from the total household income, the prevalence of poverty rises to 11.8%, a relative increase of 100%. The poverty gap (α=1) and poverty severity (α=2) indices would increase by 162% and 229%, respectively. Accordingly, as poorer households are more forest reliant, forest resources have an important income equalizing effect in our case. Access to private forest income and community forest income appears to have approximately the same effect on income equalizing; not having access to these incomes increases the prevalence, depth and severity of poverty by around 40%, 55%, and 80% respectively. For government forest derived income, the figures are 28%, 5%, and 0%, respectively.

Table 5

Foster-Greer-Thorbecke (FGT) poverty indices with and without forest income and across tenure arrangements (n=304 households), Tanahun District, Nepal

Poverty indices	With forest income		Without forest income		Without government forest income		Without community forest income		Without private forest income	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
FGT(0)	0.0592	0.0135	0.1184	0.0185	0.0756	0.0151	0.0822	0.0157	0.0855	0.0160
FGT(1)	0.0129	0.0036	0.0338	0.0064	0.0136	0.0036	0.0204	0.0049	0.0200	0.0048
FGT(2)	0.0042	0.0015	0.0138	0.0033	0.0042	0.0015	0.0078	0.0024	0.0073	0.0025

Note: Poverty line for the Western Hills of Nepal (CBS, 2011) is used in this study.

The income inequality of the surveyed households, based on all sources of income, described by a Gini coefficient of 0.34, is a little higher than the national figure of 0.32 (CBS, 2011). The decomposition of forest income inequality in the sample population by forest management regime is presented in Table 6. Forest product income diversification clearly contributes to reduced inequality across quartiles as all G_k values are higher than the aggregate Gini value. The percentage contributions of forest income to inequality (the overall Gini shares) are smaller than the percentage contributions to forest income, again indicating the equalizing effect on total income distribution. The Gini shares show that, within forest income, community forestry contributes most to overall income inequality, particular through fodder and timber incomes.

Table 6

Decomposition of forest income inequality (Gini) by management regime, Tanahun District, 2009-10 (n = 304 households)

Management regime	Products	S_k	G_k	R_k	$S_k \cdot G_k \cdot R_k$	Gini share	Overall Gini share	Marginal change	Overall change
Government managed	Firewood	0.0199	0.8451	-0.0845	-0.0014	-0.0042	0.0008	-0.0242	-0.0052
	Fodder	0.2556	0.4545	0.6062	0.0704	0.2094	0.0305	-0.0462	-0.0474
	Sub-total	0.2755	0.4326	0.5789	0.0690	0.2052	0.0313	-0.0703	-0.0526
Community managed	Firewood	0.0955	0.4564	0.6501	0.0283	0.0843	0.0121	-0.0112	-0.0170
	Fodder	0.3194	0.6383	0.8005	0.1632	0.4853	0.0544	0.1659	-0.0429
	Timber	0.0791	0.9564	0.8408	0.0636	0.1892	0.0344	0.1101	0.0103
	Pole	0.0005	0.9882	0.6350	0.0003	0.0009	0.0001	0.0004	0.0000
	Charcoal	0.0020	0.5363	-0.1995	-0.0002	-0.0006	0.0003	-0.0026	-0.0003
	Sub-total	0.4965	0.5740	0.8956	0.2552	0.7590	0.1013	0.2625	-0.0499
Private managed	Firewood	0.0337	0.6797	-0.0201	-0.0005	-0.0014	0.0011	-0.0351	-0.0092
	Fodder	0.1937	0.5941	0.1076	0.0124	0.0368	0.0057	-0.1569	-0.0533
	Bedding	0.0005	0.5315	0.3924	0.0001	0.0003	0.0001	-0.0002	-0.0001
	Sub-total	0.2279	0.5589	0.0944	0.0120	0.0358	0.0069	-0.1922	-0.0626
Total		**1**			**0.336**	**1**	0.1395		-0.1651

Note: S_k represent the k^{th} income source's share of total household income, G_k is the Gini of income source k and measures the inequality of the income distribution of source k; and R_k is the Gini correlation between income source k.

The aggregate Gini coefficient decreases most by a marginal change in private managed forest income, in particular through fodder income, and less so through income from government managed forests; it increases through community forestry income, in particular due to fodder and timber incomes. More generally, we found that a 1% increase in forest income, other things being equal, results in a 0.16% decrease in overall income inequality.

3.4 Determinants of forest income across tenure type

Results of the OLS regression model for analyzing determinants of forest income across the three tenure types are presented in Table 7. The control variables in the model are jointly significant, as showed by the Wald Chi-square test value of 49.72 (df: 10, p<0.000). We did not see multicollinearity (VIF <3.0) or heteroscedasticity (insignificant White test under the hypothesis H0= homoscedasticity).

Table 7
Results of OLS regression for analyzing determinants of forest income in three management regimes (n=304), Tanahun District, 2009-10

Explanatory variables	Government-managed forest			Community forest			Private forest		
	Coef.	**SE**	**P-value**	**Coef.**	**SE**	**P-value**	**Coef.**	**SE**	**P-value**
Age of HH head (Years)	-0.0021	0.0033	0.532	-0.0034	0.011	0.770	-0.0108	0.0125	0.390
Average education (Years)	-0.0285	0.0219	0.194	-0.0295	0.0781	0.706	0.0429	0.0826	0.604
Caste (1= *Dalit*)	0.0246	0.1256	0.845	1.111**	0.4484	0.014	-0.7612	0.4737	0.109
Children under 7 years (No.)	-0.0825	0.0727	0.257	-0.3197	0.2596	0.219	0.3375	0.2743	0.220
CF size (ha)	-0.1476	0.2560	0.565	0.8915	0.9138	0.330	-0.2023	0.9653	0.834
HH size (aeu)	-0.0083	0.0408	0.838	-0.0910	0.1459	0.533	-0.0992	0.1541	0.520
Landholding (ha)	-0.0082	0.0230	0.720	-0.1951**	0.0821	0.018	0.5269***	0.0868	0.000
Livestock holding (LSU)	0.0679	0.1067	0.525	2.971***	0.3810	0.000	3.916***	0.4025	0.000
Remittance (NRs)	0.1951**	0.0918	0.034	-0.7055**	0.3279	0.032	0.1456	0.3464	0.674
Village location (1= near market)	-0.3705***	0.1351	0.007	-0.7721	0.4824	0.111	1.933***	0.5096	0.000
Constant	0.6170	0.2754	0.026	2.190	0.9828	0.027	-0.8112	1.038	0.435
N	304			304			304		
R^2	0.071			0.306			0.439		

***significant at 1% level; ** significant at 5% level
+dependent variable is per adult equivalent forest income in three management regimes

Of the ten variables used in the OLS regression model, we found two significant variables in the government-managed forest regime (remittances and village location), four in the community forest regime (caste, landholding, livestock holding, and remittance) and, three in the private forests regime (landholding, livestock holding, and village location) (see Table 7). Interestingly, the direction of some of the significant variables varies across the three regimes (landholding, remittance, and village location). Only livestock holding is significantly and positively correlated income from community forests as well as from private trees. *Dalits* (low caste) derive significantly higher incomes from community forests in comparison to other caste groups.

4. Discussion

4.1 Forest income

Based on 7,978 households from 333 villages in 24 developing, tropical and sub-tropical countries across three continents (Latin America, Asia, and Sub-Saharan Africa), Angelsen et al. (2014) find that forest incomes account for 22.2% of total household incomes. Through a meta-analysis of 51 case studies from 17 countries, Vedeld et al. (2007) revealed that forest environmental income represents on average 22% of the total income in the population sampled. Cavendish (2000) estimated that 35% of the total income of rural households in communal areas of Zimbabwe originates from environmental products. Fisher (2004) showed that 30% of household income in rural Malawi is accounted for by forest income. In the Dendi District of south western Ethiopia, Mamo et al. (2007) have found that forest income contributes 39% to average household income. Similarly, Godoy et al. (2002) have estimated that, on average, 17-45% of household earnings across four Amerindian villages in the Bolivian lowlands and eastern Honduras is generated from forest activities. Forest income contribution of 9-19% in Sri Lanka (Illukpitiya and Yanagida, 2008) and 23-35% in Ethiopia (Babulo et al., 2009) have also been reported. Although there are diverging views on the share of forest income to different income categories of households, and it is difficult to compare studies due to differences in methods and definitions (Wollenberg, 2000), our results of total forest income contributing 5.8% to total household income, ranging from 3.8 to 17.4% for the richest and poorest, respectively, indicate that forest incomes in our site are at the lower end of the scale. This is in line with the other studies from Nepal: Meilby et al. (2014) reported average figures from 3.0 to 11.3% across a range of sites; Aryal and Angelsen (2007) 6-22% in the Nepalese mid-hills; Chhetri et al. (2014) found a range of 11.0-29.5% in a remote Middle hills site; while Rayamajhi et al. (2012), in a high altitude location, reported 12-31%. Given the relative affluence of our case villages this is not surprising, but the comparatively high dependency of the poorest households on forest incomes combined with the screwed distribution of incomes from community forests suggest that the poverty alleviating potential of community forestry is not fully realised (see below).

4.2 Role of forest income in poverty and inequality

On the basis of headcount measure of poverty, we found that only 5.9% of the surveyed population lives below the poverty line, which is well below the national figure of 25.1% (CBS, 2011). Inferences drawn from poverty indices and Gini decomposition, however, showed that forest resources have an important income equalizing and poverty alleviating effect, with the prevalence of poverty rising to 11.8% and the poverty gap (α=1) as well as poverty severity (α=2) indices increasing by 162% and 229%, respectively, if forest incomes are excluded. This resonates well with similar studies; the seminal research by Jodha (1986) who found that the Gini coefficient in dry regions in India increases by as much as 34% when income derived from forest gathering is ignored. Reddy and Chakravarty (1999) found that although the inequality effect of ignoring forest income was very marginal, poverty would increase by as much as 28%,if forest incomes did not exist. Fisher (2004) estimated that income inequality in southern Malawi would increase 12% if forest incomes were excluded. Lopez-Feldman et al. (2007) have highlighted that when forest income in

Mexico is ignored in poverty calculations, the severity of poor people increases more at the regional and community levels (17.1% and 18.4%, respectively), than at the national level (10.8%). Das (2010) reports that income from forests under joint forest management in Bankura District of Bengal, India reduces income inequality by about 12%, while Angelsen et al. (2014) find that across their studied 7978 households, forest incomes account for a slightly higher share of the poorer than richer households' total income while the per aeu value of forest products extracted by the 20% best-off households was five times that of the poorest 20%. In Nepal, Chhetri et al. (2014) found that excluding environmental income from total household income increased the prevalence of extreme poverty by 59% and the poverty gap and poverty severity indices by 110 and 162%, respectively.

Accordingly, our study supports a general picture of forest income being relatively more important to the poorest households while the richest are deriving significantly higher absolute forest incomes. However, the difference in absolute forest incomes between the poorest and the richest quartile in our case is primarily caused by the fact that the richest quartile extract almost twice as much fodder from community forests as the other three quartiles although they also extract significantly more fodder from private trees and similar amounts as the other household categories from government forests. The richest quartile also tends to extract more timber from community forests than the other three quartiles although this difference is not statistically significant (see Table 4). This illustrates an apparent general challenge to community forestry: it tends, at least initially, to consolidate pre-existing local-level income inequalities rather than the opposite (e.g. Green and Lund in press, Lund et al., 2014). In our case, the underlying reason is that the harvesting rules are either 'need-based', which is the case for timber where households are allocated harvesting rights by the executive committee based on their need to repair existing or construct new housesand pay a volume-based fee for the harvested amount that is independent of their income status, or 'time bound open-access', which is the case for fodder that may be collected in unlimited quantities and for free during specified time periods. Such harvesting rules tend to favour the already wealthy, who in this case hold comparatively more livestock. The poverty alleviating and income equalising potential held by community forestry is, thus, constrained by the very mechanism (local-level decision making authority) it has promoted. This, however, need not be a permanent outcome as the disadvantaged majority (here 75% of the sample) may acquire decision-making positions, through democratic elections, and then change the operational rules (Saito-Jensen et al., 2010; Lund and Saito-Jensen, 2013). For this to happen, the disadvantaged must discover and perceive the distributive outcomes of current rules as unfair and subsequently manage to form coalitions that are strong enough to either topple existing executive committees or open a deliberative rule-changing process. Analytical and communicative assistance, e.g. from NGOs, might, therefore, be a way to unleash the poverty reducing and income equalizing potential of community forestry.

4.3 Determinants of forest income

Of the ten explanatory variables included in OLS regression model, we found four variables (landholding size, livestock holding, remittances, and caste) as significant in community forestry regime. Similarly, three variables (landholding size, livestock holding, and village location) were found significant in private forest management regime whereas only two variables (remittances and village location) were significant in government-managed forests. The models explain between 7% and 44% of the variation, with the highest R^2 for the model focused on private management regime.

Though *Dalits* are often discriminated and have fewer income opportunities (CBS, 2011; Thoms, 2008), we found significant difference between caste and forest income in case of community forestry regime. Surprisingly, we did not find significant difference between forest sizes and forest income in any of the three tenure arrangements. Jagger et al. (2014) found positive and significant relationships between income from private forests and forest size. Contrary to the hypothesis that the more labour, the higher income from labour intensive forest extraction activities (Olsen and Larsen, 2003; Adhikari et al., 2004), we did not find significant difference between household size and forest income for any of the three tenure arrangements. We found a significant negative relationship between landholding income community forests and a significant positive relation to income from private trees/forest. This is not surprising as one would expect households with more land to have space for more trees including trees with particularly good fodder, firewood and timber value when these are scarce in surrounding forest areas. Official remittances, excluding informal flows and flows from India, represent about 25-30 percent of the Gross Domestic Product (GDP) in Nepal (World Bank, 2011). In our study this is reflected amongst the three highest income quartiles which derived an impressive 34.0-40.5% of their annual income from this source while this was only 12.5% for the poorest quartile (Table 3). Surprisingly, remittances were significantly and positively correlated with income from government forests while they were significantly and negatively correlated with income from community forests but insignificant in relation to income from private trees/forests (Table 7). A possible explanation could be that, amongst the wealthier households in the sample, a minority (the best-off quartile) collect more fodder in community forests than the two middle quartiles who both derive a high share of their incomes from remittances (Table 3) and for some reason collect more of their fodder consumption in government forests than the best off quartile households (Table 4). Although accounting for a small share of any income quartile's total income (Table 4), livestock holding is significantly and positively correlated with income from community forests and with income from private trees. As mentioned, this suggests that the harvesting rules for community forests favour households who have livestock keeping combined with private tree growing as one of their main livelihood strategies. Location of the village is also an important factor in deriving forest income. We found village location significantly and negatively correlated with income from government-managed forests and significantly and positively correlated with income from private trees/forest (Table 7). This suggests that incomes from government-managed forests to some extent substitute incomes which are more available close to markets. That incomes from community forests do not play a similar role could be explained through stricter access regulation while the significant and positive correlation with income from private trees/forest suggests a more specialized and possibly market oriented production. This supports that location strongly influences households' ability and willingness to engage in forest activities, also given other existing income opportunities (Kamanga et al., 2009).

5. Conclusion

In the forest policy discourse, the role of forest resources in reducing income disparities and contribution to rural development has received high attention in recent years. Natural resources are an integral part of rural income in Nepal and poorer segments of society depend relatively much on them as this study also supports. In general, we find that forest incomes have an income equalizing effect and serve to reduce extreme poverty, the poverty gap as well as the severity of poverty.

A key aspect of forest governance is regulating who extracts what products in which quantities from what areas; hence it is important to distinguish between incomes from forests and trees under different tenure arrangements. Overall, we found that the poorest quarter of households derive 17.4% of their annual income from forests. The richest quartile derived only 3.8% of their annual income from forests but in absolute terms this was almost 50% higher than those of the poorest quartile. The income from private trees among the richest was almost twice that of the poorest, which is not surprising given the fact that richer households have more land and more trees than poor households. Yet, the richest also derived 74% higher incomes than the poorest from community forests, a difference that mainly stems from the fact that they extract almost twice as much fodder. Incomes from government-managed forests are in absolute terms surprisingly similar across income quartiles.

These results show that although community forestry was intended to further enhance the value of forest and hence combine sustainable forest use with improving the poorest rural households' livelihoods, the exact opposite has happened. The underlying reason stems from the way product extraction and pricing is governed in community forests. Firewood is generally distributed in equal shares to member households and at equal prices. Timber is distributed for subsistence use according to documented needs for maintenance or new construction, also at fixed prices per cft. Fodder is normally a time bound open access resource. All these rules generally favour rich and resourceful households who thus, and in full accordance with the rules, appropriate comparatively higher values from the common forests. Accordingly, the poverty reduction and income equalizing potential of community forestry can only be realised through a modification of rules that govern product extraction and pricing at CFUG level. This should in theory be possible as it is the minority who benefit disproportionally, but it requires that the poorest households discover the mechanisms of inequity and manage to form coalitions with other household categories.

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Appendix

Overview of the expected relationships for explanatory variables determining forest income in the Middle Hills of Nepal. Mean and standard deviations from household (n=304) survey

Explanatory variables	Exp. sign	Description	Mean	SD
Household characteristics				
AGE	-	Age of household head (yrs). Assets accumulate with age (CBS, 2005; Chhetri, 2010); forest extraction is strenuous (Rayamajhi et al., 2012); both lead to less forest income with increasing age	47	14
AVGEDN	-	Average education of adult household members (yrs). Employment opportunities increase with education (Adhikari et al., 2004; CBS, 2011) making people drop low return forest activities	5.77	2.43
CASTE	+	1=*Dalit,* 0= other castes. *Dalits* are often discriminated and have fewer income opportunities (CBS, 2011; Thoms, 2008) increasing income from forests	0.151	0.358
Productive assets				
LANDSIZE	-	Land owned per aeu (ha). The more land, the less income from forest (Reddy and Chakravarty, 1999; Adhikari et al., 2004)	2.56	2.27
LSU	-	Per aeu livestock units. The more livestock, the less income from forests (Adhikari et al., 2004)	0.562	0.503
FORESTSIZE	+	Forest area (ha) per household. The more forest per hh, the higher forest incomes	0.485	0.265
Labour capital				
HHSIZE	+	Number of individuals (aeu). The more labour, the higher income from labour intensive forest extraction activities (Olsen and Larsen, 2003; Adhikari et al., 2004)	2.72	1.34
CHILDREN<7	+	Number of children under seven years of age. The more dependents, the higher the forest income	0.444	0.715
RMTNC	-	Household with remittance income (1=yes, 0=no). Allows investment in productive capacity thereby smoothing income and promoting economic growth (Combes and Ebeke, 2010; Rayamajhi et al., 2012) leading to less forest income	0.542	0.498
Village				
LOCATION	-	1=market near, 0=market far. Market near households have alternative income opportunities (Rayamajhi et al., 2012) and thus less forest income	0.398	0.490

Paper 3

Socio-economic determinants of growing trees on farms in the middle hills of Nepal

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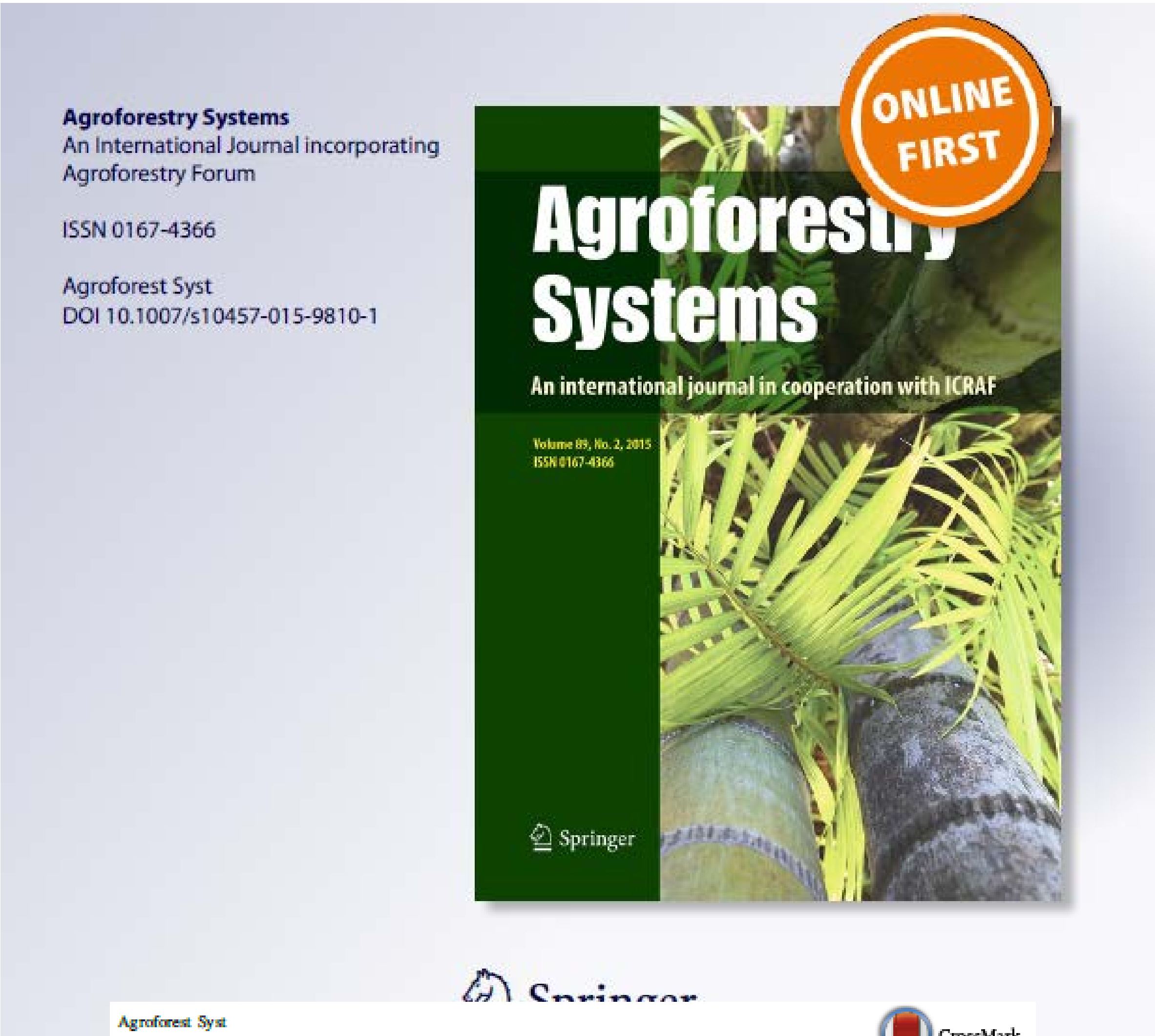

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Socio-economic determinants of growing trees on farms in the middle hills of Nepal

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Abstract

On-farm tree growing is potentially important for livelihood strategies and forest conservation, and varies greatly according to local contexts. A detailed knowledge base is therefore needed, requiring, inter alia, the documentation of factors associated with growing trees on farms. The present study surveyed 304 randomly sampled households in ten community forestry user groups in Nepal, eliciting data on demographics, income and consumption of tree products. All trees on households' farm land were registered by species. Farmers had on average 65 trees per hectare and a total of 92 species were found. The Shannon-Wiener index was 2.46 and Simpson's Dominance index was 0.15. Trees on farmland contributed on average 43% of households' firewood and fodder consumption. Apparent determinants of tree growing were identified through OLS regression; they included size of land and livestock holdings, education and firewood consumption, while income, ethnicity and sex of household head were not significant. Households' network and distance between household dwellings and the forest were negatively related with on-farm tree growing. Findings indicate that community forestry practices work to the detriment of the poorest households.

Keywords Nepal. Trees on farm land. Trees outside forests. Determinants

Introduction

Globally, agroforestry is found on almost half of the world's agricultural lands (Zomer et al. 2009) and environmental products are known to be vital for rural livelihoods (Angelsen et al. 2014). Although trees on farm land may reduce agricultural crop yield (Dhanya et al. 2013) agroforestry offers alternative benefits in terms of biodiversity conservation, carbon sequestration (Ajit et al. 2013), erosion and flood control (Mekonen 2009), and an overall optimization of the farming system for rural livelihoods (Tiwari et al. 2004). The importance of trees on farm land is therefore well established and promoted by many development agencies.

Agroforestry, as part of a multifunctional working landscape, can play a major role in conserving and even enhancing biodiversity from farms to the landscape level in both tropical and temperate regions of the world (Jose 2012). The concept of multifunctionality has proven to be fundamental to the strengthening of the sustainability of people's livelihoods (Callo-Concha and Denich 2014). Agroforestry systems allow synergistic interactions between woody and non-woody components to increase productivity and diversify total land output, while conserving the environment in a sustainable manner (Nair and Nair 2003). Weyerhaeuser and Kahrl (2006) found that trees planted on farms in Southwest China contributed more to farmer livelihoods and conservation of ecosystem services than trees from plantations. In Nepal, farmers have been growing trees along with field crops on their farm land to maintain land productivity and to provide for subsistence needs, including timber, fodder for livestock and fuelwood for cooking (Neupane et al. 2002). Apart from supporting local livelihoods, agroforestry systems practices in Nepal have contributed to diversifying livelihoods and increasing socio-ecological resilience against climate change (Pandit et al. 2014).

Farmers maintain and plant trees in farming landscapes that enhance food, fuel and medical security, especially for low-income rural people and during hungry periods, diversify income, lower production risk and optimize the management of resources (Arnold and Dewees 1995). A number of biophysical and socio-economic factors determine, however, whether farmers will grow trees on their farms (Garforth et al. 1999). Montambault and Alavalapati (2005) conclude in a review that the effects of household level socio-economic factors on the adoption of agroforestry practices merits more attention. The most important factors found in the available literature include farm size, sex, age and education of household head, household size, wealth and livestock holdings, as well as access to forests (e.g., Shackleton 2008; Mekonnen 2009). Factors are unlikely to be valid across national regions (Ndayambaje et al. 2013), meaning that several studies are needed to understand what factors promote tree planting in a country.

Agriculture is the mainstay of the Nepalese economy and together with forestry it contributes 35.3% of the total gross domestic product (GoN 2013a, b). Trees play a vital role in providing the energy inputs to ensure the survival of the hill farming communities (Carter and Gilmour 1989). Nationally, however, the forest resources disappear at an estimated annual rate of 1.7% (DFRS 1999) and farmers' access to remaining national forest resources is increasingly limited by effective restrictions imposed by the national community forestry programme (Thoms 2008). A growing demand for forest products is then assumed to have motivated people to grow trees on their farm land (Kanel 1995; Das and Oli 2001). Early studies described trees as integral components of farming systems (Thapa and Paudel 2000; Das and Oli 2001; Garforth et al. 1999) but also found associated reductions in the production of agricultural crops (Tiwari et al. 2004). Social aspects of agroforestry have been studied by, e.g., Neupane et al. (2002) and Regmi and Garforth (2010), but only one study has so far looked systematically into what determines the growing of trees on farm land (Webb and Dhakal 2011). Our purpose is, therefore, to contribute towards an understanding of the extent and determinants of on-farm tree growing in Nepal. The specific objectives of the paper are to: a) document the composition, diversity and uses of farm trees in mid-hill region of Nepal, b) analyze the explanatory factors responsible for the extent of tree growing on farm land. The paper posits a hypothesis that the extent of tree growing on farm land is associated with demographic, economic, asset and other variables.

Materials and methods

The study areas

The study focused on Tanahun District in the Western Development Region. It is located in the physiographic region called the middle hills, between the lowlands in the south and the mountains in the north. The district covers an area of 1546 km^2 and has a population density of about 209 people per km^2. The altitudinal range of the district varies from 200 to 2325 meter above sea level. The average annual rainfall in the district is 1761 mm; the mean maximum and minimum temperature are 38-48^{0}C and 5-6^{0}C, respectively. The average household size is 4.13 and the literacy rate is 85% (CBS 2012). The people of Nepal are categorized in terms of either their caste (Hindu-based) or their ethnic group (CBS 2012). There are 80 caste/ethnic groups in the district. The majority of the population depends on agriculture to sustain their livelihoods, and the average landholding per household is 0.92 ha (DFO 2013). A large highway (the Prithvi highway) passes through the study area and provides relatively easy access to the cities of Pokhara and Kathmandu (Fig. 1).

The specific study areas were identified through the Community Forestry Programme, a national programme that engages more than 11 million people in currently about 18,300 Community Forest User Groups (CFUGs) (DoF 2014). Most people in the Nepalese middle hills are members of a CFUG, easily recognizable local organisations, and these were therefore selected as the point of making contact with research respondents. All 456 registered CFUGs in Tanahun District (as of Fiscal Year (FY) 2008/2009) were listed, and 10 were selected that all have more than 15 years of experience with community forestry (Fig. 1). The natural forests handed over for community management in the 10 CFUGs are dominated by the tree species *Shorea robusta* and *Schima-castanopsis*. Four of the selected CFUGs are located close to a market, 6 are remote. The altitudinal range of the 10 forests varies from 453 to 865 masl. Table 1 provides background information on the CFUGs included in the study.

Table 1 General information of selected CFUGs (DFO 2009; survey results)

CFUG name	Location (VDC-ward)	Total HH	Total Population	HH[b] size (Number)	Area (ha)	CFUG Age
Akala[a]	Byas-1	318	1307	5.71 (2.13)[c]	38.7	20
Basudev Pahara	Ghansikuwa-1	147	867	5.90 (1.81)	44	19
Bhayarthan[a]	Byas-1	107	559	4-97 (2.31)	28.35	20
Birata[a]	Byas-11	129	602	5.23 (2.32)	42	15
Chisapani	Ghansikuwa-2,7	179	879	5.27 (1.85)	141	17
Kali	Ghansikuwa-8	228	1234	5.37 (2.26)	63.69	20
Paripakha	Kyamin-3	63	367	5.13 (1.99)	57.12	16
Ripa Tersapakha	Kyamin-9	191	1074	6.12 (3.14)	54.37	19
Saldanda	Kyamin-2	236	1332	4.87 (2.01)	148.5	18
Tekanthumka[a]	Byas-8	282	1955	5.1 (1.78)	83	16
Total/average				5.37 (2.20)		-

[a]CFUGs located closer to a market (1.16-4.20 km), i.e. in a municipality. CFUGs located farther from markets (6.42-12.72 km) are found in the rural Village Development Committees

[b]HH refers to Household

[c] Figures in parentheses show standard deviation

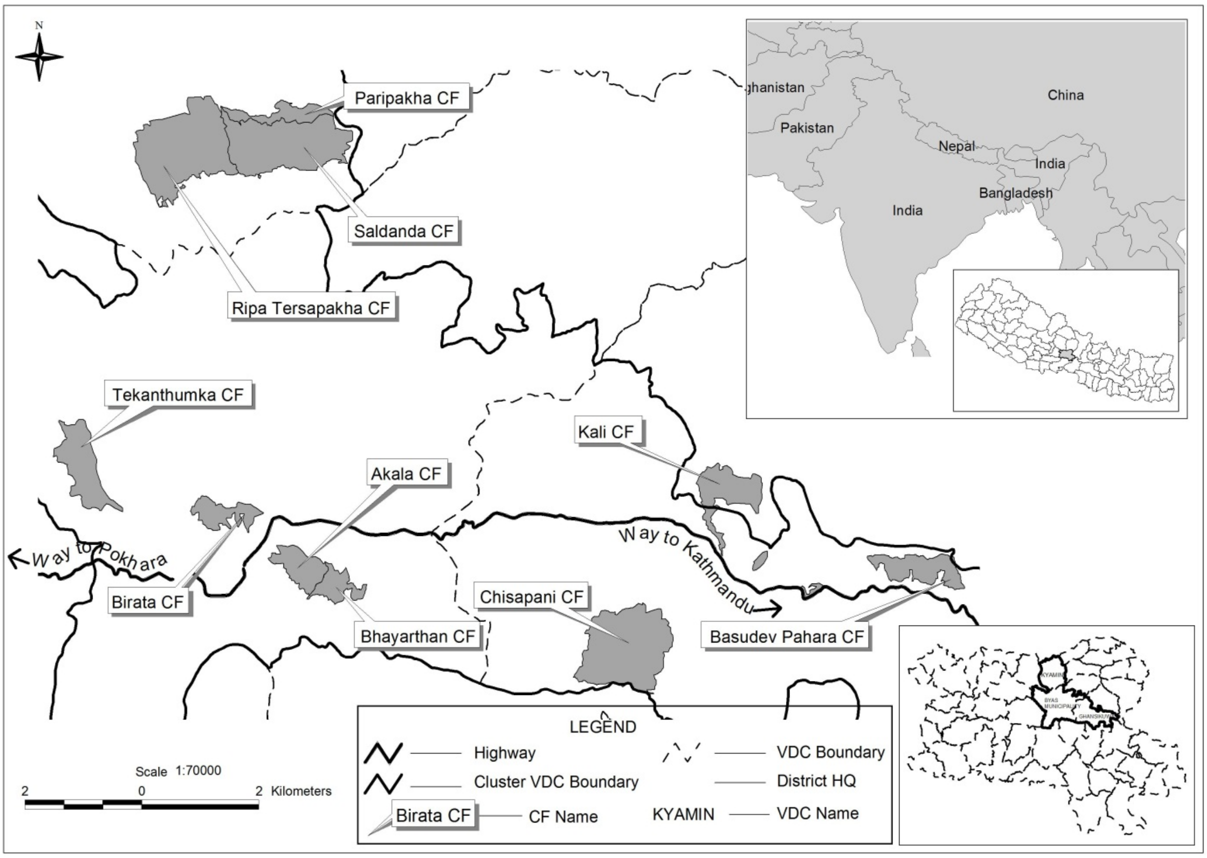

Fig. 1 Location of Nepal andthe studied communities

Methods of Data Collection

The study describes farmers' tree growing and identifies determinants for growing trees on farm through quantitative registrations supplemented with qualitative information supporting the interpretation of the quantitative data. Data were collected during January-July 2010 following three approaches: a household survey, counting and recording of farm trees and focus group discussions.

A total of 304 households were randomly selected, with a minimum of 30 households from each of the ten selected CFUGs. The sampling frame consisted of member lists obtained from CFUG offices; the sampling intensity was 16% for all CFUGs. The household survey comprised structured questions on household demographics, assets, annual consumption of firewood and fodder (tree foliage), income sources and amounts of income from the various sources in the past year. Formulation and administration of the household survey followed the approach used by the Poverty Environment Network (Angelsen et al. 2011). Woody plants on the farms of the 304 randomly selected households were considered trees outside forests as defined by FAO (2006); in this case the trees were found in homegardens and scattered on the farmland, no private blocks of forest were encountered. The trees were all registered by species and their uses recorded. After gathering of the information group discussions were conducted with samples households and five purposefully selected key informants to crosscheck, contextualize and validate the information obtained and to discuss constraints associated with tree growing in the area

Data Analysis

Data were analyzed using SPSS 16 (SPSS Inc. 2007) and STATA 11 (StataCorp. 2009) software. Trees on farms were analysed in terms of diversity and dominance using the Shannon-Wiener Diversity Index and the Simpson's Dominance Index. Ranking of tree species followed Howland and Howland (1984). The Shannon-Wiener Index takes a value of zero when there is only one species in a community, and a maximum value when all species are present in equal abundance (Mohan et al. 2007); values higher than 2 are considered medium to high diversity (Barbour et al. 1987):

$$H = - \sum_{i=1}^{s} p_i \ln p_i,$$

where H is the Shannon-Wiener index of diversity, p_i is the importance value of a species as a proportion of all species.

The Simpson's Dominance Index represents the probability that any two species encountered at random would be different:

$$D = \sum p_i^2,$$

where D is the index number and p_i is the importance value of a species as a proportion of all species.

Household income included cash and subsistence production of agricultural and livestock products and own collection of forest products, income from business, wages, salaries, and remittances received from household members migrated for work. Total income was calculated as net incomes without accounting for household's own labour. Household production, e.g. agricultural produce, was valued at local market prices and in case of products with only subsistence uses, barter values. Household demographics, asset and income variables were investigated regarding their association with tree growing using Chi^2 and Spearman's correlation. An OLS regression model was subsequently built with the explanatory factors found to be associated with tree growing (Table 2). No multicollinearity was observed among the explanatory variables. The model was described as:

$FARMTREE = \alpha + \beta_1 \times SEX + \beta_2 \times EDU + \beta_3 \times LSU + \beta_4 \times LANDHOLD + \beta_5 \times DIST + \beta_6 \times ALTENERGY + \beta_7 \times ETHNICITY + \beta_8 \times NETWORK + \beta_9 \times FIREWOOD + \beta_{10} \times FODDER + \varepsilon, \varepsilon \sim N(0, \sigma^2)$

The model describes the relation between the number of trees on a household's farm land and a number of explanatory variables. Female-headed households are hypothesized to have more farm trees than households in general (Shackleton et al. 2008). Previous studies have described salient uses of trees on farmland to include fodder, firewood and timber (Baul et al. 2013). We therefore assume that the level of tree product consumption (firewood, fodder, timber) is positively related with growing trees on farm land, with a higher demand for these products providing a larger incentive for securing a private supply of the desired natural resource. A commonly stated proposition is that educated farmers are more likely to adopt new technologies such as growing trees on farm land (Hansen et al. 2005) and hence we hypothesize that the household head's level of education is positively related to tree growing. Higher numbers of livestock in a household demand more fodder for feeding and more firewood for cooking fodder. We assume that the amount of livestock is positively related with on-farm trees (Mekonnen 2009). More farm land permits space for tree planting and we, therefore, hypothesize that the size of the landholding is positively correlated with the number of trees on farm land (Shackleton et al. 2008). Due to transportation difficulties and costs we assume that the longer the distance between village and forests, the higher the number of farm trees, which should result in the distance between the household dwelling and the forest being positively related with tree growing (Duguma and Hager 2010). The use of alternative energy sources, such as kerosene and LP gas, is gaining ground in Nepal and is reducing the need for firewood (Heltberg et al. 2000). We assume that the use of alternative energy sources is negatively related with farm tree growing.

Table 2 Explanatory variables for tree growing.

Independent variables	Explanation	Expected sign
Sex	Dummy variable: 1 if household head is female, 0 if male	+
EDU	Continuous variable: years of formal education completed by the household head	+
LSU	Continuous variable: number of livestock units owned by the household. Adult female buffalo is considered as 1, adult male buffalo as 0.76, adult cow as 0.69, adult ox as 0.89, adult male sheep/goat as 0.23 and adult female sheep/goat as 0.20. c.f. (HMGN/ADB/FINNIDA, 1989)	+
Landhold	Continuous variable: landholdings in hectare	+
Dist	Continuous variable: distance between dwelling and nearest forest in km	+
Altenergy	Dummy variable: Household using alternate energy source =1, else=0	-
Ethnicity	Categorical variable: (1=*Brahmin/Chhetri*; 2=Indigenous/Nationalities; 3=Disadvantaged group	
Network	Dummy variable: Household involved in community-based organization=1,else=0	+
Firewood	Continuous variable: annual firewood consumption in Kg	+
Fodder	Continuous variable: annual Fodder grass consumption in Kg	+

The population of Nepal is divided into castes and this aspect has a pervasive influence on many aspects of life. Generally, people from so-called ‘higher castes’, such as Brahmin and Chhetri, are better off than people from ‘lower castes’ and some ethnic groups (Thomas-Slayter and Bhatt 1994). We wanted to test whether any difference in relation to tree growing could be detected from the household’s categorization as a disadvantaged group. Finally, it is assumed that a household’s network of relations is important for providing information on the benefits of growing trees on farm land (Nepal et al. 2007), i.e. being positively related with the dependent variable.

Results

A total of 267 households (88%) grew trees on their farm land while 37 did not. The per capita income for those households that do and do not grow trees are not significantly different ($F (1,302) = 0.120, P<0.729$). Farmers who grow trees have larger average landholdings (0.52 ha) compared with farmers who do not grow trees (0.24 ha), and the difference is statistically significant ($F (1,302) = 18.41, P<0.000$). Farmers living closer to markets (n=121) earned significantly higher incomes than more remote farmers (n=183; $F (1, 302) = 9.856, P<0.002$). Average values for the key assets of land and livestock as well as the number of households growing trees on their farms in the sample across the 10 CFUGs are presented in Table 3. The number of livestock units and trees on farms were significantly lower in CFUGs that are located closer to markets ($F (1, 302) = 56.018, p<0.001$), ($F(1,302) = 28.067$ $p<0.001$).

Table 3 Average values for key assets and trees on farmlands per household (HH) by community forestry user group (CFUG); N=304.

CFUG name	Sampled HH (no.)	Average HH size (persons)	Average Land holding per HH (ha)	Average Livestock holding per HH (LSU)	HHs growing trees on their farm land (no.)
Akala[a]	31	5.71 (2.13)[b]	0.25 (0.36)	0.86 (0.98)	21
Basudev Pahara	31	5.90 (1.81)	0.58(0.34)	2.27 (1.55)	31
Bhayarthan[a]	30	4-97 (2.31)	0.36 (0.35)	1.49 (1.35)	23
Birata[a]	30	5.23 (2.32)	0.26 (0.27)	1.17 (1.18)	21
Chisapani	30	5.27 (1.85)	0.61 (0.45)	2.87 (1.32)	30
Kali	30	5.37 (2.26)	0.68 (0.44)	1.96 (1.24)	27
Paripakha	30	5.13 (1.99)	0.86 (0.58)	2.92 (1.51)	29
Ripa Tersapakha	31	6.12 (3.14)	0.69 (0.37)	3.14 (1.33)	31
Saldanda	31	4.87 (2.01)	0.49 (0.32)	2.41 (1.57)	27
Tekanthumka[a]	30	5.1 (1.78)	0.45 (0.39)	1.98 (1.27)	27
Total/average	304	5.37 (2.20)	0.52 (0.44)	2.11 (1.51)	26.7 (3.02)

[a] CFUGs located closer to a market.

[b] Figures in parentheses are standard deviations

Diversity of Farm Trees

The average number of trees planted or retained per household, average tree density and the average tree diversity per household across the sample of farmers growing trees on their farm are presented in Table 4. We found average of 158 trees per ha of cultivated land ranging from 96 to 309. The mean number of trees per household was 65 with a range of 18-106. The average number of trees per household in the near market CFUGs is less as compared to the distant CFUGs. On an average, a household has maintained at least six different woody species on farm land, ranging from five to nine (Table 4).

A total of 92 different species were found across the sample. The number of tree species found in the studied CFs ranges from 29 to 45. Highest number of species was found in Saldanda whereas lowest number was found in Ripa Tersapakha community forest (Table 5). The Simpson's index of dominance across the sample was 0.15, with the lowest value in Akala, Chisapani and Tekanthumka and the highest in Paripakha. That means the dominance of a single or a few species was highest in Paripakha. The Simpson's Diversity Index represents the probability that any species encountered at random would be different species, and its range is between zero and one (Munishi et al. 2008). The overall Shannon-Wiener diversity index was 2.46, indicating a relatively high level of diversity (Table 5). The lowest Shannon-Wiener diversity index of 1.77 in Paripakha to the highest index of 2.88 in Birata community forests was found. The range of Shannon-Wiener diversity index is greater than zero, without limit (McGarigal and Marks, 1995; Mohan et al. 2007) and the higher the value, the greater the diversity. Values greater than two for Shannon-Wiener Index have been assigned medium to high diversity (Barbour et al. 1987).

Table 4 Status of farm trees in the studied community forestry user groups (CFUGs); N=267.

CFUG Name	Average trees/HH (no.)[b]	Average trees/ha (no.)	Average tree species/HH (no.)
Akala[a]	31 (49.75)	172 (248.91)	6 (3.13)
Basudev Pahara	49 (130.53)	161 (318.99)	6 (2.27)
Bhayarthan[a]	40 (45.13)	101 (106.81)	6 (3.32)
Birata[a]	18 (34.61)	100 (97.19)	5 (2.01)
Chisapani	59 (56.68)	181 (333.59)	9 (3.63)
Kali	106 (15.02)	164 (198.04)	6 (2.83)
Paripakha	131 (71.3)	309 (479.73)	7 (2.44)
Ripa Tersapakha	95 (117.61)	149 (207.55)	6 (2.32)
Saldanda	50 (58.07)	96 (86.03)	7 (3.25)
Tekanthumka[a]	45 (134.63)	117 (137.87)	6 (3.35)
Overall Average	65 (89.62)	158 (262.87)	6 (3.02)

[a] CFUGs located closer to a market

[b] Figures in parentheses are standard deviations

Table 5 Species richness, diversity indices and dominance; N=267.

CFUG name	Species Richness	Simpson's dominance index	Shannon-Wiener diversity index
Akala[a]	42	0.10	2.85
Basudev Pahara	31	0.15	2.39
Bhayarthan[a]	39	0.12	2.69
Birata[a]	34	0.11	2.88
Chisapani	44	0.10	2.70
Kali	38	0.13	2.38
Paripakha	32	0.30	1.77
Ripa Tersapakha	29	0.27	1.82
Saldanda	45	0.14	2.40
Tekanthumka[a]	39	0.10	2.73
Average	37	0.15	2.46

[a] CFUGs located closer to a market

Local Uses of Farm Trees

The three most common tree species per CFUG are provided in Table 6. Of the 92 tree species occurring on the farms in the sample, 55% are grown for fulfilling household fodder needs; other common uses are firewood and timber. People prefer to retain multipurpose tree species on their farm land. However, majority of trees grown on farm land are fodder trees. In our findings, we did not notice considerable differences in use of trees by the local people according to CFUGs.

Relative contribution of farm trees

Table 7 presents households' total consumption of timber, firewood and fodder in the recall year as well as the relative contribution from government managed forest, community forest and trees grown on farm land. The highest number of trees on farm land was registered for the more wealthy households, and all but the poorest harvested more firewood and fodder from trees on farm land than community forests. Households in remote CFUGs consumed more firewood than those in CFUGs located closer to a market (not shown in the table) ($F_{(1,265)}=14.832$ $p<0.001$), likely because alternative fuels are available in market. Timber is only harvested in community forests; harvest of timber from government-managed forests was restricted and private trees are primarily utilized for lopping of fodder.

Table 6 Three most common tree species on farm land and their uses; N=267.

CFUG name	Most common species	Occurrence (%)	Use (in rank from 1-3)			
			Fodder	Fuel	Fruit	Timber
Akala[a]	*Garuga pinnata*	11	1	3		2
	Premna latifolia	7	1	2		
	Ficus hispida	7	1			
Basudev Pahara	*Garuga pinnata*	17	1	3		2
	Premna latifolia	11	1	2		
	Schima wallichii	8	2	3		1
Bhayarthan[a]	*Garuga pinnata*	15	1	3		2
	Ficus hispida	7	1			
	Premna latifolia	7	1	2		
Birata[a]	*Leucaena spp*	14	1	2		
	Garuga pinnata	12	1	3		2
	Melia azederach	8	3	2		1
Chisapani	*Ficus semicordata*	11	1		2	
	Garuga pinnata	10	1	3		2
	Premna latifolia	8	1	2		
Kali	*Ficus semicordata*	10	1		2	
	Garuga pinnata	10	1	3		2
	Schima wallichii	9	2	3		1
Paripakha	*Garuga pinnata*	13	1	3		2
	Premna latifolia	13	1	2		
	Schima wallichii	11	2	3		1
Ripa Tersapakha	*Garuga pinnata*	17	1	3		2
	Premna latifolia	15	1	2		
	Ficus hispida	12	1			
Saldanda	*Premna latifolia*	13	1	2		
	Garuga pinnata	13	1	3		2
	Ficus hispida	10	1			
Tekanthumka[a]	*Garuga pinnata*	14	1	3		2
	Premna latifolia	11	1	2		
	Ficus hispida	7	1			

[a] CFUGs located closer to a market

Table 7 Annual consumption of timber, firewood and fodder per capita: total and by origin of products; N=267.

Income quintiles	Trees on farm land	Total consumption			Government-managed Forests			Community Forests			Trees on Farm land		
		T[a]	Fi[b]	Fo[b]	T %	Fi %	Fo %	T %	Fi %	Fo %	T %	Fi %	Fo %
1. Lowest 20%	61	0	55.7	509	0	21.01	30.84	0	42.19	30.26	0	36.80	38.90
2. 21-40%	54	20.0	90.7	488	0	22.05	15.98	100	26.02	33.81	0	51.93	50.20
3. 41-60%	52	32.5	57.4	716	0	13.94	27.79	100	42.86	28.91	0	43.21	43.30
4. 61-80%	82	11.3	76.5	791	0	39.22	34.13	100	29.15	21.37	0	31.63	44.50
5. Highest 20%	77	19.1	43.1	973	0	0	41.11	100	47.33	12.27	0	52.67	41.62
Total	65.2	82.9	323.4	3,477	0	21.55	31.75	100	35.37	24.82	0	43.07	43.43

[a] T refers to Timber. Total consumption of timber is measured in cubic feet

[b] Fi refers to Firewood and Fo to Fodder. Firewood and fodder are measured in *bhari* – a load of approx. 35 kg

Determinants of Tree Growing

Chi^2 and Spearman's correlation tests showed that the age of the household head, the household size and the income were not significantly correlated with the number of trees on households' farm land (Table 8).

Table 8 Pearson and Spearman's correlation between trees on farm and independent variables

Explanatory variables	Pearson correlation	P-value	Spearman's rho (rs)	P-value
Sex	-	-	-0.052	0.539
EDU	-	-	0.536***	0.000
LSU	0.312***	0.000	-	-
Landholding	0.336***	0.000	-	-
Dist	0.095	0.121	-	-
Altenergy	-	-	-0.185***	0.002
Ethnicity	-	-	-0.147**	0.016
Network	-	-	0.174***	0.004
Firewood	0.303***	0.000	-	-
Fodder	0.277***	0.000	-	-

*** Significant at 0.01 level

Results from the OLS regression are provided in Table 9. Our data confirm several of the expected relations, e.g. a positive relation between livestock holdings and tree growing and a negative relationship with the use of other energy sources than firewood. Contrary to our expectations, the sex of the household head was not very important, nor was households' membership in networks or fodder consumption.

Table 9 Determinants of tree growing on farmland; N= 267

Variables	Coeff	Std.Err.	T	P>|t|
CONSTANT	-54.628	20.870	-2.62	0.009***
SEX	15.738	9.528	1.65	0.100*
EDU	7.373	1.345	5.48	0.000***
ETHNICITY	-0.652	6.507	-0.100	0.920
LSU	8.058	4.099	1.970	0.050**
LANDHOLD	32.614	11.792	2.77	0.006***
DIST	27.528	5.653	4.870	0.000***
ALTENERGY	-15.728	9.363	-1.680	0.094*
NETWORK	6.762	10.118	0.670	0.505
FIREWOOD	0.009	0.003	3.13	0.002***
FODDER	0.001	0.001	1.280	0.202

Adjusted R^2= 0.348. RMSE= 72.388; N = 267

* significant at 0.1 level; ** significant at 0.05 level; *** significant at 0.01 level

Discussion

Extent of Tree Growing on Farm Land

The present study found an average of 158 trees per hectare of farmland and 65 trees per household. These figures are relatively high compared to national data of 15 trees per hectare and 39 trees per household and figures for Tanahun district of 20 trees per hectare and 55 trees per household (CBS 2004). The national estimate includes all physiographic zones of Nepal, and farms in high altitudes generally do not contain many trees. An early study found 298 trees per hectare along a transect from Sindhupalchok to Kavrepalanchok district (Carter and Gilmour 1989) and recent studies found an average of 317 planted and retained trees per hectare of farm land in Chitwan district (Regmi and Garforth 2010) and 188 trees per hectare in Dhading district. Trees on farm land are often maintained primarily for provision of firewood (Krause et al. 2007; Webb and Dhakal 2011) and densities may depend on how well other forests fulfil that demand. The selected community forests were all well established and access to supplemental firewood is arguably relatively secure; this may account for the relatively low density of trees on farm land in the sample.

Our findings support the proposition by Degrande et al (2006) that on-farm tree density and species diversity are explained by different variables. Although the density of trees on farm land in the sample was not especially high many different species were found on the farms, as illustrated by the relatively high Shannon-Wiener index of 2.46. We found 92 different tree species on the sampled farms, compared to 29 species in Dhading district (Webb and Dhakal 2011), 60 species in Chitwan (Kharal and Oli 2008), 48 species in Chitwan (Regmi and Garforth 2010), and 145 species including medicinal plants in Kavrepalanchok (Pandit et al 2014). Figures vary with for example climate and vegetation zones, local cultures and knowledge, and contextual factors such as institutions; figures reported from elsewhere vary widely from 32 species in Ethiopia (Tolera et al. 2008), 83 species in South Africa (Shackleton et al. 2008), 101 species in Burkina Faso (Augusseau et al 2006) to 107 species in Mexico (Lopez-Gomez et al. 2008) and 153 species in India (Mohan et al. 2007).

Determinants of Tree Growing

Our qualitative data showed that people grow trees on their farm land mainly for fulfilling forest product needs, supplementing to household economy, and also for maintaining ecological balance in the long run. We found that several of the suggested explanatory variables had a significant impact on the number of trees planted and retained on farmers' land.

Social factors

A highly significant explanatory variable was the education of the household head. Other studies have found this variable to be insignificant (Shackleton et al. 2008) or only important for female-headed households (Hansen et al. 2005) and in our case the positive influence may be due to greater access to extension by the more educated and an association between the size of the land holding, as an indicator of wealth, and the ability to pursue education. There were 113 female-headed households in the sample (42.3%), and they were not more or less likely to grow trees on their farms in our sample. This finding is different from our expectations and different from findings in Zimbabwe (Price and Campbell 1998) and South Africa, where Shackleton et al. (2008) argue that 'gender relations around land, trees and tree resources in the developing world are extremely complex and dynamic' (p. 228). Fortmann et al. (1997), for example, note the implications of patrilocality (wives moving to husbands' villages after marriage) for tree tenure when marital status changes. Tree planting and retention may have different implications for countries and regions and generalizations are hard to make. What we find here indicates that women do not tend to plant more trees on farms than men and that they do not generally face restrictions on individual tree tenure on their own land in Nepal. No association was found with networks. As for networks, the ones included here were of a relatively general nature and it cannot be ruled out that an association with more specialized networks exists as documented by Neupane et al. (2002). Though, results indicate that social networks have a positive and significant impact on the number of trees planted on private land by the households (Nepal et al. 2007), we did not find any significant relationship between networking and number of trees on farm land.

Economic factors

The total size of households' landholdings, as expected (Webb and Dhakal 2011; Sood and Mitchell 2009), had a positive influence. This was also found in other studies, and the explanation may of course be that larger landholdings will have more 'corners' where trees can be grown, but also because households with larger landholdings tend to be better off and they can therefore focus less on optimizing total farm crop output by removing trees that compete with crops (Dhanya et al. 2013). The positive influence of livestock holdings on the number of farm trees is not surprising (Garforth et al. 1999). However, an inverse relation between livestock and tree growing is found in a study from Rwanda, where timber yielded higher cash incomes than livestock products (Ndayambaje et al. 2013).

Other factors

In the present case trees on farm land supplied 43% of the consumed fodder and no timber. Fodder consumption and the number of trees on farms were not found to be related, however. It seems likely that availability of land for tree planting, access to alternative sources of fodder and needs for other tree products than fodder overruled the intuitively expected correlation between fodder consumption and number of trees. Firewood consumption is a main reason for planting trees on farm land (Krause et al. 2007; Ndayambaje et al. 2013), and we find it positively related with tree growing. Access to alternative energy is negatively related with farm tree growing which is obvious that availability of alternative energy reduces use of firewood for domestic purposes. Households are more likely to have trees if their main stove is the traditional one, which generally increases the demand for fuelwood due to its inefficiency (Mekonnen 2009). Distance from the forest to the household dwelling was positively associated with trees on farm land, as expected, probably because larger distances imply higher costs of forest product extraction (Duguma and Hager 2010).

Wealth can be measured, as in the present study, by income or by a combination of assets; as assets may include land such comparisons need to be interpreted with care. Study finding shows no relation between wealth and on-farm tree planting and retention in various farming systems (Price and Campbell 1998). They attributed the results to the general importance of trees for rural livelihoods, arguing that rural differentiation may be more marked in terms of physical assets. Our results may therefore reflect that the Nepalese farming system requires substantial input from trees, so that all households will prioritize the planting and retention of trees on their farm land to secure the supply of this vital resource. This argument also explains the lack of a relationship between ethnic group and tree growing, similar to findings by Webb and Dhakal (2011) who found that firewood consumption was unrelated with caste.

Distributional aspects

The number of trees planted or retained on farm land does not differ significantly with income. The trend in the data is, however, that households with low incomes have fewer trees (numbers as well as density) than the more wealthy. This corresponds with the finding that households in the first income quintile depend relatively more on community forests to satisfy their requirements for firewood and fodder, and they are therefore more vulnerable to restrictions on access to the forest (Thoms 2008). Furthermore, the notable result that none of the poorest households consumed any timber in the recall year while households in the other quintiles reported consumption of timber from community forests, indicate substantial present bias in community forestry against the interests of the poor. These results are in line with findings from previous studies (Malla et al. 2003) and indicate a need to reorient community forestry practice if it is to live up to national goals of reducing poverty as described in the Nepal's thirteenth development plan (GoN 2013a, b). The reported consumption of timber is conspicuous in that nothing is reported to be cut from national forests. Extraction of timber from national forests is prohibited and considered a serious offense, much more so than collection of firewood and grazing of animals; it may be, therefore, that timber consumption is underreported. That does not change the interpretation of the results in relation to community forestry, however.

Conclusion

The present study has confirmed the importance of tree products for rural Nepalese households and has shown that on-farm trees are very important in terms of supplying firewood and fodder. The three most commonly found species were primarily used for fodder, and trees on farmland provided on average 43% of households' consumed fodder and 43% of consumed firewood, but no timber. Among the determinants for on-farm tree growing, land, livestock holdings, firewood consumption and education were positively related with the number of trees on a household's farm land while distance to the forest and the use of alternative energy sources were negatively related. The sex of the household head, income, ethnicity and networks did not contribute significantly to explain on-farm tree growing.

Tree products are vital to the most prevalent rural livelihood strategies and it is reasonable to believe that rural differentiation does not show itself in this aspect, but rather in assets that require more capital. The findings indicate problems of community forestry interms of poverty alleviation, supporting arguments of elite bias.

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Paper 4

Determinants of Participation in Community Forestry in Nepal

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SUMMARY

Determinants of people's participation in community forestry activities in Tanahun district, Nepal were investigated through a survey of 304 households across ten community forest user groups, key informant interviews and informal group discussions. Data were analysed through an ordered probit model as well as through the marginal effects of socio-economic factors on the probability of households' participation. Of the 12 variables considered in this study, only gender, caste, household size, livestock holding, network and amount of firewood extraction proved statistically significant. In all household wealth categories, a moderate level of participation was by far the most common. Further, the results indicate that users participating more in community forestry activities have extracted higher amounts of firewood, fodder and timber although this relation was not statistically significant. Female headed and low caste households, however, participated significantly less than other household categories.

Keywords: Participation, ordered probit model, benefits, equity, Nepal

INTRODUCTION

Most developing countries have been and many are still practicing centralized or privatized management in large tracts of their national forest estate. The underlying justifications range from Hardin's (1968) "Tragedy of the Commons" to "High Modernism" according to which a centralized and scientifically based organization of society including the production of goods and services would service the common good in the best possible way (Scott 1999). However, as a response to centralized bureaucracies' failure to actually conserve forest resources not to mention incorporating the needs of local people in official management plans and practices, forest decentralization, i.e. the transfer of certain rights to forest resources and related revenues from the central state to local communities provided they conserve and protect these forest resources, has gained popularity over the past couple of decades (Meinzen-Dick *et al*. 1999, Conroy *et al*. 2002, White and Martin 2002, Sunderlin *et al.* 2008). Internationally, decentralization of forestry began in the mid- to late 1980s and had become a prominent feature of forest governance by the mid-1990s (Ribot *et* *al*. 2006). The aim of such decentralization policies is to increase participation of rural households in decision making and benefits related to environmental resources (Agrawal and Gupta 2005). Participation in rulemaking is highlighted as important for incorporating local knowledge necessary to improve forest resources, promoting legitimacy of forest rules, and engendering management accountability (Ribot *et al*. 2006). Several studies have also shown that local level institutions can successfully manage common pool resources through collective action (Treue *et al*. 2014, Pretty 2003, Perez-Cirera and Lovett 2006, Varughese and Ostrom 2001, Wade 1987). In line with this, researchers have revealed the importance of local people's involvement in forest resource management (Persha *et al*. 2011, Chopra *et al*. 1990, Coulibaly-Lingani *et al*. 2011, Dolisca *et al*. 2006, Poffenberger and McGean 1996).

Nepal is one of the leading countries in introducing forest management programmes that involve local communities (Agrawal and Ostrom 2001, Gautam *et al*. 2004, Gilmour and Fisher 1991, Pandit and Bevilacqua 2011). As of July 2014, 1.7 million hectares of forest land have been handed over to more than 18 300 Community Forest User Groups (CFUGs) throughout but mainly in the country's mid-hills (1 000-4 000 masl.) (DoF 2014). Representation and participation through CFUGs are fundamental tenets of the forestry legislation in Nepal.

Community-based management depends on the sustained involvement of local people who find themselves charged with management of natural resources for the good of their local community, as well as higher aggregate levels of society through the production of environmental public goods, which in the case of sustainable forest management include watershed protection, soil conservation, biodiversity conservation and carbon storage (Zanetell and Knuth 2004). Socio-economic development, participation of local people in decision-making and local collaboration can thus be seen as determinants in ensuring sustainable forest management objectives, multiple forest functions and services (Bizikova *et al*. 2012). Formalized local participation in forest governance via decentralization is often viewed as a key mechanism to provide incentives to local communities to use forests sustainably through enhanced local knowledge, stronger accountability, and perceived legitimacy of forest rules (Larson and Soto 2008, Agrawal *et al*. 2008). Further, forest systems are more likely to generate sustainable outcomes when local forest users participate in forest rulemaking (Persha *et al*. 2011).

The increasingly documented and recognized importance of people's participation in community-based forest management underscores the policy significance of recognizing the strength, and direction of factors influencing participation. While rural people may appreciate the ethical and environmental justification for conserving forests, their dedication to collective management processes and adherence to associated rules are, however, likely to heavily depend on the personal or household-level net benefits they get from participating –at least over the longer term. According to Ostrom (1998), groups managing a common pool resource may, in comparison to non-collaborating individuals, generate higher net benefits for the participants -if institutional arrangements can be established such that reciprocity, reputation and trust help to control the temptations of individual's short-run self-interest in free-riding.

The term decentralization has been coined as transfer of control over resources from the central government to local governments (Andersson 2003, Kaimowitz *et al.* 1998), and from the state to local communities (Ribot 2002). Around 10-12% of the world's natural forests are being managed under the theme of decentralized forest management and at least 35 developing countries are officially engaged in promoting decentralized forest management (Sunderlin *et al.* 2008). As a result of effective decentralization, local actors can gain control and decision making powers in three arenas: use, management and ownership (Agrawal and Ostrom 2008). Decentralized forest governance has the twin objectives of sustainable forest management and support local people's livelihoods (Capistrano and Colfer 2005, Ribot 2004, Agrawal and Ostrom 2001).

Drawing upon common pool resource theory, it was assumed that forests can be better managed with the active involvement of users (Ostrom, 1999). There is plethora of literatures claiming that involvement of local people in forest management has brought positive changes in forest cover in Nepal (Gautam *et al.* 2004, Nagendra and Gokhale 2008, Pokharel *et al.* 2007, Tachibana and Adhikari 2009). Despite the increase in number of community forests in the country, the programme is still not successful in achieving the people's effective participation in the governance and management of these forests (Agarwal 2001, Agrawal and Gupta 2005, Buchy and Subba 2003, Chhetri *et al.* 2013, Adhikari *et al.* 2014). Studies have shown that there are various socio-economic and biophysical factors influencing user's participation in community forestry activities (Agrawal and Gupta 2005, Maskey *et al.* 2006, Chhetri *et al.* 2013). Accordingly, this paper attempts to analyze the factors that determine the level of participation in community forestry activities in the Nepalese mid-hills.

CONCEPTUAL FRAMEWORK

Public participation is a voluntary process where people, individually or through organized groups, can exchange information, express opinions and articulate interests, and have the potential to influence decisions or the outcome of the matter at hand (ILO 2000). Participation refers to "an active process whereby beneficiary or client groups influence the direction and execution of the development or management of a natural resource to enhance their well-being in terms of income, personal growth, self-reliance or other values" (Little 1994). The term 'participation' is defined in several ways by various researchers. For instances, Buttoud (1999) distinguish between resource, functional, auto-mobilization, passive and active participation. On the other hand, Agarwal (2001) classify participation as active and passive, "nominal participation", "consultative participation", "activity-specific participation" and "interactive participation".

Public participation and stakeholder involvement have become an integral part of sustainable natural resources management (Daniels and Walker 2001). Participation of different stakeholders is vital to good governance in community forest management. The theoretical considerations of participation are governed by enhancing democratic governance (Dryzek 1990, Healey 1997) and practical considerations of breaking policy impasses and building legitimacy and ownership (Susskind and Cruikshank 1987). Public participation is a key ingredient of good governance and there are many advantages of involving stakeholders in the decision-making process (Pita *et al*. 2010). Rulemaking participation help shift incentive structures for forest users to undertake decisions aimed toward a more balanced prioritization between activities that maintain good forest conditions and benefit flows over longer time horizons and activities that deliver more immediate livelihoods benefits (Persha *et al*. 2011).

Lack of participation has been found to lead to implementation related inefficiencies such as problems with enforcing rules, communication flow, resource assessments and conflict resolution difficulties (Agarwal 2000). From a planner-centred perspective, participation is viewed as a device to achieve efficiency (Nuggehalli and Prokopy 2009), whereas, from a people-centred perspective, it is seen as a tool for satisfying local needs and promoting empowerment (Michener 1998). In this paper, participation refers to the user's (i) involvement in meeting/assemblies of community forest user group, (ii) involvement in community forestry activities (formulation and revision of the operation plan as well as silvicultural operations), and (iii) involvement in patrolling of the forest. Participation in collective management typically occurs in the form of labour contributions, monetary contributions, or both (Naidu 2011). Labour contribution and time spent on meeting is considered as participation of CFUG members.

METHODOLOGY

Study sites

Ten CFUGs[3] of Tanahun district were selected for this study (Figure 1). Tanahun district is situated in Western Nepal (27^0 74' to 28^0 13' N and 83^0 94' to 84^0 56' E) and covers an area of 1,546 square kilometre. Administratively, the district is sub-divided into 46 Village Development Committees[4] (VDCs) and one Municipality.

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[3]CFUGs are self-governing local level institutions responsible for managing handed-over national forests under the prevailing laws.

[4] Lowest political unit of the country

The altitudinal range varies from 200 to 2 325 masl., the average annual rainfall is 1 761 mm and the mean maximum and minimum temperatures are 38-48^{0}C and 5-6^{0}C, respectively. The total population of the district is 315 237, with 53.4% female and 46.6% male. The average household size and literacy rate are 4.13 and 85%, respectively (CBS 2012). A total of 80 caste/ethnic groups are found in the district and the majority of the population depends on agriculture for their sustenance, with average landholding per household of 0.92 ha. The ratio of forest to cultivated land in the district is 1.22, and the size of CFs varies from 0.9 to 686 ha with an average of 64.8 ha (DFO 2009, DoF 2014).The CFUGs are characterized by diverse community structure (ethnic groups, time of settlement, economic level and occupation) and various land use types as well as market access. The CFUGs' forests are mostly natural and mainly dominated by *Shorea robusta* and *Schima-castanopsis*. The Prithvi highway connecting Pokhara to Kathmandu passes through the study area (see Figure 1 and Table 1 for details).

Figure 1: Location of studied community forests in Tanahun district of western Nepal

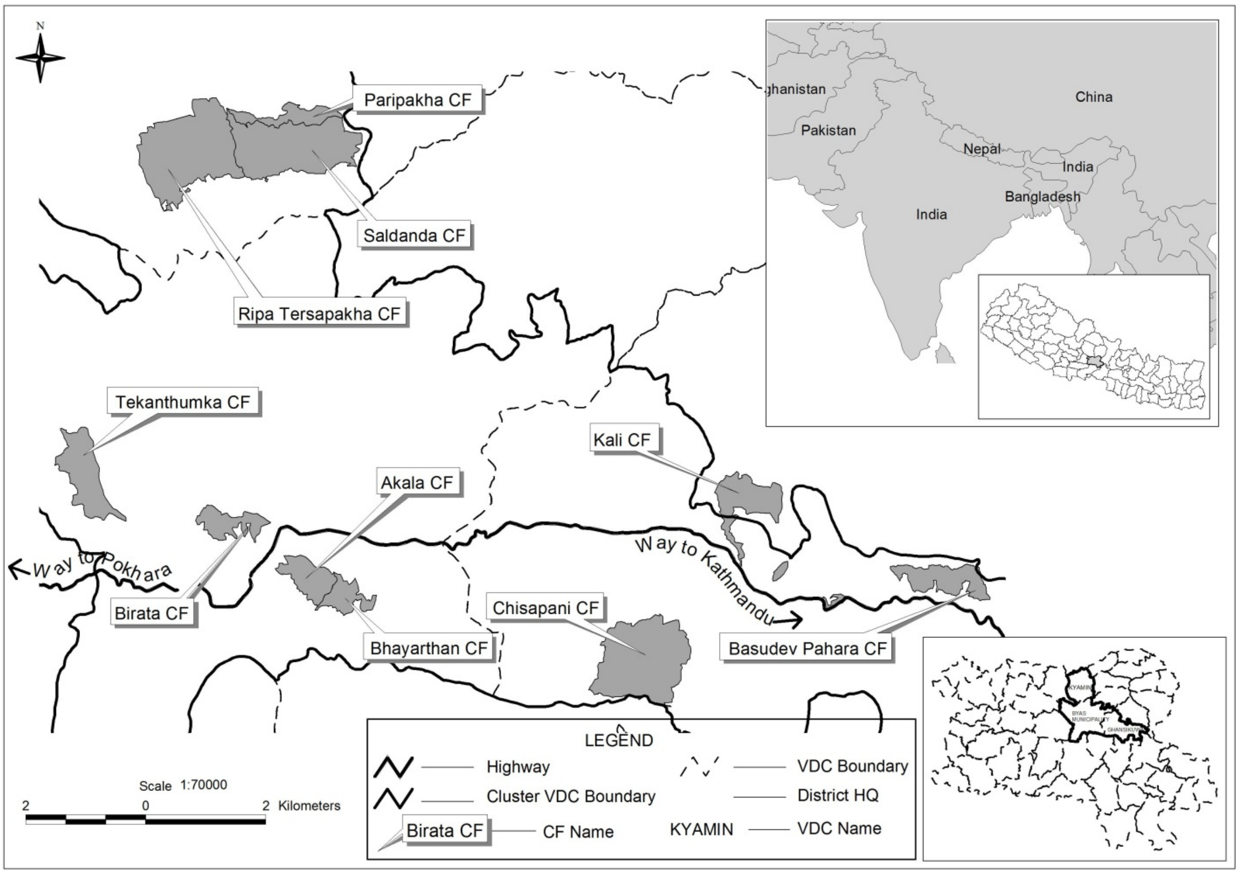


TABLE 1: Details of studied community forests

CFUG Name	Date of Handover	Total HH	Total Population	Male/ Female ratio	Forest Area (ha)	Forest Type	CF Area/HH (ha)
Akala	Sep 1993	317	1617	7/6	42.92	Natural/Sal pole dominant	0.14
Basudev Pahara	Apr 1995	147	867	7/4	56.40	Natural/Sal pole dominant	0.38
Bhayarthan	Sep 1993	107	559	6/5	30.61	Natural /Sal Pole dominant	0.29
Birata	Jul 1998	129	613	7/4	42.00	Natural/Sal pole dominant	0.33
Chisapani	Jun 1996	184	853	7/6	171.29	Natural Sal	0.93
Kali	Sep 1993	228	1234	7/6	94.05	Natural Sal	0.41
Paripakha	Jun 1997	63	367	6/5	34.40	Natural/Sal pole dominant	0.55
Ripa Tersapakha	Nov 1994	192	1074	14/1	183.68	Sal+Chilaune/Katus Mixed	0.96
Saldanda	Sep 1995	236	1334	12/3	139.24	Sal Pole to mature	0.59
Tekanthumka	Jun 1997	282	1527	6/3	71.24	Sal Pole to mature	0.25

Sources: Operational Plans of CFs, Field Survey

Species: Sal (*Shorea robusta*); Chilaune (*Schima wallichii*); Katus (*Castanopsis spp*)

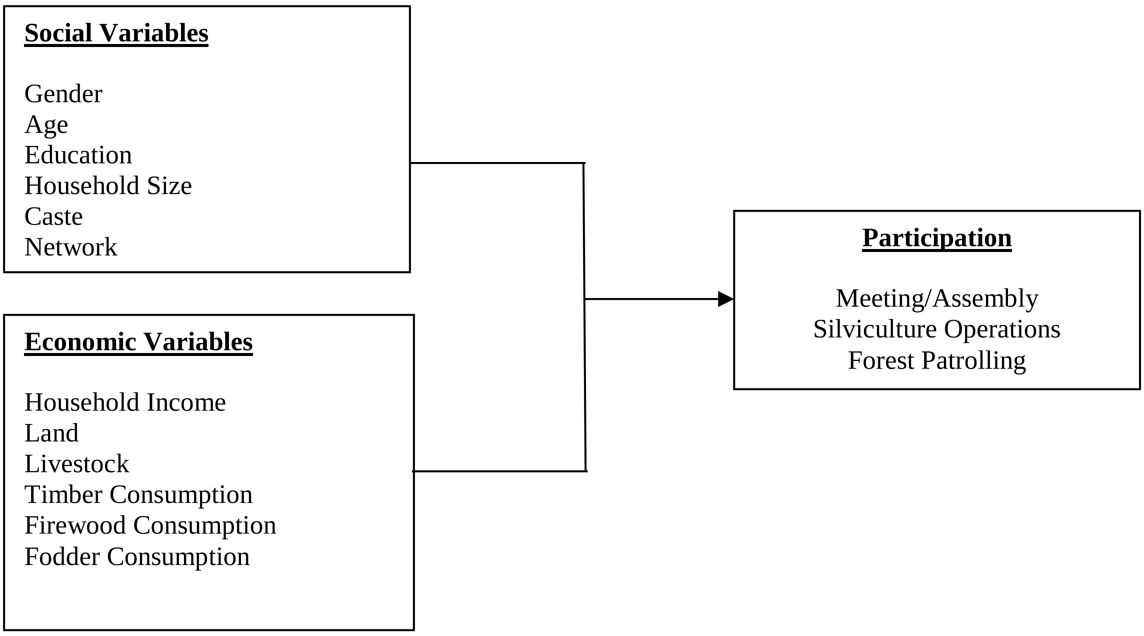
The present study is part of a larger project on community forestry in Nepal. Hence data collection took point of departure in CFUGs. The specific study areas were identified through the Community Forestry Programme, a national programme that engages more than 11 million people in currently about 18 300 CFUGs (DoF 2014). Most people in the Nepalese middle hills are members of a CFUG. They are easily recognizable local organizations and were therefore selected as the point of making contact with research respondents. Tanahun district was selected purposively as a broadly representative district of the CF programme in Nepal. All 456 registered CFUGs in Tanahun District (as of Fiscal Year 2008/2009) were listed, and 10 were selected that all have more than 10 years of experience with community forestry. The number of households involved in the CFUG ranges from 63 in Paripakha to 317 in Akala CFUG. The area of community forests ranges from 30.6 ha in Bhayarthan to 183.6 ha in Ripa Tersapakha CFUG. The majority of community forests were dominated by Sal (*Shorea robusta*) forests (Table 1).

Methods of data collection

The fieldwork was carried out during January-July, 2010 and included three components: household survey, key informant interviews and focus group discussions. A formal survey of 304 households was conducted with minimum 30 households from each CFUG. The list of households was taken from the CFUGs office. Drawing on Adams et al. (1997) user households of the selected CFUGs were then disaggregated on the basis of wealth ranking by using Participatory Rural Appraisal (PRA) approaches. In all sites, users insisted on holding a general assembly where locally meaningful wealth indicators were agreed upon. Here each and every

CFUG household was considered and, based mainly on land holding, livestock holding, housing condition, food sufficiency and off-farm income, a consensus decision made on whether it was to be defined as rich, medium or poor. On this basis a proportional random selection of households within each wealth class totalling at least 30 households in each CFUG was made for the household survey, which makes the 16% of total households in ten CFUGs. Questionnaires were translated into Nepali and pre-tested before employing them on the selected CFUGs. The household survey comprising both structured and open-ended questions captured a profile of the household, including family size, land holding, income sources, livestock holding, time of settlement, distance to forests and energy use pattern. Information on households' participation in community forestry activities and benefits accrued from the community forests were also obtained from the household survey. Key informant interviews were carried out with knowledgeable persons including CFUG executive committee members, local leaders, teachers and development workers. Group discussions were also conducted at the local level to crosscheck and validate the information obtained from household surveys. Discussions focussed on involvement of users in community forestry activities including participation in meetings, benefits received from the forests, problems associated with participation and benefit distribution. Secondary data were gathered from CFUG offices, VDC Offices, the District Forest Office, the Central Bureau of Statistics and other concerned offices, together with published and unpublished literature. Composition, minutes and decisions of the CFUG Committees on implementation of operational plans (OP) and silvicultural operations practiced were collected from the CFUG offices.

Figure 2: Schematic presentation of the socio-economic variables



Data analysis

Descriptive analysis was used to present household characteristics and information regarding member household's participation and costs and benefits of participation in community forestry activities. An ordered probit model was used to identify determinant factors that shape the level of participation in community forestry activities. Marginal effects of socio-economic factors on the level of participation were also estimated.

Variable description and descriptive statistics

The dependent variable

The dependent variable, participation, measures the household level of participation in community forestry activities. For measuring the degree of participation, the respondents were asked the following set of questions a) How do you rank your households' participation in OP preparation in comparison to other member households?, b) How do you evaluate the rate of your households' participation in non-silvicultural CFUG activities (OP implementation, rule enforcement, patrolling, defining the annual allowable extraction of different product categories from the CF)?, and c) In comparison to other member households, how do you rank your household's participation in silvicultural activities that generates rights to associated products from the CF (fodder grass cutting, lopping of trees for fodder, leaf litter collection for livestock bedding thinning of young stands, pruning of pole size trees, timber harvesting, fire line establishment/clearing, etc.)? These questions measured the degree of participation in OP formulation/revision, OP implementation and benefit distribution. The indicators were rated on a three point Likert scale (1-3). For questions a) and b) the following scale was used; 1= somewhat involved, 2= moderately involved, and 3= actively involved. For question c) 1= passive, 2= moderate, and 3= active. Depending upon the dominancy of two or three responses of these three questions, the responses on these three indicators were further scaled 1 through 3 to express the overall degree of participation. The resultant degrees of participation were: 1= passive/member only, 2= moderate, and 3= active participation.

Although the outcome of the dependent variable is discrete, the multinomial logit or probit model would fail to account for its ordinal nature (Green 2006) under the normality assumption.Hence, the ordered probit model was applied in the analysis.

$$PARTCPN = \beta_0 + \beta_1*GENDER + \beta_2*AGE + \beta_3*AVGEDN + \beta_4*CASTE + \beta_5*HHINC + \beta_6*HHSIZE + \beta_7*LAND + \beta_8*LSU + \beta_9*NTRK + \beta_{10}*FRD + \beta_{11}*FDD + \beta_{12}*TIM + \varepsilon$$

Where, PARTCPN= degree of participation in community forestry activities; $\beta_0$is a constant, β_i is the coefficient of independent variables described in Table 2, ε is the error term.

Independents variables

Independent variables were chosen through literature review. Many researchers have highlighted the socioeconomic and demographic variables that influence the involvement of local people in forestry programmes. Household characteristics are key factors since they influencedecision-making as whether or not to participate in forestry programmes (Dolisca *et al*. 2006). Participation of members in forest management programmes may vary according to their socio-economic and demographic backgrounds, such as gender, household size, educational level, age of the head of the household, marital status, household size, land tenure status (Lise 2000). Volunteering is influenced by socio-demographic factors and the ability to participate in networks, either by access tonetworks or the costs and benefits of participation (Torgler *et al*. 2011).

TABLE 2: Variables included in the ordered probit analysis

Variable	Description
PARTCPN	Degree of participation in community forestry activities (1= passive, 2= moderate, and 3= active)
GENDER	Sex of the household head (0=male, 1= female)
AGE	Age of the household head in years
AVGEDN	Average schooling years of the respondent's household members
CASTE	Caste of the household (1=lower, 2= indigenous, 3= higher)
HHINC	Total annual household income in Nepalese Rupees (NRs)*
HHSIZE	Size of the respondent's household in adult equivalent units (aeu)+
LAND	Area of land owned by the respondent (in *Ropani#*)
LSU	All livestock owned by the respondent's household in livestock units (LSU)**
NTRK	Total number of social groups to which household is attached
FRD	Per *aeu* firewood received from the CF over the past year (in *Bhari****)
FDD	Per *aeu* fodder received from the CF over the past year (in *Bhari*)
TIM	Per *aeu* timber received from the CF over the past year (in Cubic Feet)

*1 US $ equals to NRs 73 (in 2009)

+Adult Equivalent Unit (aeu), which assigns the value 1 to the first adult household member, 0.7 to each additional adult and 0.5 to each child below 15 years of age (OECD 2005)

#1 Ropani = 0.0056 ha

** 1 LSU = Adult female buffalo is considered as 1, adult male buffalo as 0.76, adult cow as 0.69, adult ox as 0.89, adult male sheep/goat as 0.23 and adult female sheep/goat as 0.20.

*** 1 Bhari = 35 kg backload

The independent variables are justified as follows: GENDER was set up as dummy variables indicating 0 for male and 1 for female. It is assumed that men participate more than women in extra household activities in a patriarchal society. AGE is another important continuous social variable. This indicates the age of the household head who has a major role in making decisions on household activities. It is assumed that old-aged persons do possess repositories of knowledge and hence utilize their experiences by sharing these in common forums/meetings. Older farmers are generally interested in collecting forest resources, while younger counterparts are more interested in and willing to participate in and contribute to decision-making that affect forestry programmes (Atmis *et al*. 2007, Beach *et al*. 2005). AVGEDN indicates the average education of the household members rather than the education of the household head. It was hypothesized that decisions regarding participation in community forestry activities is affected by schooling years of the household members. Education can serve as an important indicator of both social status and economic opportunities (Adhikari *et al*. 2004). Education also reportedly influences local people's participation in forest management and conservation (Owubah *et al*. 2001). Due to the understanding of the importance of conserving forests of educated persons, they are more likely to participate in the programme themselves and, therefore, motivate other villagers to participate as well (Jumbe and Angelsen 2007). CASTE is an ordered variable based on the hierarchical rank that exists in the Nepalese society which is 1 for lower caste (*dalit*), 2 for indigenous, and 3 for higher caste[5]. HHINC is the total income of the household. It is the sum of the income earned by the household through on-farm, off-farm and forest source represented in current Nepalese Rupees. The income of the sample households has been categorized into seven major sources: crops, livestock, service, wage, remittance, forest and miscellaneous. Household total annual income is defined as the sum of all gross incomes minus the costs of intermediate inputs and capital costs (household labour is not included as a cost), i.e. value added net income (Sjaastad *et al*. 2005). HHSIZE is used as an independent variable as the household size can significantly influence the socio-economic status of the household (Naik 1997). LAND refers to landholding of the respondent households which is one of the important economic variablesand represented in *Ropani* (1 *Ropani*= 0.0056 hectares). It is hypothesized that households having large parcels of land may not participate as actively in community forestry activities as others because they are likely to have comparatively more private trees. LSU is the number of livestock owned by household which is also an important economic variable. The number of livestock (buffaloes, goats, sheep and cattle) was converted into Livestock Units (LSU) using the criteria given by (HMGN/ADB/FINNIDA 1989). Land and livestock holding are commonly used as indicators of economic status and its variations (Adhikari *et al*. 2004, Kumar 2002). However, whereas land may be negatively related to participation in community forestry, livestock requires fodder and bedding which are common forest products. NTRK indicates the involvement of households in different social group/network which is connected to livelihood sustenance of household. Such social networks in our study sites include saving and credits groups, mother groups, goat keeping groups, agricultural groups. Networks can be formed through associations with formally constituted groups as well as non-group-based activities (Stone 2001). Involvement in political party programmes and activities also appeared a relevant indicator of network (NTRK). Yet, during field testing of the questionnaire in nearby communities the mentioning of possible affiliations with political parties resulted in much

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[5] Hierarchy of caste system is based on CBS (2009)

suspicion and heated debates that went entirely beyond community forestry. Accordingly, it was decided to ignore this as a network variable. The amount of forest products are a useful indicator of the household benefits from their participation in community forestry activities and hence we included the amount of firewood, fodder and timber received annually by a household in the analysis as these three forest products are the most used by all household categories. FRD is the per *aeu* firewood collected annually in *Bhari*). FDD is the per *aeu* fodder collected annually in *Bhari*. TIM is the per *aeu* timber collected annually (in Cubic feet). In addition to these; we also collected data on additional forest products such as poles (diameter greater than 10 cm but less than 29.9 cm), leaf litter, and charcoal. As these products were extracted in small amounts and not by all households, these products were not included in the analysis.

Table 3 depicts the descriptive statistics of the selected variables used in the ordered probit model.

TABLE 3: Variables and descriptive statistics (n=304)

Variable name	Mean	Standard deviation	Minimum	Maximum
PARTCPN	2.023	0.742	1	3
GENDER	0.428	0.496	0	1
AGE	46.83	14.003	17	80
AVGEDN	5.771	2.429	0	12.5
CASTE	2.414	0.740	1	3
HHINC (NRs)	54 811	47 239	5 454	425 015
HHSIZE (aeu)	4.36	1.75	0.51	10.66
LAND	10.279	8.586	0.19	39
LSU	2.161	1.517	0	6
NTRK	1.378	1.364	0	6
FRD	5.36	6.08	0	39.21
FDD	31.37	47.89	0	321.43
TIM	0.45	1.74	0	13.16

RESULTS

Characteristics of community forest user committee

In the 10 studied community forests, a diverse composition of community forest user group executive committees was found in terms of wealth status, gender, education level and ethnicity. According to wealth status, the executive committees of five community forests were dominated by the medium category users. All ten committees are dominated by male users, which is a common phenomenon in rural Nepal. According to education level, eight executive committees are dominated by literate users, one (Akala) by educated and one (Ripa Tersapakha) by illiterate users. The ethnic composition of the committees reveals that five committees are dominated by higher caste users, three by indigenous users and one (Saldanda) by scheduled caste (*Dalit*) users (see Table 4).

TABLE 4: Background information on latest CFUC executive committees

Name of CF	Wealth Status (%)			Gender (%)		Education (%)			Ethnicity (%)		
	Rich	Medium	Poor	Male	Female	Educated	Literate	Illiterate	Higher	Indigenous	*Dalit*
Akala	23.08	61.54	15.38	54.00	46.00	69.23	23.07	7.69	61.54	30.77	7.69
Basudev Pahara	27.27	27.27	45.45	63.64	36.36	9.09	63.64	27.27	54.55	27.27	18.18
Bhayarthan	18.18	72.73	9.09	55.00	45.00	18.18	63.64	18.18	18.18	72.73	9.09
Birata	63.64	18.18	18.18	64.00	36.00	18.68	54.55	27.27	45.00	55.00	0.00
Chisapani	46.15	38.46	15.38	54.00	46.00	7.69	76.92	15.38	54.00	0.00	46.00
Kali	23.08	61.54	15.38	54.00	46.00	7.69	76.92	15.38	30.77	69.23	0.00
Paripakha	18.18	36.36	45.45	55.00	45.00	18.18	63.64	18.18	90.91	0.00	9.09
Ripa Tersapakha	40.00	40.00	20.00	80.00	20.00	0	20	80	73.33	20.00	6.67
Saldanda	20.00	80.00	0.00	87.00	13.00	20.00	73.33	6.60	20.00	33.33	46.67
Tekanthumka	22.22	66.67	11.11	67.00	33.00	27.27	45.45	27.27	44.44	44.44	11.11

TABLE 5: Number of households by wealth rank and participation

Wealth rank	Degree of participation			Total	X^2-value	P-value
	Low (%)	Moderate (%)	Active (%)			
Poor	25 (8.2)	44 (14.5)	25 (8.2)	94 (30.9)		
Medium	26 (8.6)	54 (17.8)	31 (10.2)	111 (36.5)	7.094	0.131
Rich	29 (9.5)	39 (12.8)	31 (10.2)	99 (32.6)		
Total	80 (26.3)	137 (45.1)	87 (28.6)	**304 (100)**		

Determinants of participation

Table 5 presents the number of studied households according to wealth rank status and level of participation. It is seen that the distribution of poor, medium and rich households within each level of participation is almost similar and that, for all wealth categories, a moderate level of participation was dominant. Applying a Chi-square test, no significant difference was found between wealth status and the degree of participation (see Table 5).

Table 6 presents estimates for the ordered probit model used in the analysis. The model is highly significant, with probability Chi-squared of 0.000 and Chi-squared statistic of 67.8. Of the 12 independent variables, six (gender, caste, household size, livestock unit, network and firewood consumption) are statistically significant.

TABLE 6: Parameter estimates for the participation with ordered probit model

Variables	Coefficient	Standard error	z	P>|z|
GENDER	-0.451***	0.147	-3.06	0.002
AGE	0.005	0.005	1.02	0.310
AVGEDN	0.046	0.031	1.46	0.144
CASTE	0.208**	0.101	2.05	0.041
HHSIZE (aeu)	0.076*	0.044	1.72	0.085
HHINC	0.000	0.000	-0.01	0.992
LAND	-0.006	0.008	-0.71	0.476
LSU	0.090*	0.053	1.69	0.091
NTRK	0.226***	0.053	4.25	0.000
FRD	0.027**	0.013	2.05	0.040
FDD	-0.000	0.001	0.10	0.920
TIM	0.014	0.039	0.37	0.710
/cut1	1.009	0.437	Ancillary parameters	
/cut2	2.385	0.450		

LR Chi-square (12) =67.78; Probability > Chi-squared=0.000; Pseudo R^2 = 0.1043; Log likelihood = -290.951

Note: cut1 and cut2 are ancillary parameters, cut off points, used to calculate predicted probabilities for each level of the dependent variable.

, **, and*, indicate statistical significance of the coefficients at 10%, 5%, and 1% level, respectively.*

Gender plays an important role in participation. The high statistical significance of gender variable confirms the assumption that male headed participate more than female headed households in community forestry activities (coefficient = -0.451, significant at the 1% level). The caste variable has a positive sign and a significant relationship with participation at the 5% level thus supporting the hypothesis that lower caste users participate less than members of other castes in community forestry activities. Household size has a positive effect (yet only significant at the 10% level) on participation in community forestry activities.

Livestock holding also comes out with a positive coefficient statistically significant at the 10% level, which probably reflects that users having comparatively more of livestock need more fodder and bedding materials from the forests and hence have an incentive to participate more in community forestry activities. The high statistical significance at the 1% level and positive coefficient of the network variable reveals that users being affiliated with different social groups/networks tend to participate more in community forestry activities. Firewood consumption is positively related with and statistically significant the 5% level which suggests that users consuming higher amounts of firewood from the forests participate relatively more in community forestry activities. Although education is often a significant variable to stimulate local participation in a variety of development and natural resource management initiatives, significant relationship between education and the level of participation was not found.

Marginal effects for the degree of participation

Since active participation is important to fulfil the overall objectives community forestry the marginal effects for the degree of active participation (PARTCPN=3) was also calculated. This indicates the change in theprobability of participation in community forestry activities, when the independent variable increases by one unit. The minimum and maximum probability values for each statistically significant variables and the difference between minimum and maximum are presented in Table 7.

TABLE 7: Probability of participation, third category, at minimum to maximum value for significant variables

Variable	Probability at Minimum	Probability at maximum	Change in participation between minimum and maximum (%)
GENDER	0.162	0.120	-4.2
CASTE	0.041	0.062	2.1
HHSIZE	0.015	0.028	1.3
LSU	0.019	0.031	1.2
NTRK	0.043	0.089	4.6
FRD	0.006	0.108	10.2

Being a female user decreases the probability of participation by 4.2 percent. The probability of participation increases by 2.1 percent if users are from the higher caste category. Larger household size increases the probability of participation by 1.3 percent. The variation in livestock holding also affects the probability of participation, which increases by 1.2 percent. The probability of participation increases by 4.6 percent if the users have affiliation to social groups. More firewood consumption by user increases the level of participation by 10.2 percent. Accordingly, of the six significant variables, firewood consumption by far had the greatest impact on participation.

Benefits from community forestry

Data was also collected on benefits received by the community forest member households. Table 8 presents the amount of firewood, fodder and timber extracted annually by member households (per *aeu*). It is apparent that users participating more in community forestry activities tend to have extracted higher amounts of all the three product categories. Yet, neither the ANOVA, nor a Bonferroni test, show any significant differences between any of the three degrees of participation for any of the three forest product consumption categories.

TABLE 8: Per aeu average annual benefits received from community forest

Products	Degree of participation			Average	ANOVA F-Value
	Low (n=80)	Moderate (n=137)	High (n=87)		
Firewood (*Bhari*)	4.187	5.697	5.921	5.364	2.083
Fodder (*Bhari*)	26.207	30.270	37.851	31.370	1.299
Timber (Cft)	0.222	0.432	0.695	0.452	1.562

Note: One *Bhari* equals 35 kg backload

Involvement of user households

Table 9 gives information on costs borne by the member households for participating in different community forestry activities. On an average, each household spends at least one day per annum on community forestry activities. Users have contributed more time on meetings/assemblies than forest management and patrolling activities. ANOVA test showed a difference, but only at the 10% level between the degree of participation and user's contribution to forest management activities. It is also revealed that low and high levels of participation were significantly different but only with respect to forest management activities.

TABLE 9: Average man-day contribution of member households in community forestryactivitiesduring 2009 (n=304)

CF activities	Degree of participation			F-value	P-value
	Low (n=80)	Moderate (n=137)	High (n=87)		
Attendance at General Assembly	2.04	2.65	2.95	1.97	0.14
Forest management	1.96[a]	1.72[ab]	1.38[b]	2.52	0.08*
Patrolling	0.46	0.59	0.45	0.19	0.83
Total	4.46	4.96	4.78	0.34	0.71

**significant at 10% level; Bonferroni's test: Average man-day contributions followed by a different superscripted letter imply the difference between them is significant at the 10% level*

DISCUSSION

Overall, most of 304 surveyed households (45.1%) participated moderately in community forestry activities while the frequency of households with low and high participation was almost similar; 26.3% and 28.6%, respectively. This finding is similar to that of Chhetri *et al*. (2013) who find that the majority of the respondents (irrespective of their socio-economic attributes) enjoy a medium level of participation in various community forest management activities. Of the 12 variables included in the model to investigate determinants of participation, six namely; gender (female headed participate less than the male headed); caste (lower caste households participate less than those of higher caste); household size (bigger households participate more); livestock holding (the more livestock the higher participation);

network (households participation in other networks, participate more in community forestry) and amount of firewood extraction (the more firewood consumption the higher the participation) were found to be statistically significant.

The significantly lower participation of female headed households in community forestry activities is by no means in line with official intensions but rather a likely result of cultural practices found by other studies as well. For example, Coulibaly-Lingani *et al*. (2011) found that women's personal and household attributes constrain their participation in community organizations in southern Burkina Faso. It is also argued that fear of losing standing in the community could inhibit women from attending meetings related to collective action, since these are often held in publicly segregated spaces (Agarwal 2000). Men are considered responsible for village development and governance. Hence women are disinclined to participate in an effort that is seen to go against traditionally defined roles (Prokopy 2004).

That lower caste users participate less than members of other castes in community forestry activities is also in line with the findings of other studies. Naidu (2011) found that the caste variable had a positive and statistically significant impact on all forms of participation (meetings, maintenance, protection and monitoring activities). Lower-caste members relatively less participation in the user group activities is also found by many studies (e.g. Agrawal and Gupta 2005, Maskey *et al*. 2006, Naidu 2011). The comparatively higher opportunity cost of participation for the disadvantaged groups is often used to explain this (Bhattarai and Ojha 2000), but here we do not find a correlation between caste and wealth and nor between wealth and degree of participation in community forestry. Hence, the cultural barriers associated with the caste system seem to be the more likely causal factors in the present study. The positive effect of respondents' household size on participation in community forestry indicates that heads of large households are more interested to participate in forest management decision making process than other respondents simply because their households need more forest products for their livelihoods. Similar results are also found by other scholars (Coulibaly-Lingani *et al*. 2011, Dolisca *et al*. 2006). The likely reason being that large households have more labour capacity and extract comparably more products from the CF which gives them a slightly stronger incentive to and advantage over smaller households in terms of ability to participate. Maskey *et al*. (2006) conclude that in Nepal some heads of large households are also rich and powerful and thus may play a significant role in the decision-making process. While this sounds plausible, our study does not support a nexus between household wealth and degree of participation in community forestry activities.

Other scholars have reported that livestock holding does not have a significant relationship with the level of participation in community forestry activities (Agrawal and Gupta 2005, Naidu 2011). However, Agrawal and Gupta’s (2005) finding was based on livestock holding being positively and statistically significant correlated with three other independent variables: land, household size, and income. Moreover their study concerns Nepal's lowland, the Terai, which differs distinctly from the mid-hills in terms of social and natural resource characteristics. Although the tendency is only significant at the 10% level, our study suggests that, in hill districts, households who own comparatively large amounts of livestock seem to rely more than others on community forests for fodder and bedding material which means they have rational economic reasons for participating actively in community forestry.

That social networks facilitate participation is both suggested by theory (Ostrom 1999) and resonated empirically. Analyzing women's participation in two communities involved ina rainforest conservation project in Sri Lanka, Nuggehalli and Prokopy(2009) revealed that women learn about the group and its activities through their relationships with others in the community. It is also revealed that greater involvement of women in the community stimulates participation (Lise 2000). Individuals with experience in other formal or informal groups, and consequently endowed with social capital, are simply more likely to engage in collective action groups (White and Runge 1995).

The rational choice-based hypothes is that households, with a high degree of participation would also be the ones to extract the comparatively highest amounts of forests products was not supported by our data. Rather, the overall picture is that the, per *aeu*, extraction of forest products is quite similar irrespective of the households' degree of participation. This may appear surprising, but the underlying reason is likely to be straight forward. Across Nepal most CFUGs allocate the same amount of firewood to all member households because equality rather than equity has been the guiding rule. In the studied 10 CFUGs an equal maximum amount per household was the rule for firewood collection. However, fodder could be collected freely and timber was awarded based on specific assessments of applicant households' stated needs. Since the fodder value of the dominant tree species in the forests is very low, most households keep fodder trees on their private land (Oli *et al.* 2015a). Accordingly, our results suggest that the collective choice CF rules with respect to product extraction are *not* 'captured' by particularly active member households in an effort to maximize their private benefits from the common forest resource. While this is a positive feature the CF rules do not promote equity either. A detailed analysis of the sampled households' income and sources of income show that, on average, the per *aeu* value of CF products accounted for 17.3% of the poor households' annual income while they only accounted for 3.8% of the rich household's incomes (Oli *et al.* 2015b).

The combination of fairly high levels of CF product extraction and no apparent particular private economic determinants for households' degree of participation suggests that the CFUGs are robust institutions with high degrees of trust and reciprocity among members who all, albeit to various degrees, depend on the forest resource (c.f. Ostrom 1998). This also resonates the finding of other empirical studies. Lise (2000) for, example, found that when the condition of the forest is good and/or when people are dependent on the forest, participation goes up; Dolisca *et al.*

(2006) and Jumbe and Angelsen (2007) argued that high forest dependency stimulates participation in forest management and Dolisca *et al*. (2006), Maskey *et al*. (2006), Coulibaly-Lingani *et al*.(2011) and Jumbe and Angelsen (2007) found that degree to which users of the common forest resources participate in management activities is determined by the benefits obtained from doing so. Furthermore, sustained participation in a Bangladeshi forest, conservation efforts was ensured when participants were confident of receiving their share of income from forest harvesting (Salam *et al*. 2005). In India, Naik (1997) found that the costs and benefits of labour involvement in alternative enterprises play a crucial role in the household decision to participate in forest management. In ordered probit regression analysis, however, no any significant relationship between fodder consumption and level of participation was found. This might be because users graze their animals in open areas rather than stall feeding (c.f. Agrawal and Gupta 2005). Yet, in this case, the more likely reason is that people get fodder from private trees, c.f. above.

Some authors argue that education stimulates participation in forestry activities (Lise 2000, Dolisca *et al*. 2006, Torgler *et al*. 2011), whereas others argue that higher levels of household education reduces participation in forestry programme (Agrawal and Gupta 2005). The supposed causal reason is that better educated people are more aware of potential benefits to be derived from the forests than individuals who are illiterate (Dolisca *et al*. 2006). The rationale for positive effects of education was that informed citizens might have stronger environmental attitudes (Torgler *et al*. 2011). A higher education level may, on the other hand, provide opportunities for individuals, making them potentially less interested in participating and even reduce the dependency on forest resources (Agrawal and Gupta 2005). Chhetri *et al*. (2013) also found that education level showed no significant relation to the level of participation in forest protection and forest resource utilization. The finding of the study that education was not a significant variable in determining the level of participation in community forestry activities might, therefore, be interpreted as a sign of community forestry being fairly easy to comprehend (and rules can be enforced effectively) while all household categories in our study sites are quite dependent on products from community forests. Studies have revealed that richer families are more likely to participate in environmental conservation (Adhikari and Lovett 2006, Dolisca *et al*. 2006). The rationale is that richer farmers are acutely aware of the fatal consequences of deforestation in the study area (Dolisca *et al*. 2006). The existence of a nexus between household wealth and degree of involvement in community forestry processes is, however, not supported by the present study.

When analysing the marginal effect on the degree of participation for the six significant variables (gender, caste, household size, livestock holding, network and firewood consumption) through the ordered probit model, it was found that firewood consumption to have by far the strongest effect (10.2%), followed by network (4.6%), gender (4.2%), caste (2.1%), household size (1.3%) and livestock holding (1.2%), c.f. Table 7. This may be associated with the fact that firewood is the most commonly used forest product by all kinds of households and that users, in general, participate more in community forestry activities once they get benefits from the forests. This is in agreement with Agrawal and Gupta (2005) who found that an increase in firewood harvest from the minimum to the maximum value increases the probability of participation by 22 %. Naidu (2011), on the other hand, found caste to have the largest marginal effect on participation, and Agrawal and Gupta (2005) also found that upper caste households had 11.1% higher probability of participating in community forest activities than lower caste households. For rural households in Vietnam, Thoai and Ranola (2010) found that households with more family labour shows the greatest effect (10.25%) on decisions of them to participate in community forestry activities if their family labour supply was increased by 1%. Agrawal and Gupta (2005) also found that that as the size of the household increases from a minimum to a maximum, the probability of participating in community forestry activities rises by almost 40%. In sum, it can be said that, while the effect of firewood consumption, household size, and caste seem to differ geographically, these household characteristics nevertheless appear of general importance for the likelihood of a household participating in community forestry activities.

CONCLUSION

Our results suggest that, overall moderate participation in community forestry activities is by far the most common for rural households in the Nepalese mid-hills. Yet, there are several determinant factors, which influence the level of participation. Of the 12 variables included in the model, gender, caste, household size, livestock holding, network and amount of firewood extraction were found to be statistically significant. The wealth class of a household did, however, not seem related to the level of participation and nor did the amount of products extracted from the community forests.

The policy relevance of the results may be summarized as follows: First and foremost it appears that the kind of community forestry practiced in Nepal's mid-hills promotes robust common pool resource management institutions where households of very different status derive almost identical levels of material benefits irrespective of how actively they participate in community forest activities. Locally devised rules that effectively promote equality rather than equity are likely to be the underlying reason. Accordingly, while failing to especially benefit the poorest CFUG members, who are more dependent on forest products for their livelihoods, this arrangement seems to prevent elite capture.

However, the significantly lower participation of female headed and lower caste households in community forestry activities documents that there is room for "equity improvement". The Forest Act of 1993 allows for and the subsequent guidelines of 2009 encourage the formation of inclusive community forest user groups in the country. In practice this could be promoted through increased inclusion of these groups into community forestry activities. Furthermore, the formation of women's forest user groups either as sub-groups within existing or as new forest user groups has been an option since 1993. The District Forest Office representatives and NGOs, who are active in establishing and supporting community forest user groups could, thus, emphasize equal opportunity of castes and promote the formation of women forest user (sub-)groups in their activities.

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Paper 5

Effects of management activities on vegetation diversity, dispersion pattern and stand structure of community-managed forest (*Shorea robusta*) in Nepal

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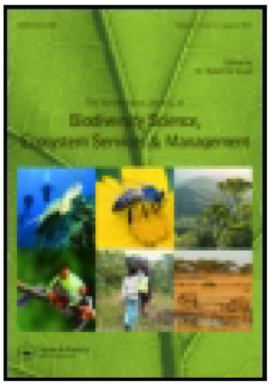

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Effects of management activities on vegetation diversity, dispersion pattern and stand structure of community-managed forest (Shorea robusta) in Nepal
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Analyzing spatial patterns of population distribution in forests may assist to infer the underlying ecological processes and the factors responsible for pattern formation. This study aimed at analyzing the effects of management activities on species richness, diversity, distribution pattern and forest stand structure in Chisapani Community Forest of Tanahun District, Nepal. The forest was stratified on the basis of crown cover and nested quadrat plots of 20 × 25 m were laid randomly. Trees having ≥ 5cm diameter at breast height (dbh) were identified, and their diameter and height were recorded. Altogether, 44 species were recorded representing 39 genera and 27 families. The mean species density of the forest was 192 trees ha^{-1} and the average basal area was 16.2 m^2 ha^{-1}. Tukey's Post-hoc test showed the significant difference in species richness between open and dense crown class. Except *Woodfordia fruticosa*, all other species were found with patchy distribution. This study showed that unrestricted access does not necessarily maintain species diversity or regulate the forest stand structure, because people preferred species with high economic potential. Hence, a strategy for maintaining species diversity and regulating stand structure, finding synergy between biodiversity conservation and conservation outcome is needed.

Keywords: spatial distribution pattern; crown cover; species diversity; richness; community forestry

Introduction

In ecological discourse, determining spatial distribution patterns has drawn central attention (Condit et al. 2000). A multitude of studies have contributed in understanding the role of spatial pattern in the assembly, association and dynamics of vegetation that takes place in the ecosystem, (e.g. Rohani et al. 1997; Perry et al. 2006; Martínez et al. 2010; Martínez et al. 2013). The analysis of spatial distribution pattern assists to evaluate the contribution of factors responsible for the formation of this pattern. These factors may include competition (Kubota and Hara 1995; Moeur 1997; Wolf 2005), establishment (Ledo et al. 2012), development (Palik et al. 2003), mortality (Peet and Christensen 1987; Das et al. 2008), and crown development (Stiell 1978). In a forest ecosystem, spatial distribution pattern may alter the canopy light environment (Sprugel et al. 2009), as well as understory plant abundance, composition, and diversity. Canopy density determines the air temperature and humidity in the understory (Sharpe 1996). The manipulation of crown cover through human activities (e.g. lopping) or natural disturbance (e.g. wind throw) causes changes in light environment interaction and in turn, changes the structure and composition of species.

In nature, individuals of a population may be distributed in their habitat in a random, a clumped (aggregated), or a regular (uniform) pattern. Perry et al. (2006) mentioned two spatial (global and local) pattern analysis techniques. Larson and Churchill (2012) in their review found that global pattern analysis techniques (mostly analytic) were dominantly used in comparison to local techniques. However, global pattern does not necessarily quantify spatial heterogeneity within a local scale. Thelocal spatial pattern analysis describes the variation of spatial pattern within the area of interest. Quadrat based point pattern analysis, which is the area based definition of scale, is popular in ecological studies (e.g. Heltshe & Ritchey 1984; Olsen et al. 1996; Pélissier et al. 2001).

Scientists argue that understanding of the forest dynamics is fundamental to develop sound management systems (Fuhrer 2000; Sokpon and Biaou 2002; Obiri et al. 2002). Timely and accurate change detection of earth's surface features provides the foundation for better understanding the relationships and interactions between human and natural phenomena to better manage and use resources (Lu et al. 2004; Deng et al. 2008). Researchers in the past have used various methods for assessing forest conditions, depending upon individual preferences, research objective and data availability (Gautam et al. 2004). Depending on the quality of data, Remote Sensing (RS) provide useful spatial information to assess forest cover changes, but an analysis of the social processes influencing land-use decisions is necessary to understand the factors leading to different conservation outcomes (Mascia et al. 2003). In the recent days, climate change is attributed to change in vegetation richness. Although there is limited support of climate change in pattern formation, Geographical Information System (GIS) added vegetation analysis based on the crown cover analysis may prove to be fundamental in decision-making at management and activities level.

Shorea robusta (Generally known as Sal) forests are among the most disturbed forests in South Asia (Sapkota et al. 2009), because of heavy pressure from local people for timber, firewood, fodder, and litter collection. In Nepal, hill Sal forests are being handed over to local community for management as Community Forest (CF). Although the number and coverage of CF are increasing, there exists limited information on biodiversity conservation in terms of species richness, taxonomic diversity, and crown coverage due to lack of in-depth study and research (GoN 2009). This issue is highly aggravated due to choice of major species selection by users. As Community Forest Users Groups (CFUGs) are managing such forests, apparently, this demands evaluation of stand structure, regeneration condition, and temporal changes in species diversity in order to assist in the formation of effective management strategies without compromising fulfillment of basic needs of local people.

As per the provisions mentioned in Operational Plan (OP), CFUG carry out tending operations; mostly thinning, pruning, and shrub clearing. Ojha and Bhattarai (2001)documented that Sal is the single species highly preferred even in the mixed Sal forest to convert their Sal mixed forest into pure Sal forest, exclusively written in the OP. This type of density management could result in changes in vegetation and species diversity. Therefore, understanding the effect of such management activities on structure, diversity and richness, and local pattern is important for management purposes and at the policy level as well, especially where there is no pragmatic policy like in Nepal. Comparing effect of management intervention at larger spatial and temporal scale is beyond the scope of this study. However, the study based on cross-sectional use of data is expected to form the basis for such analysis for future days. This study aims to (1) describe the relationship between crown cover, and stand structure of the species occurring in natural Sal forest under the hypothesis that spatial distribution pattern of woody species follow the random pattern with respect to habitat, and (2) examine the effect of crown cover in species richness, diversity and composition.

Materials and methods

Study area

The study was carried out in hill Sal forest of Tanahun district (see Figure 1). Tanahun district is situated in the western development region of Nepal ($27^0$03’ to $28^0$05’ N and 83^0 75’ to 84^0 34’ E). The study area (171.29 ha) is located between minimum and maximum of longitude (27^0 58’2’’and 27^0 58’52’’) and latitude (84^0 19’ 53’’ to 84^0 20’ 56’’E). The altitudinal range of the area varies from 435 to 694 masl. Average annual precipitation in the nearest weather station in the district is 1691 mm year^{-1}. The mean maximum and minimum temperature are 29.5^0C and 17.4^0C, respectively.

The area is characterized by the presence of secondary and old growth Sal dominated forest following *Adina cordifolia, Schima wallichii, Lagerstroemia* *parviflora*, and *Mallotus philippinensis* in tree layer. Most frequent five species after Sal up to 535 masl, in decreasing order of frequency, are: *S. wallichii, L. parviflora, A. cordifolia, M. Philippinensis*, and *Cleistocalys operculatus*. Four of them that are most frequent in lower altitude are same except *Semecarpus anacardimum*, which replace the *C. opercalatus* in frequency in middle part of forest (535-635 masl). At the highest altitude region (>635) also *S. wallichii* is most frequent associates followed by *A. cordifolia, L. parviflora, M. Philippinensis, S. anacardium*. Selective logging, intense pressure of fuel wood extraction, lopping and top cutting of major species are the causes of disturbance in the forest especially in low crown covered area.

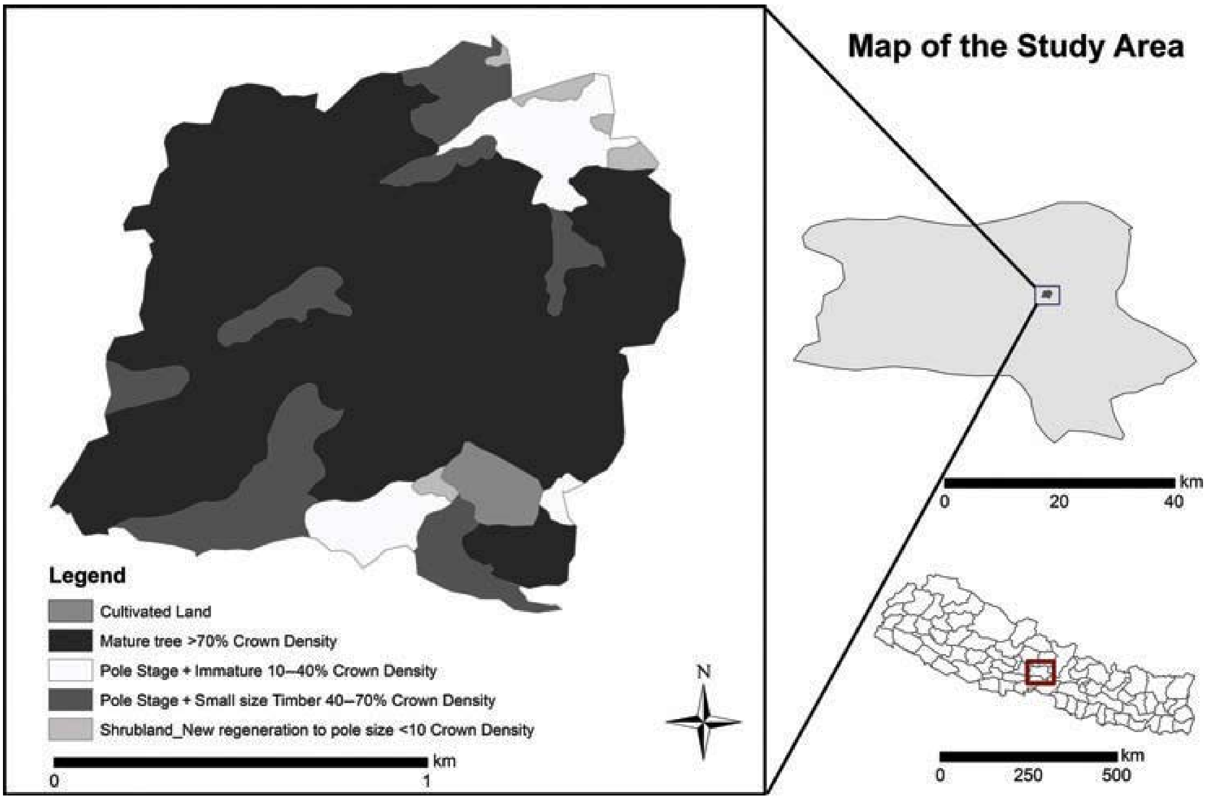

Figure 1. Location map of the study area.

Vegetation sampling

This study employed stratified random sampling based on crown cover and proportional allocation method was used to determine the number of sample plots. Sample plots having dimension of 20×25m, with three sub-plots of different sizes nested in the left corner of the biggest quadrat were laid out for sampling purpose.Nested sampling plots were used to secure an adequate sampling of the different species studied (Christensen and Heilmann-Clausen 2009). Total 23 different plots were laid out in the forest. Each sample plots (20×25m) was subjected to the measurement of a tree (>29.9 cm dbh), dbh at 1.3 m above the ground level). Among three sub-plots, sub-plots size of 10×10m (100 m^2) and 5×5m (25 m^2) were used for the measurement of pole (10-29.9 cm dbh); and sapling (4-9.9 cm dbh), respectively. Moreover, all the regenerations of woody species in the sub-plot size of 10 m^2 (2×5m) were counted and recorded. All the species were identified in-situ and any unidentified species were identified following Hara et al. (1978); Press et al. (2000).

Image analysis and crown cover classification

Boundary delineation of the study area was completed with E-trex Vista H GPS; and so generated data were made compatible to topographic digital data and orthophotos generated by the Survey Department of Nepal.

The Geo-Eye image (multispectral and panchromatic band) of March, 2009 (Path 98, Row 50) was purchased and re-projected to make compatible with topographic digital parameter. To achieve better visual interpretation, natural color composite was made based on multi band pan-sharpened image produced on it. We could not perform digital classification due to resource limitation. However, to come up with required degree of precision and accuracy that can be obtained with digital image processing (Desclée et al. 2006; Wang et al. 2008; Niccolai et al. 2010), visual interpretation of forest status, condition and composition were performed exploiting experience and knowledge of the field (Lu et al. 2004). For the purpose of this study, forest resource condition was assessed in terms of crown cover following Land Resource Mapping Project (LRMP 1986) and the resulted Crown Density (CD) class were Dense (>70% cover), Thin (40-70% cover), and Open (10-40% cover). To verify the accuracy of visual image interpretation for crown cover, we checked our resultant crown cover with the average crown cover measured at the interval of 5 m in each plot. We found all the plots laid in the respective crown class agree with the ground based crown density measurement using the densiometer at 20 points in each plot. Spatial variability in understory light is largely determined by several characteristics of over-story plants e.g. vegetation structure, spatial pattern, height, and cover, which vary simultaneously along the grassland/forest continuum (Martens et al. 2000). In a forested ecosystem, tree crowns provide descriptive information in evaluation of the condition of the forest (Niccolai et al. 2010). Crown cover (Baland et al. 2010) is known to be highly correlated with other measures of the forest stock such as bole biomass, total above ground biomass, and basal area (Tiwari and Singh 1987). The forest canopy is one of the chief determinants in assessing the plant growth and survival and the nature of the vegetation (Jennings et al. 1999). Hence, crown cover can be used as the indicator of degradation and/ or disturbance of the forest.

Data analysis

In ecological study, species Diversity (D) is a complex term because it takes into account both the species richness (R) and evenness (E). In this study, richness is the actual number of species used in dataset based on presence-absence data, whereas, evenness represents the effective number of species expressed as a proportion of the actual number of species in the dataset (Tuomisto 2013).

The most widely used diversity measure is the Shannon-Wiener index, (Shannon entropy) and the Gini Simpson index, but they are not themselves diversities (Jost 2006; Jost et al. 2010). Diversity is calculated based on abundance data and is measured in effective number of species (Hill 1973); to make the dataset follow the replication principle we used the Equation (1) to define the diversity of species

$$^{q}\mathrm{D} = \frac{1}{\sqrt[q-1]{\sum_{i=1}^{R} p_i \, p_i^{\,q-1}}} \quad (1)$$

Where, ^{q}D is a diversity of order q, p_i is the proportional abundance of species i in the dataset. Species diversity ^{q}D (hereafter denoted as D) equals the inverse of meanp_i, and it is the effective number of species. When q=1, each individual has the same probability of being chosen, and hence the probability that the chosen individual represents species i equals p_i . When q=0, each species has the same probability of being chosen irrespective of its proportional abundance. When q=2 basic sum (sum of the term inside the root) represent Simpson index (Simpson 1949; Hill 1973; Jost 2006) and hence equation is inverse of Simpson index, which represent the true diversity of order 2.

Morisita's Index of Dispersion (I_δ) (Equation (3)) was used to discern the dispersion pattern of species (Krebs 1999). Uniform index value(M_u) (Equation(4)) and aggregation index value (M_c) (Equation (5)) were calculated as follows:

$$I_\partial = n\left[\frac{\sum x^2 - \sum x}{(\sum x)^2 - \sum x}\right] \quad (2)$$

$$M_u = \left[\frac{x^2{}_{0.975} - n + \sum x}{(\sum x) - 1}\right] \quad (3)$$

$$M_c = \left[\frac{x^2{}_{0.025} - n + \sum x}{(\sum x) - 1}\right] \quad (4)$$

Where n is the sample size, x is the number of individuals,$x^2{}_{0.025}$,$x^2{}_{0.975}$ are the right tailed chi-squared value at 2.5% and 97.5% with n-1 degree of freedom. Based on the Equations (2-4) values standard Morisita Index (I_p) were calculated following four different conditions, they are:

1) When, $I_\partial \geq M_c > 1$, then $I_p = 0.5 + 0.5\left[\frac{I_\partial - M_c}{n - M_c}\right]$ (5),

2) When,$M_c > I_\partial \geq 1$, then $I_p = 0.5\left[\frac{I_\partial - 1}{M_c - 1}\right]$ (6),

3) When, $1 > I_\partial > M_u$, then $I_p = -0.5\left[\frac{I_\partial - 1}{M_u - 1}\right]$ (7), and

4) When, $1 > M_u > I_\partial$, then $I_p = -0.5 + 0.5\left[\frac{I_\partial - 1}{M_u - 1}\right]$ (8)

Value of I_p ranges from where negative value indicate uniform pattern, zero indicates a random pattern and positive value indicates degree of aggregation (clumped) pattern.

Additionally, following Jobidon et al. (2004), we also calculated Total Basal Area of species (TBA) at plot level and basal area of major associated species of Sal (ABA). ABA to TBA ratio at plot level is used to represent the proportion of Sal associated species. A value of proportion (1:0) represents pure associates' species cover, while the reverse proportion (0:1) that leads to value 1 represent the pure Sal cover. To quantify the effect of associate tree species on plant diversity and associated species productivity, we established the linear relationships for species Richness versus ABA/TBA ratio and *D* versus ABA/TBA ratio. Similarly, examining the effect of ABA/TBA ratio on plant diversity, regression equations were fitted for (1) Species Richness versus canopy cover, and (2) *D* versus canopy cover. We used the regression equation due to nature of data (ratio), and to see the trade-offs between dependent and independent variables.

Socio-economic and historical data collection and analysis

Information about socio-economic and demography along with the households' knowledge on CF processes, historical context of forest management, perception on forest condition, energy use pattern, farm-tree growing, forest development activities, forest products distribution and utilization and rule enforcement were obtained from 30 randomly selected household surveys. Past historical information regarding the forest condition and underlying causes of forest structure change was collected through informal discussion with key informants during the field survey. In addition, two focused group discussion were conducted while understanding the historical dynamics of forest management and associated socioeconomic drivers of forest condition change. Moreover, OP and constitution, of forest of different time, research reports related to study site, meeting minutes, policy and legislative documents were also used to infer about socioeconomics related to forest dynamics.

Results

Stand Structure

In total, 44 different species were recorded representing 39 genera and 27 families. Three canopy density class (hereafter referred as canopy class) i.e. dense, thin, and open harbors 42, 18, and 8 species respectively (Table 1). In all canopy class, Sal was largely dominant. In tree layers (>29.9 cm dbh), dominance of Sal was followed by *A. cordifolia, S. wallichii, L. parviflora*. The mean density across all stratums was 192 trees ha^{-1}. The highest tree density was 180 trees ha^{-1} for Sal, followed by *S. wallichii* (76 trees ha^{-1}), *A. cordifolia* (43 trees ha^{-1}), *L. parviflora* (34 trees ha^{-1}), and *M. philippinensis* (32 trees ha^{-1}). As expected, highest stem density was recorded for dense, followed by thin and open CD category (see Table 1). The average basal area across all stratums was 16.2 m^2ha^{-1} highest was recorded for dense stratum i.e. (18 m^2ha^{-1}), while the least was recorded for open CD (11 m^2ha^{-1}). The highest average diameter (33.2 cm) was recorded for open crown class, while the least was recorded for thin crown class (27.9 cm). Number of individual is varied from 3 to 16 per quadrat.

Table 1. Summary of forest structure across crown class.

Crown class	Species richness	No. of stem (ha^{-1})	Basal area (m^2/ha^{-1})	Diameter	
				Mean	CV (%)
Open (0-40%)	8	100	10.99	33.2	54.85
Thin (40-70%)	18	164	12.94	27.9	54.54
Dense (>70%)	42	213	17.95	29.5	48.46
Total	44	192	16.18	29.3	49.84

Significant inverse relationship was found while plotting the total number of individuals per hectare against diameter class (Figure 2(a)) for whole forest (R^2_{adj} =0.967, p= 0.011) and open crown class (Figure 2(b)). Similarly logistic equation was found significant for the thin (Figure 2(c)) and dense crown class (Figure 2(d)).

In open crown category fewer number of larger trees exist and the rate of number of individuals fall with increase in diameter class which is greater for denser crown category than for thin crown category (Figure, 2(d)).

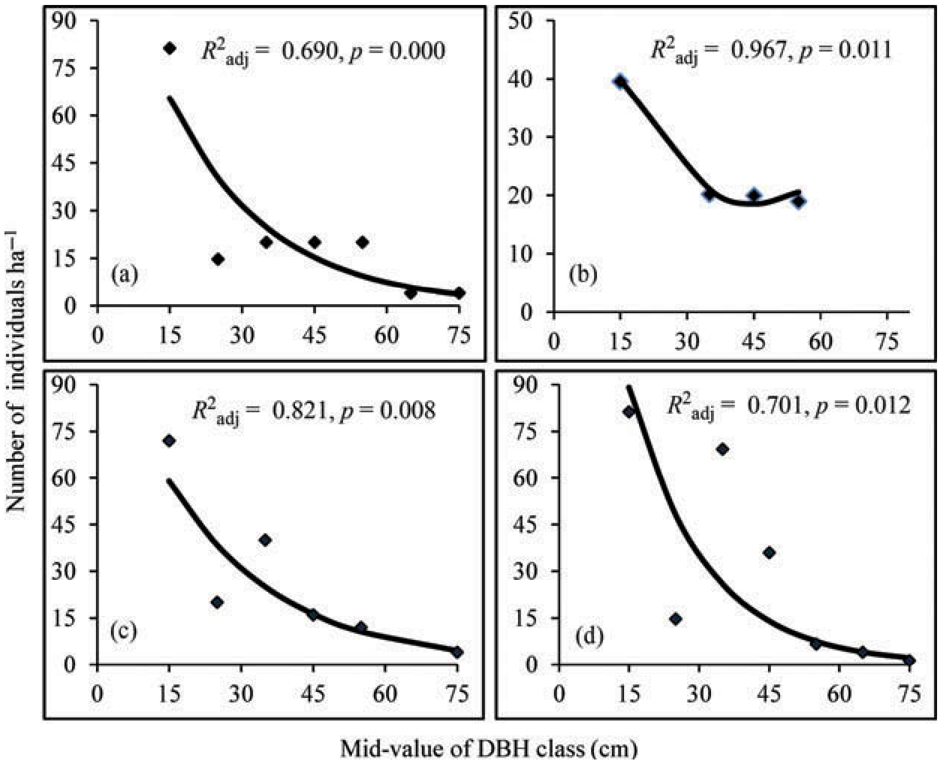

Figure 2. Relationship between number individuals per hectare to mid value of diameter class for (a) whole forest and (b) open, (c) thin, and (d) dense crown density category.

Spatial distribution pattern

Of the 18 species, 8 species were recorded only in dense crown canopy. They are: *Albizia procera, C. operculatus, W. fruticosa, Syzigium cumini, Castanopsis indica, Swida oblonga, Wendlandia exserta*, and *Colebrookea oppositifolia. Wightia speciossissima, Terminilia tomentosa, L. parviflora*, and *Phyllanthus emblica* follow either random or aggregated pattern. Only one species, *W. fruticosa* was found uniformly distributed, whereas the rest of all other species were found with patchy (clumped) distribution. *L. parviflora, M. philippinensis,* and *S. robusta* were found in all three crown density class, while rest of the five species was found only in two stratums as shown in Table 2.

Table 2. Distribution pattern and density (number ha^{-1}) of species across crown class.

Species	Crown density		
	Open	Thin	Dense
Phyllanthus emblica		20^R	73^C
Terminalia tomentosa		47^C	30^R
Wightia speciosissima		20^C	33^C
Semecarpus anacardium		20^R	32^C
Lagerstroemia parviflora	40^R	33^R	33^C
Gracinia xanthochymus		60^C	71^C
Schima Wallichii		80^C	76^C
Woodfordia fruticosa			20^U
Colebrookea oppositifolia			35^C
Syzizium cumini			100^C
Castonopsis indica			100^C
Cleistocalyx operculatus			47^C
Swida oblonga			69^C
Albizia procera			53^C
Wendlandia exserta			35^C
Adina cordifolia		47^C	28^C
Shorea robusta	470^C	700^C	389^C
Mallotus philippinensis	260^C	127^C	80^C

Note: The superscripts R, C, and U, respectively, indicate random, clumped and uniform distribution pattern.

Distribution pattern of species like *P. emblica, T. tomentosa, S. anacardium* was not consistent across CD class (Table 2).

Canopy density and its effects on plant species richness, diversity and abundance

True diversity (q=2, Equation (2)) varies from 0.398 to 2.59 in Chisapani CF. Species diversity was highest in the dense crown class followed by thin and open. Distance from nearest settlement significantly predicted diversity, β=0.639, $t(21) = 3.810$, $p < 0.001$. Distance from nearest settlement also explained a significant proportion of variance in diversity, $R^2 = 0.409$, $F(1,21) = 14.517$, $p < 0.001$. Similarly, distance from nearest road varies significantly with species diversity, β=0.721, $t(21) = 4.744$, $p < 0.001$. Distance from nearest settlement also explained a significant proportion of variance in diversity, R^2 = 0.520, $F(1,21)$ = 22.792, p <0.001. The highest species diversity was recorded in South, South-East and West facing. However, the analysis of variances does not show significant changes in diversity with slope (F=0.388, p=0.684). Similarly, species diversity does not vary significantly across the crown class (F=1.902, p=0.177). On the contrary, species richness across crown class was significant only at the 10% chance of committing type I error (F=3.387, p=0.059). Tukey's post-hoc test shows the difference between open and dense crown class; dense crown class had higher species richness than open crown class.

Table 3. Regression equation for the relation between species richness (R) and ratio of Sal associates' basal area to total basal area (ABA/TBA); true diversity (D) and ABA/TBA; R and crown density class (CD), and D and CD.

Model Name	Model form	β_0	β_1	β_2	R^2_{adj}	P value	Figure
Linear	$R= \beta_0+(\beta_1\times SBA/TBA)$	6.576 (0.000)	5.656 (0.004)		0.321	0.004	3A
Quadratic	$D=\beta_0+(\beta_1\times SBA/TBA)+ (\beta_2\times SBA/TBA^2)$	1.083 (0.000)	3.053 (0.004)	-2.179 (0.066)	0.519	0.000	3B
Exponential	$\ln(R) = \ln(\beta_0) + (\beta_1\times CD)$	3.988 (0.007)	0.999 (0.064)		0.119	0.064	3C
Linear	$D= \beta_0+(\beta_1\times CD)$	0.845 (0.103)	1.077 (0.174)		0.045	0.174	Not shown

Species richness of the three combined strata (CD) was only moderately affected by the proportion of associated species of Sal in the canopy (R^2_{adj}= 0.321, p = 0.004) (see Table 3 and Figure 3 (a)). Species diversity reached to peak (at ABA/TBA= 0.7), started to increase at 0.1 and declined after 0.7 and the relation was quadratic. Species diversity and richness are linearly declined as the ratio of ABA to TBA increased. Any significant difference between the abundance of species (all), and regeneration across CD was not found. However, the study revealed the significant difference between tree species abundance across CD (F=7.631, p=0.004). As expected, numbers of tree species were found increased with increase in CD, nevertheless, thin and dense CD does not show any difference.

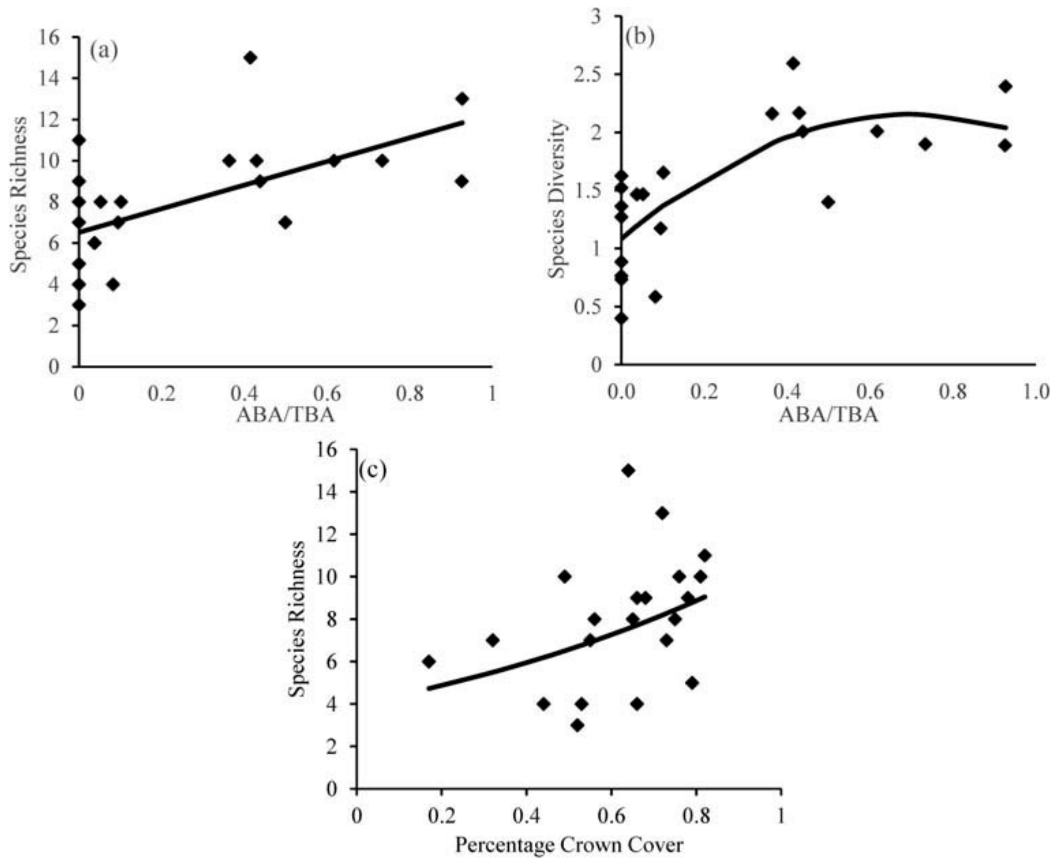

Figure 3. Relationship between (a) species richness (R) and the ratio of Sal associates basal area to total basal area (ABA/TBA), (b) species diversity and ABA/TBA, and (c) R versus crown cover.

Regression on diversity versus canopy class did not show any significant relation (see Table 3). This signifies that although the species richness increases with increase in CD it does not necessarily increase the species diversity because the species diversity is function of both species richness and species abundance.

Discussion

The study revealed that the number of stems ha^{-1} and basal area ha^{-1} did not vary significantly across the three CD. The tree layer had the lowest stem density, progressively increases with saplings and seedlings, and revealed the phenomenon that is generally exhibited by a healthy vegetation community (Mligo et al. 2009). The study showed the direct relation between density of woody species and the CD. This can be attributed to decreased human pressure with increase in CD, as the dense forest is located relatively far from the nearby settlement. Moreover, higher diameter class had lower density across the CD class (Figure 2). Although, the local people generally concentrate on lower diameter class and especially on thin crown class, still the density of small-sized tree is higher in the forest.In Chisapani CF, density of trees is progressively declined from lower to higher diameter class, as revealed by inverse relationship (Figure 2 (a)). This observation is in line with the observation of Sapkota et al. (2009) in seasonally dry deciduous Sal forest in Terai area of Nepal. They found an inverse relationship between the overall stand density and the diameter class in all forests, except in the most disturbed forest. Our results of mean basal area of trees ha^{-1} was higher than that of Sagar et al. (2003) (8.5-13.8 m^2ha^{-1}) in the dry tropical forest of India and Timilsina et al. (2007)(13.4 m^2ha^{-1}) in western Terai of Nepal. Similar results were recorded by Sapkota et al. (2009) (12.5-19.3 m^2ha^{-1}) along the disturbance gradient in Chure area of Nepal.

Likewise, observation of relatively low stem density (192 trees ha^{-1}) is consistent with other studies (e.g. Rautiainen 1999; Sagar et al. 2003). However, densities of Sal forests in Bardia National Park of Nepal reported by Shrestha and Jha (1997) (348 trees ha^{-1}), in Tanahun district of Nepal by Rai (1999) (658 trees ha^{-1}) and (743 trees ha^{-1}), and in India (Shukla and Pandey 2000) (814 trees ha^{-1}) (Rawat and Bhainsora 1999) (254-376 trees ha^{-1}) superseded the overall mean.

Human intervention on forest for satisfying their needs of fuel-wood, fodder, litter, and minor forest products, as well as grazing and browsing can alter species' habitats (Pandey and Shukla, 1999). Consequently, species richness and diversity in disturbance prevailing area largely depend on the species response to such disturbances; some may withstand the disturbances, while others may become extinct locally (Sagar et al. 2003; Mligo et al. 2009). True species diversity of Chisapani CF is low; ranges from 0.398 to 2.593 and average species diversity per plot is 1.519. This observation is in line with Stainton (1972) explaining species-poor nature of Sal forest. Average diversity of species increases with increase in CD class. Open crown class has almost half less diversity than dense category. This may be due to either proportional allocation of sampling plots according to species-area relationships; larger area harbors, more species or selective logging carried out in the previous year's leading to loss of the regeneration of species.

Shrestha and Jha (1997) mentioned that selective logging, burning, overgrazing, and indiscriminate cutting for firewood and building timbers can turn old growth Sal forests into heavy admixtures of other tree species, especially *T. Tomentosa*. The result of this study also supports this phenomena; reduction of density of species from thin to dense crown category. This also proves that the CD class can be considered as disturbance gradient. To put it different, in the present study species diversity is increased with decreasing level of disturbance. Leigh (1965) suggested that stability increases with the complexity of the ecosystems that is with the number of species and with the number of interactions between them. MacArthur (1955) pointed out that diversity is a function of the number of species.The stability has been reported to increase with diversity (Shafi and Yarranton, 1973). Therefore, disturbance in the dry deciduous forest can potentially lead to a decrease in stability and complexity of the ecosystems. Researchers indicated that shifting of clumped to uniform distribution pattern is associated with change from higher to lower stem density (Sagar et al. 2003; Sapkota et al. 2009), and the result of this study is in line with their findings. Distribution pattern of *P. emblica, T. tomentosa, S. anacardium* was not consistent across crown density class indicating that species response varies across crown openings which create different habitat condition through variation in light. Similarly, in case of *T. tomentosa* changed in distribution pattern (thin to dense, CD), support the hypotheses that the random pattern in fact is transformation of clumped pattern caused by disturbances and competition of neighboring trees (Lepš and Kindlemann 1987; Rozas and Antonio Fernandez prieto 2000). The study revealed that such shift in pattern from one CD to another hinted that crown cover can be considered as disturbance gradient. Out of 18 species in Table 2 one species has random distribution in open, three in thin, and one in dense crown category, which reject our hypothesis that the spatial distribution pattern of woody species follow the random pattern with respect to habitat. One possibility, in this case, in shift in distribution pattern may be due to light-loving character of species, which was not found in case of dense top canopy. On the other hand, decrease in density was found in shade-loving species like *M. philipinensis* with increase in CD. Nevertheless, compounded effects of anthropogenic and natural disturbances affect species' distribution patterns (Rozas and Antonio Fernandez Prieto 2000; Kiester 2013). In the present study, species represented by single individuals varied from 25% (open crown) to 38% (thin crown). This is higher than the observation of Sagar et al. (2003) (18-30%). Regardless of disturbance (crown category), Sal was found in higher density being dominant species of the forest. Therefore, Sal can be considered as disturbance tolerant species (Pandey and Shukla 2001).

Increasing the proportion in basal area of associate species of Sal in the Chisapani CF showed a positive linear relation with species richness (Figure 3 (a)) and curvilinear to species diversity (Figure 3 (a)). Species diversity was increased up to ABA to TBA reached to 0.7, then after it started to fall. Considering that diversity is related to disturbance, natural mix Sal forest with subject to frequent disturbances (crown opening, loping, and logging) are likely to maintain higher levels of diversity compared to close canopy. However, the results suggest that denser canopy coverage shows higher species richness (Figure 3 (c)) and diversity (figure not shown). This is because local people's dependency on forest is function of distance; the nearer the forest the heavier the pressure (logging, grazing, browsing, lopping, and litter collection). Consequently, it is hard to quantify the proportion of the single disturbance among multitude of disturbances that takes place at one time. However, Vetaas (1997) indicated that small scale lopping regime (in his case, <5%) enhance the habitat diversity and species richness of vascular plants. Nevertheless, large-scale canopy disturbance reduce diversity and change the species composition, which supports our observation.

Conclusion

Total number of individuals of species across the CD revealed the significant relations described by linear regression. True species diversity and species richness increased with CD. Most of the species showed the clumped distribution and we reject our hypothesis of woody vegetation in Sal forest follow the random pattern, but they did not exhibit the constant relation with CD. Conversely, unlike other studies, considering the CD as disturbance gradient, advanced regeneration increased with increasing CD. However, the pole number was found to be highest in the thin crown class. In all the CD, Sal was found to be dominant. Species richness and diversity increased to certain level with increase in the ratio of ABA to TBA per plot.

Multitude of factors like anthropogenic, socioeconomic, and environmental either alone or jointly affect the forest structural, functional, and compositional aspects at varying scale and intensity, which play a crucial role in conservation, maintenance, and degradation of forest biodiversity in Sal CF of Nepal. Therefore, strategies that aim to protect biodiversity, increase stand structural diversity, and maximize natural Sal mixed forests' productivity by means of thinning and pruning, without affecting local needs are required. Nevertheless, study to quantify for thresholds (standard) should be carried out at community-managed Sal forest for species diversity to be reached within the canopy cover of mixed-Sal forest.

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Appendix

QUESTIONNAIRE FOR HOUSEHOLD SURVEY

Mr. Bishwa Nath Oli, Doctoral Student at Danish Centre for Forest, Landscape and Planning, Faculty of Life Sciences, CopenhagenUniversity, is conducting research on 'Evaluating community forestry processes and outcomes: evidences from selected community forests of Nepal'. The data that will be collected from you is a part of my research for the fulfilment of Ph D degree. As this research is not aimed for any development project, the information being generated from you will solely be for academic purposes and there are no risks and benefits for participating in this research.

The research has the main question as how existing management practices of the community forest user groups are effective in bringing changes in the state of forests and in improving the utilization of forests. We will appreciate if you agree to co-operate us by answering the set of questions. It may take approximately one hour to answer the questions. Your identity will be kept confidential to the extent provided by law in any report produced. You have the right to withdraw from the study at any time without consequence.

If you have any questions about the research, you may contact at the following address:

In Denmark		**In Nepal**
Supervisor Thorsten Treue, Ph D Associate Professor Danish Centre for Forest, Landscape and Planning Faculty of Life Sciences University of Copenhagen Rolighedsvej 23 1958 Frederiksberg C Denmark Tel. +45 3533 1759 Fax +45 3533 1508 E-mail:ttr@life.ku.dk URL: www.en.sl.life.ku.dk	Researcher Bishwa Nath Oli Ph D Student Danish Centre for Forest, Landscape and Planning Faculty of Life Sciences University of Copenhagen Rolighedsvej 23 1958 Frederiksberg C Denmark Tel. +45 3533 1737 E-mail: bno@life.ku.dk URL: www.en.sl.life.ku.dk	Researcher Bishwa Nath Oli Ph D Student C/O ComForM Project, Institute of Forestry, Hariyo Kharka, Pokhara, Kaski, NEPAL Or GPO Box 21719, Kathmandu, NEPAL Mobile: 9841 217761 E-mail: bn_oli@yahoo.com

CONTROL INFORMATION

Questionnaire No.: ☐

Task	**Date(s)**	**By who?**	**Status OK? If not, give comments**
Interview			
Checking questionnaire			
Coding questionnaire			
Entering data			
Checking & approving data entry			

A. GENERAL

1. District:		2. Name of the CF:
3. VDC:	4. Ward Number:	5. Tole:

1. Who are the members of the household?

Household ID	Name of household member	Relation to household head[1)]	Age	Sex *(0=male 1=female)*	Education *(number of years completed)*
1		HH head =code 0			
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					

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

2. Social status

1. Ethnicity/Caste status *(Tick any one)*	Status			
	Brahmin/Chhetri	Indigenous/Nationalities	*Dalit*	Others

2. Dominant Profession *(Tick any one)*	Status				
	Agriculture	Business	Service	Wage Labour	Other

3. Since how long have you been here? *(Tick any one)*	Status				
	Since birth	For more than 20 years	10-20 years	1-10 years	Recent (<1 year)

4. Affiliation to CF *(Tick any one)*	Status				
	General Member	Executive Member	Advisor	Not Affiliated	Other
CF:					
CF:					
CF:					

3. Landholding and crop production

3.1 Could you provide following information on landholding and tenure.

Land type	Own land (*Ropani*)	Rented in (*Ropani*)	Rented out (*Ropani*)	Remarks
Irrigated				
Non-irrigated				
Pasture/Grazing				
Private forest				
Other, specify				
Total				

3.2 What are the quantities and values of crops that your household has harvested during the past one year?

1. Crops	2. Area of production (Ropani*)*	3. Total production (5+6)	4. Unit (for production)	5.Own use	6. Sold	7. Price per unit	8.Total value (3*7)
Paddy							
Maize							
Millet							
Wheat							
Buckwheat							
Mustard							
Lentils							
Potato							
Onion							
Green vegetables							
Fruits							
Fish							
Others							

4. Livestock holding

4.1 Annual income from live animals

Livestock type	Number	Own consumption	Sale	Price per unit	Total income (NRs)	Remarks
Buffalo						
Cattle		xxxxxxxxxxxxxxx				
Goat						
Sheep						
Pig						
Horse		xxxxxxxxxxxxxxx				
Chicken						
Duck						
Other						

4.2 Other income from livestock

Item	Yield (first 3 months)	Yield (second 3 months)	Yield (third 3 months)	Yield (fourth 3 months)	Total Yield	Price per unit	Total income
Milk							
Eggs							
Draught							
Other							

5. Forest income

1. Forest product	2. Collected where[1]?	3. Quantity collected (5+6)	4. Unit	5. Own use	6. Sold	7. Price per unit	8. Gross value (3*7)	9.Transport/ marketing costs (total)	10. Purch. inputs & hired labour	11. Net income (8-9-10)
Timber			Cft							
Poles			Piece							
Firewood			Bhari							
Fodder and grass			Bhari							
Fruits and nuts										
Litter and leaves			Bhari							
NTFPs										
Others										

[1]: Codes: 1-community forest; 2-neighbouring CF; 3-Government-managed forest; 4-Privately-owned trees/forest; 5- Other, specify

6. Off-farm income

Sources of income	No. of HH member involved	Total annual income (NRs)	Remarks
Service			
Business			
Wage labour			
Industry (forest-based and other)			
Remittances			
Other, specify			

7. Other asset holdings

1. Do you own a house or plot in an urban area?	*(1-0)*
2. Is your main house a multi story house?	*(1-0)*
3. What is the roofing material of your main house? *(tick only one)*	Tiles
	Iron sheet
	Grass/straw roof
	Concrete
4. What is the largest single source of income for your household? *(tick only one)*	Agriculture
	Remittances
	Formal employment
	Business
	Paid labour
	Other
5. What are your sources of energy for cooking and heating? *(tick as appropriate)*	Firewood
	Biogas
	LPG Gas
	Kerosene
	Electricity
	Solar set
	Saw dust stove
	Other, specify

6. Do any household member(s) own any motorised transport vehicles? *(note down how many the household member(s) own)*	Motorcycle
	Car/Jeep
	Tractor
	Truck
	Other, specify

7. Do you sell any of your agricultural harvest?	*(1-0)*
8. Approximately how many months can your staple food harvest support your household?	*(# of months*
9. Do you have helpers in your household?	*(1-0)*
10. Do you usually employ people to help you in farming?	*(1-0)*
11. Do any of your children attend English boarding school or have they attended earlier?	*(1-0)*
12. Do you have television set in your house?	*(1-0)*

4. Average annual expenditures of household

SN	Name of Items	Total Amount	Remark
1	Food/Grain		
2	Clothing		
3	Oil/Kerosene		
4	Salt/Sugar/Tea etc		
6	Electricity		
6	Water supply		
7	Education		
8	Medicine		
9	Social activities		
10	Entertainment		
11	Travel		
12	Other		
13	Other		
14	Other		

5. What community-based organizations and groups (including political parties and civil societies) are members of your household presently member of? *(mention the number of household members as appropriate)*

SN	Name of Organizations/Committees	General member	In Executive committee
1			
2			
3			
4			
5			
6			
7			
8			

6. Training/exposure

1. Have you received any type of training/exposure through CFUG and forest-based agencies[1]?			*(1-0)*
2. If yes, could you give the list of such training/exposure?	Name of training	Duration	When
	1. Forest management training		
	2. NTFP management		
	3. Forest-based enterprise		
	4. Nursery and plantation		
	5. Forest inventory		
	6. Office management		
	7. Gender and development		
	8. Other, specify		

[1]-means DFO, Projects, I/NGOs working in the field of forestry

B. OPERATIONAL PLAN FORMULATION, IMPLEMENTATION AND REVISION

1. Are you aware of the constitution of CFUG and operational plan of the forest?	*(1-0)*
2. If yes, what do you mean by an operational plan? *(please write few words)*	
3. Were you consulted during the preparation of constitution and operational plan?	*(1-0)*
4. If yes, were you involved in drafting the plan?	*(1-0)*
5. How have the activities been carried out by the CFUGC? *(please tick)*	*Following the provisions of OP and constitution*
	Based on decisions made by the CFUGC
	Based on decisions made by the General Assembly
	On an ad-hoc basis, without following provisions
	Other, specify
6. Please mention any 3 activities carried out without following provisions mentioned in OP.	i.
	ii.
	iii.
7. What level of support is received for formulation of the plan and from whom? *(Please tick)*	*Technical support from DFO*
	Financial and material support from DFO
	Technical support from project/NGOs
	Financial and material support from Project/NGOs
	Financial and material support from local government
	Technical support from hired expert consultant
	Other, specify
8. Would you say something about member households' participation in operational plan preparation? *(Please tick)*	*Actively involved*
	Moderately involved
	Somewhat involved
	Not involved
	Don't know
9. In your opinion, what are the possible reasons for passive participation of member households in operational plan preparation? *(Please tick)*	*Users lack information on process*
	Users can not afford to contribute their time
	Users do not have faith in CFUGC
	Users were indifferent in CFUG activities
	The process was dominated by local elites
	The process was dominated by Forest Department
	Other, specify
10. In your opinion, operational forest management plan reflects interests of which segments of the society? *(Please tick)*	*Poor and landless*
	Local elites
	Forest Department
	General users
	Forest traders/contractors
	Political leaders
	Local government
	FECOFUN/NGO/Civil Society
	Other, specify
11. How was the information collected for the formulation of the OP? *(Please tick)*	*Collected by the CFUGC members*
	Collected by Forest technicians with the help of users
	Collected by hired experts
	Collected voluntarily by users
	Other, specify
12. Was this collected information really translated into the OP?	*(1-0)*
13. How much time does it take to draft the plan (including inventory works) of your CF?	*days*
14. How frequently the CFUGC follows provisions of the OP in conducting activities? *(Please tick)*	*Always*
	In most cases
	Frequently
	Rarely
	Never

15. How has the plan been approved in the general assembly? *(Please tick)*	*Consensus*
	Extraordinary majority (2/3)
	Simple majority
	Putting pressure from some executives and elites
	Other, specify
16. How was the draft plan shared among the users? *(Please tick)*	*Organizing Tole level meetings*
	In General Assembly
	Sharing with key persons of each Tole
	Informed to those who come to CFUGC
17. In your opinion, what problems have you seen during the formulation, implementation and revision process of the plan? *(List out any three major)*	i.
	ii.
	iii.
18. What would be the possible solutions to overcome these problems? *(List out any three major)*	i.
	ii.
	iii.

C. FOREST RESOURCES

1. How far is it from the house/homestead to the edge of the community 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. How far is it from the house/homestead to the edge of the nearest forest (other than CF) 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*
3. What is the current status of your community forest? *(please tick)*	Planted forest	
	Poorly stocked degraded natural forest	
	Moderately stocked natural forest	
	Well stocked natural forest	
	Mixed natural and planted forest	
	Other, specify	
4. Have you planted or do you have trees on farmland?		*(1-0)*

5. If yes, could you please give following details?

SN	Local Name	Scientific Name	No of Trees/Area Planted	Purpose[1]

[1]Codes: 1= Firewood for domestic use; 2= Firewood for sale; 3= Fodder for domestic use; 4= Fodder for sale; 5= Timber for domestic use; 6= Timber for sale; 7= Environmental balance; 8= Other, specify

6. How is the role of forest resources in your house? *(Please tick)*	*Main source of timber/Firewood/fodder for domestic use*
	Income from sale of forest products
	Support to agriculture production
	Support from sale/collection of forest products at the time of crisis
	Environmental services received
	Other, specify

7. In your opinion, can forest resources be a medium of poverty alleviation?	*(1-0)*

C1. FOREST PROTECTION

1. What is the mechanism of forest protection in your CF?

Details of forest protection activities	Mechanism[1]	Who[2]	Who supports[3]	Type of support[4]
Forest fire control				
Grazing control				
Encroachment control				
Control of illegal extraction				
Soil conservation				
Biodiversity conservation				
Other, specify				

[1] Code: 1= Awareness generation; 2= group patrolling; 3= Turn wise patrolling; 4= provision of forest watcher; 5= Sign boards for publicity; 6= plantation of soil stabilizing species; 7= other
[2] Code: 1= FUGC; 2= All CFUG members; 3= Other, specify
[3] Code: 1=DFO; 2=Project/INGO; 3= NGO/CBOs; 4=Other, specify
[4] Code: 1= Technical support; 2= Material support; 3= Financial support; 4= Other, specify

2. In your opinion, are there any problems in forest protection?	*(1-0)*
3. If yes, could you cite any three problems that were encountered during protection of the CF?	i.
	ii.
	iii.
4. What would be the possible solutions to overcome these problems? *(List out any three major)*	i.
	ii.
	iii.

C2. MANAGEMENT PRACTICES

1. What type of silvicultural operations/forest development activitiesare being practiced in the CF?

Silvicultural operations	Practiced in your CF *(1-0)*	Your participation *(1-0)*	Who supports[1]	Type of support[2]
Cleaning				
Singling				
Pruning				
Thinning				
Fire line construction				
Demonstration plot				
Nursery				
Plantation				
Harvesting and stacking				
Shrubland improvement				
Others				

[1] Code: 1=DFO; 2=Project/INGO; 3= NGO/CBOs; 4=Other, specify
[2] Code: 1= Technical support; 2= Material support; 3= Financial support; 4= Other, specify

2. Before the introduction of CF, in what kind of forest management activities did you involve?

Activities	Time spent (mandays/year)	Frequency of activity	Compensation (in NRs)
Meetings			
Boundary clearing			
Fire line making			
Patrolling			
Thinning/pruning			

Planting			
Other, specify			
Other, specify			

3. During the last year, did your household involve in any forest management activities?			*(1-0)*
4. If yes, please mention the kind of activities?			
Activities	Time spent (mandays/year)	Frequency of activity	Compensation (in NRs)
Meetings			
Boundary clearing			
Fire line making			
Patrolling			
Thinning/pruning			
Planting			
Other, specify			
Other, specify			

5. In your opinion, are there any improvements in forest resource condition after the establishment of CF? *(please tick)*	Status		
	No it has remained the same	Yes, it has improved	Yes, it has degraded

6. If improved, what are the indicators? *(plese tick)*	Indicators				
	Increase in crown cover	Increase in regeneration	Increase in stem number	Increase in diameter of trees	Other, specify

7. If degraded, what are the indicators? *(please tick)*	Indicators				
	Decrease in crown cover	Decrease in regeneration	Decrease in stem number	Drying of water source	Other, specify

8. If improved, mention the most important reasons for such improvement *(please tick)*	Reasons				
	Strong rule enforcement & sanctioning of violations	Under-use of forest products	Plantation	Use of nearby government forests	Other, specify

9. If degraded, mention the most important reasons for deterioration *(please tick)*	Reasons					
	Weak rule enforcement	Over-use of forest products	Encroachment	Conflicts among the users	Natural calamities	Others

10. Could you say something about the condition of nearby government forest after the establishment of CF. *(please tick)*	Status		
	It has remained the same	It has improved	It has degraded

11. If improved, mention the most important reasons for such improvement	Reasons					
	Strong rule enforcement	Less pressure	Plantation	Forest is far	Other, specify	Other, specify

(please tick)						
12. If degraded, mention the most important reasons for deterioration	Reasons					
	Weak rule enforcement	Over-use by communities	Encroachment	Natural calamities	Other, specify	Other, specify
(please tick)						

D. FOREST PRODUCTS EXTRACTION, DISTRIBUTION AND UTILIZATION

1. How many times the forest is opened for forest products extraction in a year?	*Times/year*
2. How do you know when to collect various forest products? *(Please tick)*	*Attending FUG committee meeting*
	Informed by FUGC members
	Informed by members
	FUG Assembly
	Other, specify
3. How have the timber and fuelwood been extracted from the forests? *(please tick)*	*As per the annual allowable cut mentioned in the operational plan*
	As per the need of the users
	As per the quota fixed by the CFUGC
	As per the quota fixed by general assembly
	Other, specify
4. How is the role of District Forest Office staff with respect to harvesting operation? *(please tick)*	*Setting the annual harvesting level of timber*
	Criteria for allocation of timber to CFUG members
	Setting aside areas of the CF for harvesting
	Other, specify
5. How frequently the harvesting operations were monitored by the DFO staff? *(please specify)*	*Always*
	In most cases
	In some cases
	Rarely
	Never
6. Are you aware of the forest inventory work as prescribed by the Department of Forests?	*(1-0)*

7. Could you please tell something about forest products collected by your household at different time periods?

Products	Before CF Establish		Before 10 Years		Before 5 Years		Now (Last year)	
	Where[1]	Quantity	Where[1]	Quantity	Where[1]	Quantity	Where[1]	Quantity
Log								
Timber								
Poles								
Firewood								
Fodder								
Bedding								
Other								

[1]Codes: 1= Government forests; 2= Community forests; 3= Privately grown trees; 4= Other, specify

8. Last year, what forest products did your household collect and sell if any?

Products	From where	Collection unit	Amount of units collected	Total FUG fee paid (NRs)	Collection and processing cost (NRs)	Selling unit	Amount of units sold	Total selling value (NRs)
Logs								
Sawn timber								
Poles								
Firewood								

Fodder								
Bedding materials								
Other								

9. Last year, what forest products did your household collect for own use if any?

Products	Use	From where	Total FUG fee paid (NRs)	Remarks
Logs				
Sawn timber				
Poles				
Firewood				
Fodder				
Bedding materials				
Other				

10. Are you satisfied with the forest products extraction system and distribution mechanism?	*(1-0)*

11. If no, what are the reasons behind this? *(Please tick)*	Reasons				
	Extraction is not as per the plan	No equity in distribution of forest products	Forest products not received as and when needed	Commercialization rather than fulfilling user needs	Other, specify

12. Are there any restrictions regarding collection of forest products?	*(1-0)*

13. If yes, how do you fulfil your forest products needs? *(Please tick)*	Sources/Mechanisms				
	From another community forest	From nearby government-managed forest	From privately grown trees	We do not need forest products in our household	Other, specify

E. GOVERNANCE

1. Does someone in your household normally/regularly attend the FUG activities[1]?		*(1-0)*
2. If 'yes': in your household, who normally attends FUG meetings and participates in other FUG activities? *Codes: 1=only the wife; 2=both, but mainly the wife; 3=both participate about equally; 4=both, but mainly the husband; 5=only the husband; 6=mainly son(s); 7=mainly daughter(s); 8=mainly husband & son(s); 10=mainly wife & daughter(s); 9=other arrangements not described above.*		
3. If you do not participate in FUG activities, what are the reasons? *(please rank the options)*	FUG members generally belong to other group(s) (ethnic, political party, religion, age, etc.) than I do	Rank (1-3)
	Cannot afford to contribute the time	
	Cannot afford to contribute the required cash payment	
	FUG membership will restrict my use of the forest, and I want to use the forest as I need it	
	I don't believe FUG is very effective in managing the forest	
	Not interested in the activities undertaken by existing FUGs	
	Corruption in FUG	
	Interested in joining but needs more information	
	Unaware of presence of FUG	
4. How do you evaluate the rate of your participation in FUG activities? *(Please tick)*	*Strong participation*	
	Occasional participation	
	Not very often	
	Hardly ever	

5. Have you ever addressed the FUGC in any way to voice any problems or dissatisfactions? *(tick as appropriate)*	*No*	
	Yes, orally to a FUGC member	
	Yes, in a letter to the FUGC	
	Yes, in a demonstration, blockade or other group activity	
	Yes, in another way, please specify	
6. If you have addressed the FUGC, did it have any effect? *(tick only one)*	*No, the protest was ignored or responded negatively without acting*	
	Yes, the FUGC responded positively, but did not act	
	Yes, the FUGC responded positively, acted, but it did not change the situation	
	Yes, the FUGC responded positively, acted, and the situation improved	
	Yes, the FUGC responded and acted negatively and the situation worsened	

7. How decisions are made in GA meeting? *(please tick)*	*Consensus*
	Majority
	Voting
	By force/suppressing
	Other, specify
8. How is the process to elect executive committee members of the CF? *(please tick)*	*Consensus*
	Majority
	Voting
	By force/suppressing
	Other, specify
9. Are you satisfied with the way the executives are selected?	*(1-0)*
10. Has the election been influenced by political ideology?	*(1-0)*
11. Do you know the names and positions of the present CFUGC?	*(1-0)*

12. If yes, could you provide name with any 5 positions.	*Name*	*Position*
		Chairperson
		Vice-chair
		Secretary
		Treasurer
		Member

13. Have you talked to any FUGC members about issues concerning the FUG within the last one year?*Code: 1=No; 2=Yes; 3=Yes, a few times; 4= Yes, several times*	
14. How do the CFUGC present financial and managerial decisions? *(please tick)*	*Orally at CFUG general assembly*
	Orally at ward meetings
	Orally at tole meetings
	In written notices on the notice board
	In written notices in public places where all can see
	Others, specify
15. Who can inspect the CFUGC minutes and financial reporting details? *(please tick)*	*CFUGC members*
	All CFUG members
	DFO officials
	NGO
	VDC officials
	Former CFUGC members
	Other, please specify
16. Do you follow/monitor decisions of the CFUGC by reading minutes from meetings?	*(1-0)*
17. Are the rules/practices of the CFUGC fair and equitable?	*(1-0)*
18. If no, how can they be made fair and equitable in your view? *(please mention important three)*	1.
	2.
	3.
19. Are you satisfied with the general performance of the FUGC?	*(1-0)*
20. If yes, Why?	

(please mention)	
21. If no, why?	
(please mention)	

F. SANCTIONING, MONITORING AND RULE ENFORCEMENT

1. In your opinion, are the regulations mentioned in the operational plan clear and easy to understand?	*(1-0)*
2. In your opinion, do majority of users follow rules and regulations mentioned in the operational plan?	*(1-0)*
3. If not, what are the possible reasons for breaking the rules? *(please tick)*	*Lack of ownership over forests*
	Allotments from the CF is not sufficient for fulfilling household needs
	Conflict with CFUGC members
	CF has curtailed the traditional rights on use of forests
	Temptation for making money from forest products sale
	Other, specify
4. If yes, what are the main reasons for majority of members to follow rules and regulations? *(please tick)*	*They respect the rules*
	They know the value of the forest and nature
	The threat of social disapproval
	The threat of monetary fines
	Rule following may bring benefits to all households
	Other, specify
5. Have you or anyone in your family been penalized for breaking rules?	*(1-0)*
6. If yes, what were the reasons for being penalized? *(please tick)*	*Illegal extraction of forest products*
	Grazing in the restricted areas
	Setting fires
	Fund misuse
	Encroachment
	Other, specify
7. If yes, what kind of punishments was given to those violations? *(please tick)*	*Verbal chastisement*
	A cash fine (in NRs………………………..)
	Temporary restriction on harvesting rights
	Required labour input
	Public apologies
	Temporary suspension from the CFUG
	Others
8. Who takes the decision on charging penalties? *(please tick)*	*General Assembly*
	Executive Committee
	Sub-committees
	Influential authority of the committee
	Other, specify

G. FUND MANAGEMENT AND MOBILIZATION

1. What are the sources of fund in the CF?	*(Code[1])*
2. What type of community development activities are financed by the FUG? *(select the appropriate)*	*(Code[2])*
3. How decision is made for allocating funds for different activities?	*(Code[3])*

4. Are the provisions mentioned in the OP followed in mobilizing the funds?		*(1-0)*
5. Have you noticed any conflict regarding fund mobilization of the CFUG?		*(1-0)*
6. Were you consulted or have you raised any issues regarding FUG fund mobilization aspects?		*(1-0)*
7. Are you satisfied with the fund mobilization decision of the FUGC?		*(1-0)*
8. If no, what are the reasons behind your dissatisfaction? *(please tick)*	The investment decision is biased, not need-based	
	Decisions are not based on existing rules of OP	
	The investment favours well-off households' interest	
	The decision is influenced by local elites and DFO	
	Other, specify	
9. In your opinion, how the FUG fund could be better invested in future? *(please tick as appropriate)*	1. Loan to poor members for support to entrepreneurship development	
	2. Scholarship to needy and deserving students	
	3. Capacity development of the users through skill-based training	
	4. Community development activities in users' priority	
	5. Forest development activities	
	6. Deposit the money in bank and do nothing	
	7. Other, specify	

Code[1]: 1- Forest products sale; 2-Membership fee; 3-Penalties; 4-Donations/support; 5-Other, specify
Code[2]: 1-Drinking water, 2-Electricity, 3-Roads, 4-School, 5- Irrigation, 6-Health Post, 7-Temple/Monastery, 8-Community house, 9-Other, specify
Code[3]: 1-Consensus in GA; 2-Majority in GA; 3-Need-based; 4-Interest of FUGC; 5- Influence of local elites; 6-Other, specify

10. Last year, what did you pay for your annual FUG membership fee?	*There is no membership fee*	*(Tick)*
	Paid in cash	*NRs*
	Paid in labour	*Days*
	Did not pay in any way	*(Tick)*

H. MISCELLANEOUS

1. Please state whether you agree to the following statements concerning your perception to the CFUG functioning and state of the forest? *(tick only one per row)*

Statement	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
I feel that forest condition has improved after the implementation of CF programme					
I feel that utilization of the CF has been improved					
I feel that CFUGC has fairly accomplished the activities					
I feel that OP has been formulated and implemented in consultation with majority users					
I feel that unnecessary restrictions have been imposed with the introduction of CF					
I feel that users have been benefiting from community development activities funded by the CFUG					
I feel that CF has increased equal access to forest resource base					
I feel that CFUG activities are crucial in bringing social focused outcomes					

2. Apart from these questions, are there any suggestions you would like to add regarding processes and outcomes of community forestry programme?

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I. ENUMERATOR/RESEARCHER ASSESSMENT OF THE HOUSEHOLD

1.	How is the interest and cooperation of the respondent? *Codes: 1=Very good; 2=Good; 3=Fair; 4=Poor*	
2.	How reliable is the information provided by this household? *Codes: 1=poor; 2=reasonably reliable; 3=very reliable*	
3.	How is the respondent's level of knowledge about his/her rights as a FUG member? *Codes: 1=very high; 2=high; 3=moderate; 4=low; 5=very low*	

MANY THANKS FOR YOUR COOPERATION