Universität für Bodenkultur Wien

Towards Green Economy: An Analysis of Community-managed Forests in Nepal

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Submitted by:
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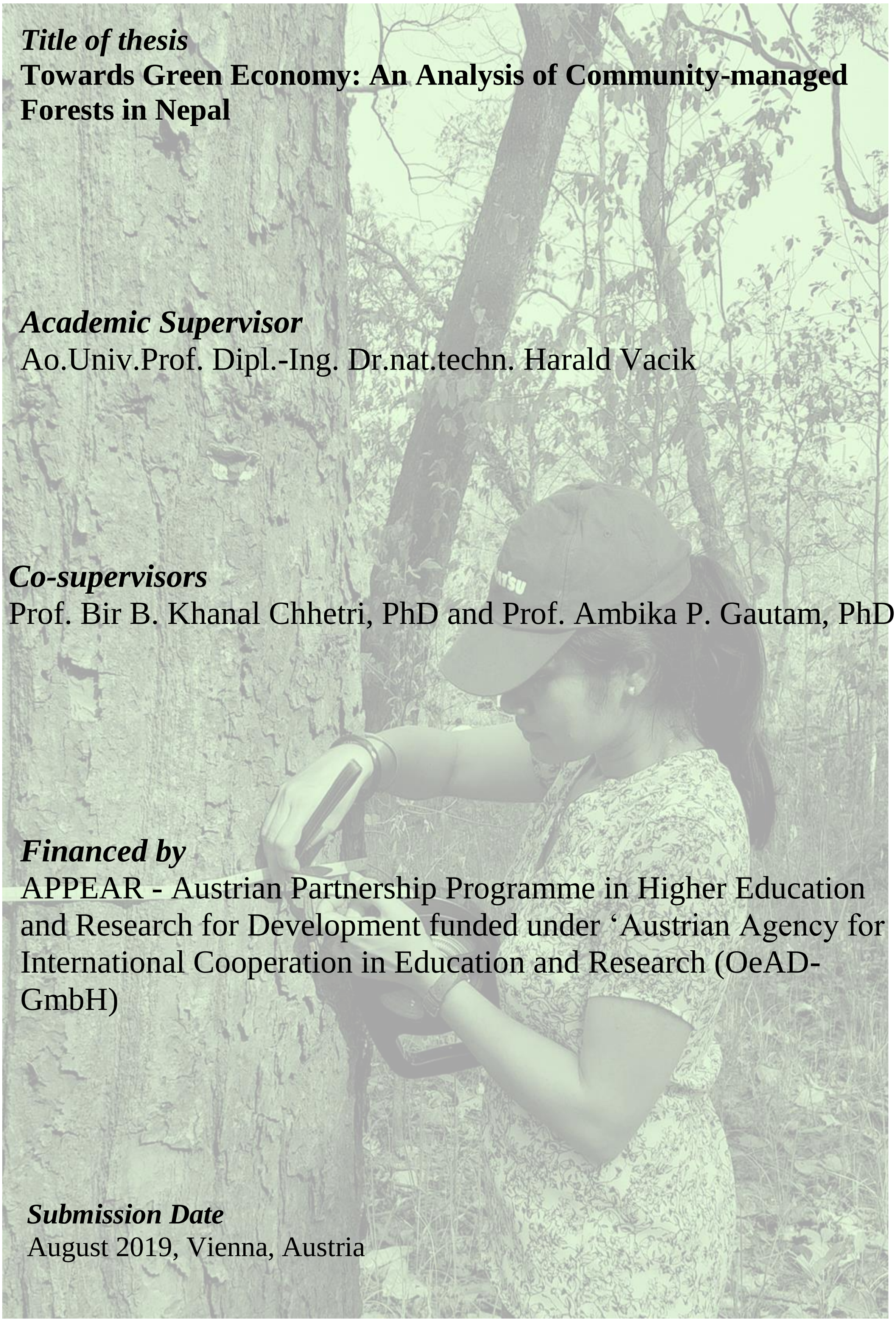

Title of thesis

Towards Green Economy: An Analysis of Community-managed Forests in Nepal

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Dedication

To my mother (Ama) ***Mrs. Sunmaya Baral*** who passed away, while I was struggling to finish my sturdy journey of Ph.D. Your wish to see me completing my Ph.D. remains unfulfilled. There was a competition between finishing my thesis and your life, and you won.

I am proud to enlighten in your name and I wish to be by your side and to be your daughter in many births to come. I always miss your calls--full of wishes-- your shoulders to share my sorrow and your lap to rest, Ama!

Abstract

In Nepal, community-managed forests (CMFs) are considered a success for forest conservation, but they are often criticized for underutilizing their economic potential. Transitioning CMFs from a green economy perspective requires a combination of activities leading to improved human well-being while reducing environmental risks and minimizing carbon emissions. Therefore, this research explores the role of CMFs in promoting the green economy perspective and assesses the instruments, investments, and plans that support forest management. The study conducted an intensive study in two community forests of Nepal and assessed current management practices of seven additional CMFs. Data was collected through forest inventory, household surveys, key informant interviews, focus group discussions, and identification of stakeholder preferences.

In terms of resource sustainability, the studied forests are being managed in an ecologically sustainable manner and indicate improvement in stand conditions. However, these improvements are often not related to successful design and implementation of forest management plans (FMPs). While resources are more exploited in commercial forests, users were not allowed to harvest according to the plan. In addition, findings reveal that nearly half of the investments of the community forest user groups were directed towards private goods. This helped in improving their economic well-being, with low-income groups becaming more affluent. Regarding carbon emissions, more than two-thirds of households were dependent on fuelwood, mainly for cooking. Consumption of fuelwood depends on various factors, such as per capita income, livestock numbers, landholding, and family size. The analysis of the appropriate management options to enhance contribution to the green economy revealed that multiple forest management is the most preferred option, followed by scientific forest management. When shifting the focus of forest management from an ecological dimension to a more economic perspective requires appropriate policies along with a sustainable supply of resources for human well-being. As Nepal is in the process of stabilizing federalization, policies to be formulated will need to encompass the green economy perspective.

Zusammenfassung

Gemeinschaftlich bewirtschaftete Wälder (Community-managed forests - CMFs) sind ein Garant für einen erfolgreichen Schutz der Wälder in Nepal. Diese Bewirtschaftung wurde aber oft auch kritisiert, weil das wirtschaftliche Potenzial ungenützt bleibt. Die Einführung einer umweltfreundlichen Wirtschaftsperspektive erfordert daher die Kombination von Aktivitäten, die zu einem besseren Wohlbefinden der lokalen Bevölkerung führen, während gleichzeitig Umweltrisiken reduziert und Kohlenstoffemissionen minimiert werden. Diese Forschungsarbeit untersucht daher die Bedeutung von Instrumenten, Investitionen und Bewirtschaftungsplänen bei dieser Transformation. Die Studie analysiert das Management in mehreren CMFs, wobei Daten zur Waldinventur erhoben, Haushaltsbefragungen und Diskussionen in Fokusgruppen durchgeführt worden sind. Es zeigt sich, dass die Wälder im Hinblick auf die natürlichen Ressourcen nachhaltig bewirtschaftet werden, und die untersuchten Wälder verbesserte Bestandeszustände zeigen. Die Verbesserungen stehen jedoch oft nicht im Zusammenhang mit der Gestaltung und Umsetzung der Bewirtschaftungspläne. Einerseits werden die Ressourcen in kommerziell bewirtschaften Wäldern stärker genutzt, andererseits ernten die Nutzer oft weniger als den zulässigen Holzeinschlag. Darüber hinaus zeigen die Ergebnisse, dass fast die Hälfte der Investitionen der CMFs in private Güter floss. Dies hat dazu beigetragen, das wirtschaftliche Wohlergehen generell zu verbessern, wobei Gruppen mit niedrigem Einkommen wohlhabender wurden. Aus Sicht der Kohlenstoffemissionen sind mehr als zwei Drittel der Haushalte auf Brennholz, vor allem zum Kochen angewiesen. Der Verbrauch von Brennholz hängt vom Pro-Kopf-Einkommen, dem Viehbestand, Landbesitz und der Familiengröße ab. Die Analyse von geeigneten Bewirtschaftungsoptionen ergab, dass eine Mehrzweck-Waldwirtschaft zu bevorzugen ist, gefolgt von einer rein wissenschaftlich ausgerichteten Waldbewirtschaftung. Bei der zukünftigen Verlagerung von einer ökologischen zu einer ökonomischeren Perspektive sind daher alle Prinzipien einer nachhaltigen Waldwirtschaft zu berücksichtigen. Die Umstellung erfordert eine angemessene Politik und eine nachhaltige Bereitstellung von Ressourcen für das Wohlergehen der Menschen.

सारांश - Summary in Nepali

वन संरक्षणको दृष्टिकोणबाट नेपालमा विद्यमान समुदायद्धारा व्यवस्थित वन पद्धतिलाई सफल मानिएता पनि आर्थिक सम्भावनाहरूको उपयोग नगरेका कारण संरक्षण उन्मुख भएको भनी आलोचना गरिएको पाइन्छ । यस अध्ययनमा समुदायद्वारा व्यवस्थापन गरिएका वनहरूले हरित अर्थतन्त्रमा पुऱ्याएको योगदानको विश्लेषण गरिएको छ । सो क्रममा वन व्यवस्थापनसंग सम्बन्धित नीतिगत तथा कानुनी संरचना, लगानीको अवस्था र योजनाहरूको कार्यान्वयनको स्थितिको समेत समिक्षा गरिएको छ । यो अध्ययन मूलतः नेपालका दुई सामुदायिक वनमा केन्द्रित भएता पनि समुदायद्वारा व्यवस्थापन गरिएका थप सातवटा वनहरुमा समेत आधारित रहेको छ । यो अध्ययनको लागि वन स्रोत मापन, घरधुरी सर्वेक्षण, मुख्य सूचनादाताहरुसँगको अन्तर्वार्ता, लक्षित समूह छलफल र राष्ट्रिय तथा स्थानीय सरोकारवालाहरुसंगको अन्तरक्रिया लगायतका विधिहरू प्रयोग गरी तथ्याङ्क सङ्कलन गरिएको थियो ।

समुदायद्धारा व्यवस्थित वन पर्यावरणीय दृष्टिकोणले दिगो रुपमा व्यवस्थापन भएको र वनको मौज्दात तथा अवस्थामा सुधार आएको अध्ययनले देखाएको छ । यद्यपि यस्तो सुधार वन व्यवस्थापन योजनाको कार्यन्वयनसँग खासै सम्बन्धित भएको देखिदैंन । एकातिर व्यवसायिक तवरले व्यवस्थापन गरिएका वनहरूमा स्रोतहरूको बढी दोहन गरिएको छ भने अर्कोतर्फ उपभोक्ताहरुले कार्ययोजना अनुरुप काठ काट्न नपाएको अवस्था छ । सामुदायिक वन उपभोक्ता समूहहरूले आफ्नो आम्दानीको झन्डै आधा लगानी निजी वस्तुहरूमा गरेको देखिएको छ । यसले मुख्यतः निम्न आय भएका उपभोक्ताहरुको आर्थिक अवस्था सुधार गर्न सहयोग पुगेको छ् । त्यस्तै गरि खाना पकाउने इन्धनका लागि दुई तिहाइभन्दा बढी घरपरिवार दाउरामा आश्रित रहेका र दाउराको खपत आयस्तरसंग बिपरित संबन्ध राख्दछ । त्यसैले हरित गृह ग्याँसको उत्सर्जन न्युनीकरण गर्न समुदायको आयस्तर बृद्दि गर्न जरुरी छ । हरित अर्थतन्त्रमा समुदायद्धारा व्यवस्थित वनको योगदान बढाउन उपयुक्त व्यवस्थापनका विकल्पहरूको विश्लेषण गर्दा बहुउद्देश्यीय वन व्यवस्थापन र वैज्ञानिक वन व्यवस्थापन क्रमशः बढी उपयुक्त विकल्प हुने देखिन्छ । तसर्थ देशको आर्थिक समृद्धिमा वनको योगदान अभिवृद्धि गर्ने राष्ट्रिय उद्देश्य रहेकोमा, वन पैदावरको दिगो आपूर्ति गर्ने दिशामा उन्मुख नीति तर्जुमा गर्न आवश्यक देखिन्छ ।

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May God bless you all!

Acronyms

AAH	Average Annual Harvest
AHP	Analytic Hierarchy Process
BZCF	Buffer Zone Community Forestry
BZM	Buffer Zone Management
ColF	Collaborative Forestry
CMF	Community Managed Forests
CF	Community Forest
CFUG	Community Forest User Group
CI	Consistency Ratio
C&I	Criteria and Indicator
ColF	Collaborative Forestry
DBH	Diameter at Breast Height
DFO	District Forest Official/ District Forest Office
DFRS	Department of Forest Research and Survey
4Ds	Dead, Dying, Diseases and Deformed
DoFs	Department of Forests
DRR	Disaster Risk Reduction
Ei	Economic Indices
FGD	Focus Group Discussion
FMP	Forest Management Plan
GDP	Gross Domestic Product
G/R Ratio	Growth to Removal Ratio
HA	Hectare
HHs	Households
INGO	International Non-governmental Organization
ITTO	International Tropical Timber Organization
IVI	Importance Value Index
LF	Leasehold Forestry
MCA	Multicriteria Analysis
MFSC	Ministry of Forests and Soil Conservation
MoFE	Ministry of Forests and Environment
MOI	Management Option I
MOII	Management Option II
MOIII	Management Option III
MOIV	Management Option IV
OHF	Other Hill Forest
OTHF	Other Terai Hardwood Forest
PCA	Principal Component Analysis
PRA	Participatory Rapid Appraisal
SCF	Schima Castonopsis Forest
SDGs	Sustainable Development Goals
SRF	*Shorea robusta* Forest
UNEP	United Nations Environment Programme
UN	United Nations
VDC	Village Development Committees

Preface

I have been involved in the forestry sector of Nepal since 2001. I have worked and interacted with several researchers, policymakers, planners, international and national forestry experts, and forest users on different aspects of the forestry sector in Nepal and beyond. Following the Government of Nepal's recognition of community forestry as a strategy for forest conservation and rural development in late 1978, many studies have been conducted on the contributions of community-managed forests (CMFs) focusing on social and economic aspects of local communities. While working as a researcher, policy reviewer, and programme implementer, I have hardly seen any change in the goal of CMF.

From a period of undermanaged forestry and resultant forest degradation to the present day, there have been a lot of changes in the forestry sector. Denuded hills and flat plains are covered by greenery, a fact we all are proud of. However, whether forests are gaining in quality or not has yet to be examined. Similarly, planners ignore the plight of over-mature trees, which are degrading. Likewise, community forest user groups are investing community funds in various community development activities, which are socially recognized, but they do not acknowledge that they need to focus more on human well-being. Based on my knowledge and personal experience, I decided to undertake this research whether we are following the same motto of conservation that we adopted over four decades ago are there have been any changes.

This dissertation carried out for partial fulfillment of the requirements for the Doctor of Philosophy (Ph.D.) degree at the Institute of Silviculture, University of Natural Resources and Life Sciences, Austria. 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 2016 to 2018. The fieldwork was carried out in nine community-managed forests, and in which major focus was on the long-term data of the Institute of Forestry, i.e. Kankali community forest and Tebrikot community forest respectively in Chitwan and Kaski districts of Nepal. The research adopted both qualitative and quantitative approaches. It assessed contribution to the green economy focusing on resource sustainability, human well-being, carbon emission and appropriate policy options for community-managed forests. The work has produced seven papers, among which five were considered for thesis production.

List of Publications

This thesis is based on the work presented in the following papers, which are referred to in the text by the corresponding Roman numerals.

(I) Baral, S., & Vacik, H. (2018). What Governs Tree Harvesting in Community Forestry—Regulatory Instruments or Forest Bureaucrats' Discretion? ***Forests,*** *9* (10), 649.

(II) Baral, S, Gautam, A.P and Harald Vacik, H. (2018). "Ecological and economical sustainability assessment of community forest management in Nepal: A reality check. ***"Journal of Sustainable Forestry*** 1-22.

(III) Baral, S., Chhetri, B. B. K., Baral, H., & Vacik, H. (2019). Investments in different taxonomies of goods: What should Nepal's community forest user groups prioritize? ***Forest Policy and Economics,*** *100*, 24-32.

(IV) Baral, S., Gauli, K., Paudel, A., Basnyat, B., Upadhyaya, R., & Vacik H. (2019). Factors affecting fuelwood consumption and CO_2 emissions: an example from a community-managed forest of Nepal. Submitted to ***Journal of Energy Research & Social Science***

(V) Baral, S., Khadka, C & Vacik, H. (2019). Using MCA tools for evaluating community-managed forests from a green economy perspective: Lessons from Nepal. Accepted with minor revision in ***"International Journal of Sustainable Development and World Ecology".***

Following additional paper were produced/published as a part of the PhD research but not included in the thesis:

(I) Baral, S., Gaire, P. N., Aryal S., Pandey M., Rayamajhi S., Vacik H. (2019). Growth Ring Measurements of *Shorea robusta* Reveal Responses to Climatic Variation. ***Forests,*** (10), 466. doi:10.3390/f10060466

(II) Baral, S., Vacik H., Chettri B.B K., & Gauli, K. (2018). The pertinent role of forest inventory in making choice of silvicultural operations in community forests of Nepal. ***Banko Janakari Journal,*** Special Issue No. 4, 2018

1 INTRODUCTION

1.1 Background

About 2.4 billion people worldwide rely on forests for their livelihoods, particularly for energy, food and other subsistence needs (FAO, 2018). A paradigm shift in forest management from the state to the community has been introduced across the world (Aryal *et al.*, 2019; Gilmour, 2018). Community forestry (CF) promotes sustainable and more equitable forest management in many developing countries (Gross-Camp *et al.*, 2019). In 1970s, CF evolved in Nepal as a result of the "Himalayan environmental crisis", to address the problems of deforestation and environmental degradation (Ives & Messerli, 1989). Further it institutionalized through the Forest Act 1993 and Forest Rule 1995 in Nepal. The Forest Act 1993 envisions forest user groups as autonomous local institutions comprising village residents using common forests, with rights to independently manage and undertake decisions regarding protection, management, and utilization of forests, including harvesting and sale of forest products (Pokharel, 2008; Acharya, 2002). With the passage of time, an extensive forestry reform process has been made in the policy and guidelines to make community-managed forests (CMFs) more people-centric; however, they are becoming more complicated in practice (Ribot, 2009; Ribot *et al.*, 2006). As Nepal is transforming to federalization, the federal government is bringing new forest act and regulations, and the provincial governments are developing federal forest act and regulations, which may pave the way to manage forest appropriately.

Starting with CF, several approaches of CMFs were introduced, which subsequently became vehicles for forest conservation (Bhandari *et al.*, 2019). The various regulatory frameworks introduced during the four decades of CMFs somehow have not exactly become instrumental in utilizing forest resources (Basnyat *et al.*, 2018a, b; Toft *et al.*, 2015) because of the deeply engrained mindset of policymakers and forest bureaucrats, as well as local communities. As a result of poor forest management practices, forests are either over-mature or dense with low-quality trees (Baral *et al.*, 2018b; Subedi *et al.*, 2014). Subedi *et al.*, (2014) and Thomas (2008) argue that the conservation approach of CF is responsible for hindering the economic potential of forests.

Despite huge investment by government and international nongovernmental organizations (INGOs) in CMFs, the real benefit from forests in terms of their potential use has not materialized (Subedi *et al.*, 2014). The forestry sector has a strong potential to contribute to the green economy and more sustainable society (Gross-Camp *et al.*, 2019), in particular by meeting the green economy objectives, mainly through biomass energy, green infrastructure building and carbon sinks (UNEP, 2011a). Trade-in forest products and services is an important driver in the transition to a green economy. Forest products such as timber, firewood and non-timber forest products (NTFPs) and services, namely tourism, biodiversity and carbon, contributed to nearly one-third of the Gross Domestic Product (GDP) of Nepal, where forest products, mainly timber and firewood, contributed to 9.48 percent of the GDP (NFA, 2008). Of the total timber sold in Nepal, CFs alone contributed nearly two-thirds of the supply (DoF, 2018a), which is much less than their capacity. Local communities, who have been managing forests for years, are unwilling to manage forests just for subsistence use as they are not able to realize the economic potential of forests (Maryudi *et al.*, 2012). As a result, CMFs are questioned for their role in sustainability, efficiency, equity, democratic participation, and poverty reduction (UNDESA, 2012).

There are two schools of thought governing CMF in Nepal; the first is the conservative thought that trees should not be cut, and forests should be protected, whereas the second is concerned with maximizing economic returns by cutting trees (Yadav *et al.*, 2009). However, sustainable resource management practices, including silvicultural operations, are largely ignored in community forestry. Managing natural uneven-aged forests without considering appropriate silvicultural operations is one of the bottlenecks to maximizing the economic returns (Nolet *et al.*, 2018; Wang *et al.*, 2004).

A growing number of research works have assessed the linkages between the Sustainable Development Goals (SDGs) and other existing practices of CMFs. Such studies have focused on explaining the linkages between the various approaches of management and the SDGs (De Jong *et al.*, 2018; Gratzer & Keeton, 2017). CF is being implemented with a focus on human development and stability of forests. United Nations adopted the SDGs in 2015 to meet the human needs and overall stability of the environment (Agarwal, 2018), where the green economy pathway can be a means to bridge CMFs towards meeting SDGs. In case the CMFs are managed from the green economy pathway, forest management can be transformed from a conservation-oriented one to a much more broad-based strategy of forest use towards meeting SDGs by fulfilling various targets in Nepal (Aryal *et al.*, 2019).

1.2 Rationale of the Study

CF is one of the major forest management programmes adopted by the Government of Nepal with the strategy of community participation in the management of national forests (KC *et al.,* 2014; Baral *et al.,* 2009; Bartlett, 1992). It is directly or indirectly contributing to human well-being by reducing environmental risks and increasing the self-reliance of forest products (Walelign & Jiao, 2017; Paudel *et al.,* 2014). The CMF has the potentiality to supply 1.31 million cubic meters of timber annually (Subedi *et al.,* 2014). However, CMF is hindered by imperfect policy, legislative and bureaucratic hurdles, along with high transaction costs, on the harvesting of forest products (Basnyat *et al.,* 2018a; Baral *et al.,* 2018c). As a result of this, the volume of timber import is increasing in Nepal despite the country's huge potential to meet domestic needs (Subedi *et al.,* 2014; Kanel *et al.,* 2012). According to the Federation of Forest-Based Industry and Trade Nepal, 0.83 million m3 of timber was imported from Malaysia, Indonesia, Burma, Vietnam, New Zealand, Denmark, Africa, and Australia in 2015 at a cost of NRs 88 billion. At the same time, about 1 million m3 of timber from Nepal's forests was decaying and wasted due to strict regulations against extracting dead trees (The Himalayan Times June 20, 2016). The growth and removal of forest products should be balanced in such a way that forest resources will not be over- or under-stocked (Butt & Price, 1999). Baral *et al.,* (2018a) and Oli & Treue (2013) observe that positive forest cover changes in the community forests of Nepal, but they are not solely the outcomes of sustainable forest management. However, in-depth study of the ecological and economic sustainability of forest is needed to reach a definitive conclusion. DFRS (2015) shows that the growing stock volume of forests has declined despite increment in forest cover. This begs the question of whether forests are being managed sustainably or not. If the present trend continues, the economic potential of the forest is likely to decline.

In addition to this, conservation-oriented management in Nepal has further undermined the economic potential of CMFs. Forests are not technically managed, and silvicultural operations and forest harvesting are not carried out systematically (Yadav *et al.,* 2009; Bansyat *et al.,* 2018b). As a result of poor silvicultural practices, forests are dense with either over-mature or low-quality trees (Bansyat *et al.,* 2018b; Yadav *et al.,* 2009). The conservation-oriented management of CMFs over the last four decades has less practical relevance and is less likely to contribute towards ecological and economic sustainability (Kant, 2013). Bhandari *et al.,* (2019); Farley (2010) and Yadav *et al.,* (2009) argue that the conservation approach is hindering the realization of the economic potential of CMFs and, thereby, undermining their contributions towards the well-being of local communities.

Not only are CMFs conservation-oriented, but a blanket approach is being practised towards CMFs, which vary in terms of community, region, forest type, and forest dependency (Gelo, D & Koch, S.F, 2012). The degree of dependency on forest resources and management objectives in the hills differs from those in the terai; however, management interventions are almost identical and address neither the needs of local communities nor forest conditions. Appropriateness of community forests in the lowland terai always remained in question, considering the community composition, dependency on forest resources and economic potential of the forest (Gelo, D & Koch, S.F, 2012; Lversen *et al.*, 2006; Baral, 2002), was overlooked.

Forest sustainability and economic well-being of the local community is crucial for enhancing the contributions of CMF to the green economy; these considerations must be taken, together with sustainable management of forest in accordance with community needs. Though CMF has positive outcomes on social and environmental aspects, it is weak on economic and ecological aspects (Utting, 2015; Chhetri *et al.*, 2013; Lund *et al.*, 2009). Likewise, there is a dearth of information to assess forest sustainability from the ecological and economic lens and its appropriateness in different physiographic regions of the country. Recent scholarly works primarily focus on examining the impacts of CMFs on livelihoods, promotion of good governance, and improvement in forest conditions (Lund *et al.*, 2014; Paudel *et al.*, 2014; Thomas, 2008; Pokharel *et al.*, 2007; Malla *et al.*, 2003). Karki (2013) emphasises exploring the role and contributions of CMF towards the green economy in order to ensure the sustainability of forests. Hence, CMF's success and sustainability should integrate ecological sustainability, social equity, and economic efficiency for long-term use of the resources so that the expectations of users and society at large remain consistent (Hanna & Munasinghe, 1995a cited in Pagdee *et al.*, 2006; Agrawal, 2001). The above discussion points at the need for exploring ecological and economic sustainability of CMF. This will provide opportunities for improving the CMF practices so as to better contribute to sustainable growth and/or explore innovative models that adequately address the heterogeneity context. In order to examine the pathway of the green economy in CMF, the thesis draws on an array of the theoretical framework and methodological approaches to the green economy.

1.3 Objectives

The main aim of this research is to understand the CMF from the green economy perspective, which focuses on the three pillars of the green economy, viz. reasons for controlling forest harvesting practices, human well-being and low carbon emission. This is further addressed through the following specific objectives:

- Understanding whether regulatory instruments or bureaucrats' discretion leads to forest harvesting,
- Identification of the impact of forest harvesting practices on ecological and economic sustainability,
- Examination of community forests' resource flow on different taxonomies of goods, including effects on households' well-being,
- Assessment of the relationship between socio-economic factors and carbon emission, and
- Exploration of appropriate CMF options for enhancing the green economy

1.4 Research Questions

Table 1: Research questions, methods of data collection and means of verification

Research questions	Mean of verification	Data collection
How do regulatory instruments including Forest Management Plans (FMPs), or forest bureaucrats, determine the harvesting practices in Nepal's CMFs?	Forest stand condition Actual and allowable harvesting practices Quality and health of forest	Forest inventory Document analysis of records, minutes and management plan Policy document review & analysis
How do CMFs contribute to ecological & economic sustainability?	Forest stand condition, Extent of extraction of forest resource especially timber Maintenance of tree species diversity	Forest Inventory
How the income from CMFs is distributed and which well-being categories are benefiting?	Private goods Public goods Common goods	Household survey Key informant interview, focus group discussion
How socio-economic factors had affected on the amount of carbon emission?	Types of energy consumptions, Number of members in households, Per capita income, Education	Household survey Key informant interview, focus group discussion
Which forest management approaches should now remain in the priority?	Resource sustainability Human well-being Carbon friendly development	Stakeholder workshops Expert interview Multicriteria-analysis

1.5 Structure and Organization of the Thesis

Chapter 1- presents the core argument to explore CMF practices, framing influence of the governing knowledge discourse and research which undermines the green economy of the nation. The thesis builds on the argument using the framework of the four major aspects of the green economy which examine the changing dynamics of CMF practices, including, silvicultural options; regulatory instruments, resource sustainability; and reinvestment and carbon friendly development. The argument is developed drawing on the five papers/publications included in this thesis.

Chapter 2- presents the theoretical and analytical basis of the research. The theoretical aspect largely focuses on the pillars of the green economy. The analytical framework presents research questions and the accompanying indicators to seek answers along the framework of the aforementioned pillars of the green economy.

Chapter 3- begins with a brief overview of the study's context within the system of community managed forest in Nepal, with a particular focus given to the specific study sites and justification for the selection of these sites.

Chapter 4- presents the research methodologies used in collecting the data. The remainder of the chapter further describes the tools used for the analysis of data.

Chapter 5- is a compilation of the findings from the five papers and the previous chapters to examine consequences of the practices associated with CMFs and green economy focusing on resource sustainability, human well-being, regulatory instruments in the forest harvesting and management approach for the realizing the green economy.

Chapter 6- explains the finding of the study with discussion and examines in detail the relationship between the CMFs and the green economy perspective.

Chapter 7- provides conclusions and recommendations for the policy makers, implementers and researchers.

2 THEORETICAL AND ANALYTICAL FRAMEWORK

2.1 Theoretical Framework

Green economy: Concept

The Rio'92 stressed that human beings can contribute to environmental conservation by advancing economic development (UNEP, 2011a). During economic crisis in 2008, politicians considered greening the economy (Brand, 2012) at global level and at national level (Karki, 2013) that might support in bringing economic sustainability. In fact, the global financial crisis coined the term "green economy". The governments and International Non-Governmental Organizations grappled this thought to reboot the economy in a more sustainable way (Georgeson *et al.,* 2017; Brand, 2012). As a result, several countries and organizations launched "green stimulus" programmes. The United Nations Environment Programme (UNEP) is an early champion, launching its green economy initiative in October 2008. However, there exists disparity between developed and developing nations; hence, the UN, in 2012, brought world leaders together in Rio+20 conference to bring them on one page. In the conference, 196 member countries state representatives signed the declaration titled 'The Future We Want', who overwhelmingly valued the concept of Green Economy both for Sustainable Development and Poverty Reduction (Karki, 2013).

In light of the Rio+20 conference, green economy or green growth is a new buzzword in sustainability discourses. Lorek & Spangenberg (2013) states that greening the economy is an old demand and a reemerging issue of policy debate since the early 1970s. However, green growth is a political catchword, coined to overcome reservations of the business sector for all kinds of 'greenery', regardless of the potential economic benefits (ibid). Business has always been at the core of the green economy concept. Moreover, the green economy also produces economic benefits which are at the heart of a nation's development (UNEP, 2011a, b, c).

Green economy amongst its diverse fields has a blurred boundary. Transitioning to a green economy requires a new mindset of managing forests (Karki, 2013). UNEP (2011) explains three major foci- resource sustainability, improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities and low carbon emissions with appropriate policy and forest management options.

Community managed forests response to a green economy

Globally, Nepal appears at the forefront of CMF practices (Gilmour, 2016). The Forest Act of 1993 and Forest Regulation of 1995 provide the CMF with strong instruments of the legal base. Later, the Forest Policy of 2000 focused on community empowerment and institution building for forest management and community development. Initially, the focus of CMF was mainly on the conservation of degraded forests (Bhandari, *et al.*, 2019). The then Ministry of Forest and Soil Conservation (MFSC) decreed the Forest Policy 2015 (MFSC, 2015) with vision of "forestry for prosperity". The vision was later revised by the Ministry of Forests and Environment (MoFE) in the Forest Policy 2018 as "Prosperous Nepal and Happy Nepali", which gave priority to the green economy and green employment through scientific and sustainable management of forest resources. Evolution of the green economy thinking would be a positive development in Nepal's CMFs since forest managers can be better rewarded or compensated for their efforts in producing ecosystem services. CMFs and their ecosystems play a vital role in realizing forests as a vehicle for achieving green economy with the characteristics of renewable resources, biological diversity, reduced environmental risks, increased productivity and efficiency of natural resource use, natural capital used within ecological limits and reduced adverse environmental impact and improved natural hazard/risk management which contribute to sustainability (Barkin & Fuente, 2013).

CMF has the potential to contribute to all three (economic, environmental and social) pillars of the green economy by investing in community development, forest management, livelihood improvement, and green infrastructures, such as plantation, tree stands improvement and alternative energy (Karki, 2013). This research sees the sustainability of forest management as meeting the green economy goals - human well-being and social equity, and low carbon emission either from the forest stocks or from the utilization of the stock. Each CMF has different management objectives; however, the primary goal remains the same, i.e. improving human well-being and promoting forest resource conservation, with the active involvement of local communities. However, the sustainability of CMF in the future in general and its contribution to the realization of the green economy, in particular, depend on management and sustainable resource utilization (NPC, 2019).

Community managed forests, green economy and resource sustainability

Green economy is a cross-disciplinary field of study broadly concerned with the transformation of today's policies and practices towards resource sustainability. Moreover, sustainable development goals focus also on the brown economy (World Bank 2013[1]- describes economic development that relies heavily on fossil fuels and does not consider the negative side effects that economic production and consumption have on the environment), which couldn't fulfill the area of natural resource sustainability in which the green economy is a new initiative that focuses on resource sustainability (Brand, 2012) with no or minimum impact on the environment. The economic system needs transformation towards environmental sustainability and increased resource efficiency, strengthened resilience to environmental pressures and risks, and more and smarter use of green technologies and innovations. Forests are a critical link in the transition to a green economy–one that promotes sustainable development and poverty eradication (UNEP, 2011a). Brundtland *et al*., (1987) defines sustainability as meeting the needs of the present generation without compromising on the livelihoods of future generations.

Ecological and economic sustainability accounts for balancing societal needs while maintaining natural resources (Costanza *et al*., 2007; Common & Stagl, 2005; Sample, 2004). This can be achieved either by regulating consumption at the societal level or by regulating management at the forest level. Consequently, sustainable forest management remains one of the primary priorities of global development goals (Sample, 2004; Prabhu, *et al*., 1999), where integrated approaches with ecological assessment and optimal utilization are indispensable for appropriate measurement of overall resource sustainability, assessed through criteria and indicators (Ortiz-Urbina *et al*., 2019; Khadka & Vacik, 2012).

Community managed forests, green economy and human well-being

The concept of 'green economy' has been brought into the mainstream policy discourse at the international level as a powerful tool in achieving sustainable economic development that promotes human well-being (Brand, 2012). Forests produce a range of both tangible and intangible ecosystem services and have an enormous potential to contribute to the green

[1] https://www.worldbank.org/en/news/feature/2013/06/25/growing-green-europe-and-central-asia, accessed on 12 June 2019

economy and human well-being. Despite being fundamental to human well-being, the natural capital, which includes forests, remain grossly undervalued or not valued at all, within our conventional economic system.

This concept, therefore, challenges the notions that: (i) there is an inevitable tradeoff between environmental sustainability and economic progress and (ii) a green economy would restrain growth and perpetuate poverty in the developing world (Borel-Saladin J M & Turok I. N., 2013). Local communities are attempting to maintain their quality of life and avoid the degradation of their ecosystems on the basis of their own cosmologies, which are derived from profound interactions of society. To enhance it, policymakers must, at a minimum, provide enabling environment to the local communities.

Community managed forests and low carbon emissions

CMFs have been conserving forests mainly to fulfil a community's basic needs: fuelwood and fodder. Fuelwood is a primary source of energy throughout the world and more especially in the developing countries, and the consumption behaviour has changed over time (Suwal, 2013). One-third of forests are managed by communities. CMF is one of the main sources of carbon stock. In recent years, various alternative energy sources have been explored for fulfilling energy needs. However, biomass, especially fuelwood, still constitutes a primary energy source in rural areas of developing countries (Nepal, 2008). More than one billion people in Asia depend on biomass as their main source of energy (Thapa, 2006). Nepal is one of the highest traditional fuel-consuming countries in Asia because of its high dependency on traditional biomass fuels (Suwal, 2013).

Using alternative energy or shifting to the energy-efficient options, such as biogas, solar power, wind and clean electricity are considered to be the major options available for the mitigation of greenhouse gases (Karki, 2013; WECS, 2013). CMFs plays a vital role by reinvesting their resources in enhancing the community economic condition which support in energy ladder shifting from traditional energy use to improved state of energy consumption. This supports to change the behaviours of the communities to use biogas, solar power and electricity (Oldekop *et al.*, 2019; Suwal, 2013).

CMFs, appropriate forests management and green economy

CMFs confer to landscape restoration, although their success varies across the world (Shrestha *et al.*, 2010). They involve local people at different levels of forest management, which varies with context. The global community, including Nepal, has accepted that the green economy can be an important strategy (Karki, 2013) especially for developing world. However, so far, there has been no clear policy, strategy and action plan in Nepal to achieve a green economy. The country is in the process of reformulating its forest policies at the provincial level and proposing forest management practices appropriate for it. Both federal and provincial governments emphasize the need for considering the sustainability dimensions in policy processes to fulfill long-term sustainable forest management (SFM). Different forest management practices are crucial in the immediate and long-term way forward for forest management, in which the green economy guides the choices between contrasting forest management options by taking prosperity and sustainable forest management at hand.

Guided by the above discussion, figure 1 presents a framework, how CMF can contribute to the green economy, specifically focusing on 4 Ps (People, Policy, Perspectives, and Practices). Taking CMF as an illustrative case, I first explored (a) resource sustainability (b) human well-being and social equity, (c) low carbon emissions (d) appropriate forest management.

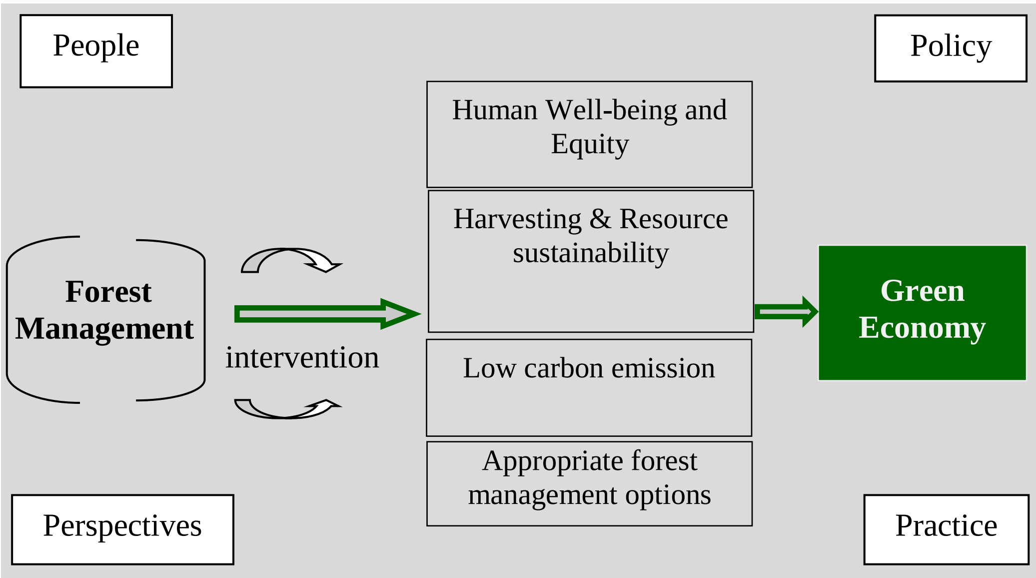


Figure 1: Conceptual Framework

2.2 Analytical Framework

Various researchers- research projects, institutions, and disciplines have developed distinct ratified frameworks to frame forest management, such as the Department for International Development (DFID) Framework, Sustainability Framework, Millennium Development Goals (MDGs), Sustainable Development Goals (SDGs), green growth, and green economy. These frameworks are being used worldwide to give justice to forest dependents. Whichever framework is utilized all follow economic, environmental and social well-being of communities and forests. All frameworks attempt to conserve forests while and fulfilling people's needs (Ortiz-Urbina *et al.*, 2019; Charnley & Poe, 2007). This thesis empirically investigates in reviving CMFs in order to better enhance the realization of the green economy. Framing green economy in the CMFs can support to meet the SDGs goal 1- reducing poverty, goal 13 - carbon capture and storage and goal 15- biodiversity conservation. Nevertheless, other goals are indirectly meet if forests are managed from green economy perspectives.

The green economy is assessed in terms of resource sustainability, human well-being and social equity, low carbon emission, and appropriate policy and management practice. This suggests that, if the country can develop a policy which can accommodate the pillars of the green economy, in the future, the country will not need to depend on others (Joshi *et al.*, 2018). Building on green economy perspective, the research has explored how the CMF policy contributes to the realization of the green economic objective. Figure 2 presents the analytical framework. Papers I and II analyse forest management through the lens of resource sustainability. Likewise, paper III analyses forest management through the lens of human well-being and social equity, papers III and IV analyses low carbon emissions, and paper V analyses, appropriate policy and management practice.

Paper I - What Governs Tree Harvesting in Community Forestry- Regulatory Instruments or Forest Bureaucrats' Discretion? - analyses how regulatory instruments including FMPs, or forest bureaucrats, determine the harvesting practices in Nepal's CMFs. This further investigates tree harvesting practices in CF and its effects on forest sustainability, using the forest inventory panel dataset of three consecutive periods (2010, 2013 and 2016), together with qualitative information obtained by key informant interviews and a review of records of the community forest users' group.

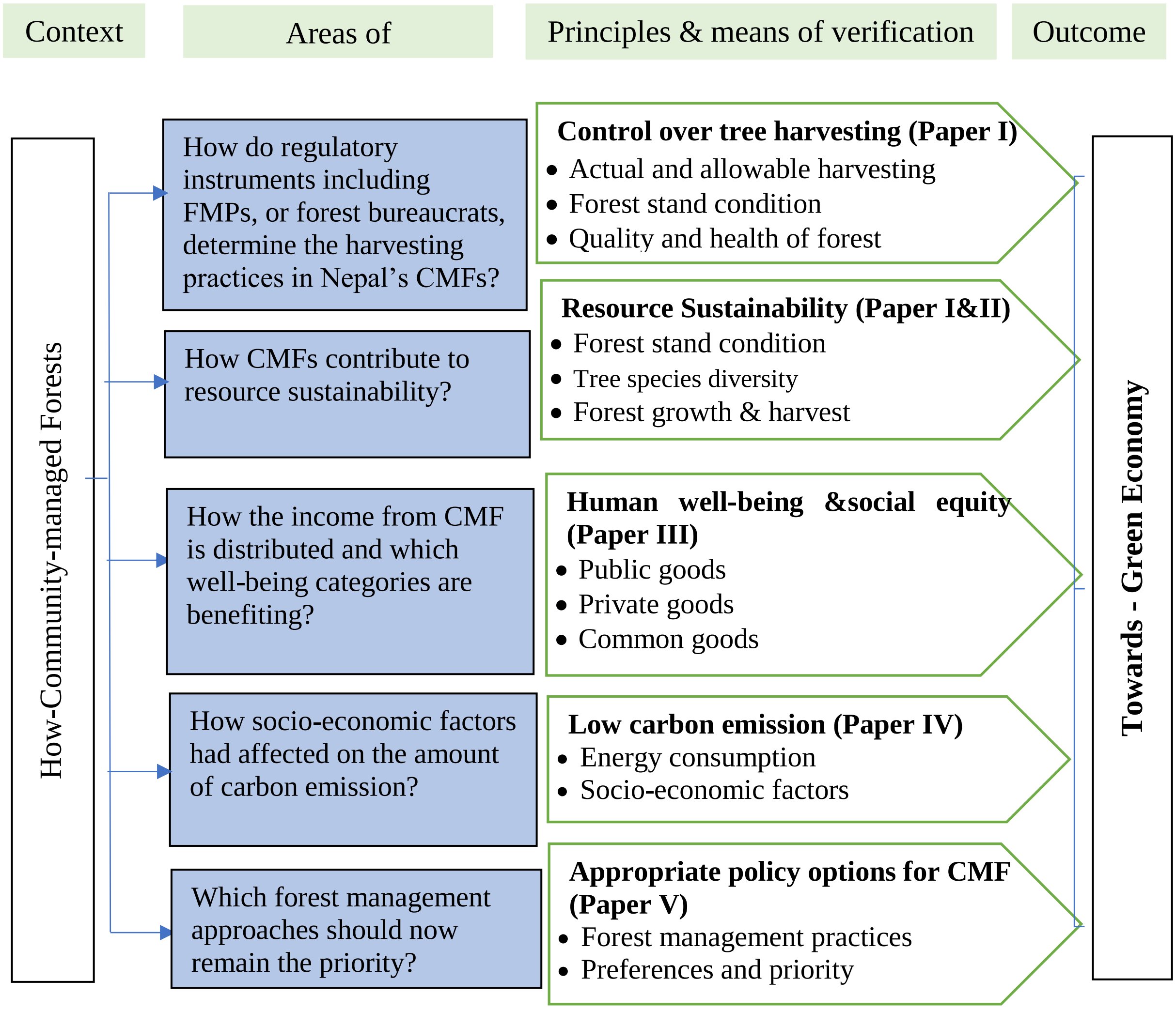


Figure 2: Framework illustrating CMFs towards the realization of green economy

Paper II- Ecological & economical sustainability assessment of community forest management in Nepal: A reality check - investigates the questions of how CMFs on resource sustainability. CMFs, in two provinces are studied, representing four forest types. The sustainability was assessed based on species composition, stand density, growing stock volume, and growth-to-removal ratio using inventory data of 109 permanent sample plots from four consecutive intervals of three to five years.

Paper III- Investments in different taxonomies of goods: what should Nepal's community forest user groups prioritize? - examines how the income from CMFs are distributed and which well-being categories are benefiting. Following the concept of economic goods, this paper further elucidates how CMFs especially community forest, investment in different taxonomies of goods contributes to households' well-being.

Paper IV- Factors affecting fuelwood consumption and CO2 emissions: an example from a community-managed forest of Nepal- accounts for which factors contribute to the amount of energy consumptions from the CMF. Both qualitative and quantitative information were collected from household survey and FGDs. A regression model was run with the support of major demographic and socio-economic variables and the carbon balance was calculated in reference to carbon sequestration from forest stock and taking household carbon dioxide emissions.

Paper V- Using MCA tools for evaluating community-managed forests from a green economy perspective: lesson from Nepal- identify the criteria and indicators to assess green economy, explore the forest management practices (passive, active, scientific and multiple) and, further examine which forest management options should now remain in the priority and where the decision makers should focus.

3 STUDY CONTEXT

3.1 Country Background

Nepal is a mountainous country lying between China to the north and India to the south, east and west. Its total area is 147,181 km^2. The altitude ranges from 56 m above sea level in the south-east plain area (terai) to 8,848m in the north (CBS, 2017). With its varied topography and elevation, Nepal experiences a wide range of micro-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 (Singh *et al.*, 2011). The total population is 28.3 million, which has been growing annually at the rate of 1.32 percent, and the population density is 180 persons/km^2 (CBS, 2017). The national average household size has decreased from 5.44 in 2001 to 4.88 in 2011. About 86 percent of the total population lives in rural areas. Nearly 60.9 percent of all households use firewood as the major source of fuel for cooking (CBS, 2016). The per capita GNP of the country was US$877 in FY 2016/17 and is estimated to increase to US$1,012 in FY 2017/18 (MoF, 2017). 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, 2011). 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 (ibid). Forest and shrub together cover about 5.83 million ha, which is 44.5 percent of the total land area of the country (DFRS, 2015). The per capita forest area is 0.27 ha (MoF, 2017). There has been a significant and increasingly important value of remittances for a decade or so; however, agriculture is still the mainstay of the economy, which, combined with forestry, has a share of 33.1 percent in the national income (ibid). Administratively, the country is divided into seven provinces, seventy-seven districts, and 753 local governments. The federalization devolution of power and restructuring of the country is ongoing rapidly. Numerous plans, guidelines and policies are framing according to the new national structure both at national and provincial level.

3.2 Community-managed Forests in Nepal

As CMFs initiation, the National Forest Plan (1976) laid the foundation of CF in Nepal by recognizing the need for local people's participation in forest management (Kanel *et al.*, 2005). The Master Plan for Forestry Sector (MPFS), prepared in 1988, spurred the development of CF by including it among its six primary development programs. Building on early successes and decentralization policies, CF expanded rapidly throughout the 1990s under the auspices of the Forest Act (1993), Forest Regulations (1995), and the CF Guidelines (1999) (Gritten *et al.*, 2015) and revised in 2003 and 2014. In due course of time, Nepal's CF becomes a successful example in forest conservation worldwide. CF is one of the CMFs which is a patch of national forest land handed over by the government to the communities in the name of community forest user groups (CFUGs) for management and use. CFUG is an autonomous institution with management, extraction and exclusion rights governed by its constitution and operational plan approved by the government.

Table 2: Overview of community-managed forests

Type of CMF	Policy objectives	No. of years of operation	No of CMF	Total number HHs	Area (ha)	% of coverage
Community Forestry	Conserve, manage and utilize forests to fulfill demand of local forest products of local communities	**33** (MPFS 1988)	22,266	29,07,871	2237670.52	38.39
Collaborative Forestry (ColF)	Fullfill demand of forests products of national and regional level while contributing on national economic development along with maintaining economic stability	**16** (CFM Guidelines, 2003)	30	864015	76012.26	1.30
Leasehold Forestry	Restore forests and reduce poverty	**26** (FA, 1993)	7506	71753	43957	0.75
Buffer Zone Community Forestry	Conserve, manage and utilize forests to fulfill demand of local forest products of local communities	**23** (BZMR, 1996)	377	677,000	198,550	3.40
Total CMF			**30,179**	**1612768**	**2556190**	**43.84**

Note: Total forest are is 5,828,300 ha

Source: DFRS, 2015, DNPWC, and community forestry bulletin, 2017/18

The other form of CMFs are collaborative forestry, leasehold forestry and buffer zone community forestry (BZCF). Collaborative forestry (ColF) was initiated after the Forest Policy 2000 to address terai related issues, such as inclusion of distant users. It is a joint management of large block of government forest by the community and government. One of its objectives is to increase national and local income through active management of terai and inner-terai forest. Leasehold forestry (LF) is another type of CMF where patches of national forests are handed over to the groups of poor households for income generation activities. It was introduced in 1992 and only shrubland, land recovered from forest encroachers and natural calamities, forests with less than 20% crown cover, and areas vulnerable to soil erosion are potential areas for leasehold forestry (MFSC, 2002). The Buffer Zone Management (BZM) Rules 1996 has opened space for local participation in conservation initiatives and new avenues for constructive dialogue between park authorities and local people. This has indicated a potential shift from historically hostile park-people relations towards collaborative management of protected areas (Paudel *et al.*, 2007). The rule allows hand over the buffer zone area of protected areas for management and use of forest resources.

Nepal appears to be a global leader in decentralized forest management, which is backed by strong legal instruments, viz. Forest Act 1993 and Forest Regulation 1995. Both the Act and Regulation envision forest user groups as local institutions comprising village residents using forests, with rights to independently manage and take decisions regarding protection, management and utilization of forest, including harvesting and sale of forest products (Pokharel, 2008; Acharya, 2002). The CF was a pioneering initiative of the CMF approach, which was initiated as a measure for conservation and subsistence utilization of resources. Altogether 2.9 million households are managing a total area of 22.37 million ha, which covers 22,266 CFs (DoF, 2017). As of CF other 7913 CMFs (ColF, BZCF and LF), cover 0.3 million ha and 0.9 million households (DoF, 2018).

The Forest Policy 2000 gave priority to community empowerment and institution building. The then MFSC decreed the Forest Policy 2015 (MFSC, 2015) with the vision of "Forestry for Prosperity", which was revised by the MoFE in 2019 to "prosperous Nepal and happy Nepali". The Forest Policy 2015 also gives priority to the green economy through scientific and sustainable management of forest resources. CMFs have multi-potentiality, which can contribute to the economic, environmental and social aspects. This is examined by investing income for community development, forest management, livelihood improvement, and green infrastructures, such as plantation, tree stand improvement, and alternative energy (Baral *et al.*, 2019).

3.3 Studied Community-managed Forests

This study used Nepal's CMFs as a case. In total nine CMFs, representing two provinces, viz. Gandaki and Province 3, and three districts, viz. Chitwan, Nawalparasi and Kaski, were selected for the study, and two community forests—one each from two provinces—were selected for in-depth study. These two forests Kankali and Tebrikot also represent two physiographic regions, terai- (where economically valuable forests exist) and mid-hills- (where the CF programme evolved) respectively (Table 3 and Fig. 3). These sites were selected as they were closely monitored by the IoF, because of the existence permanent research plots established by them. In addition, these sites had a long history of management (more than five years) and income generation by selling forest products. They also represent similar contexts, such as the location from the city center, forest management practices, objective of forest management, and community's dependence on forest products.

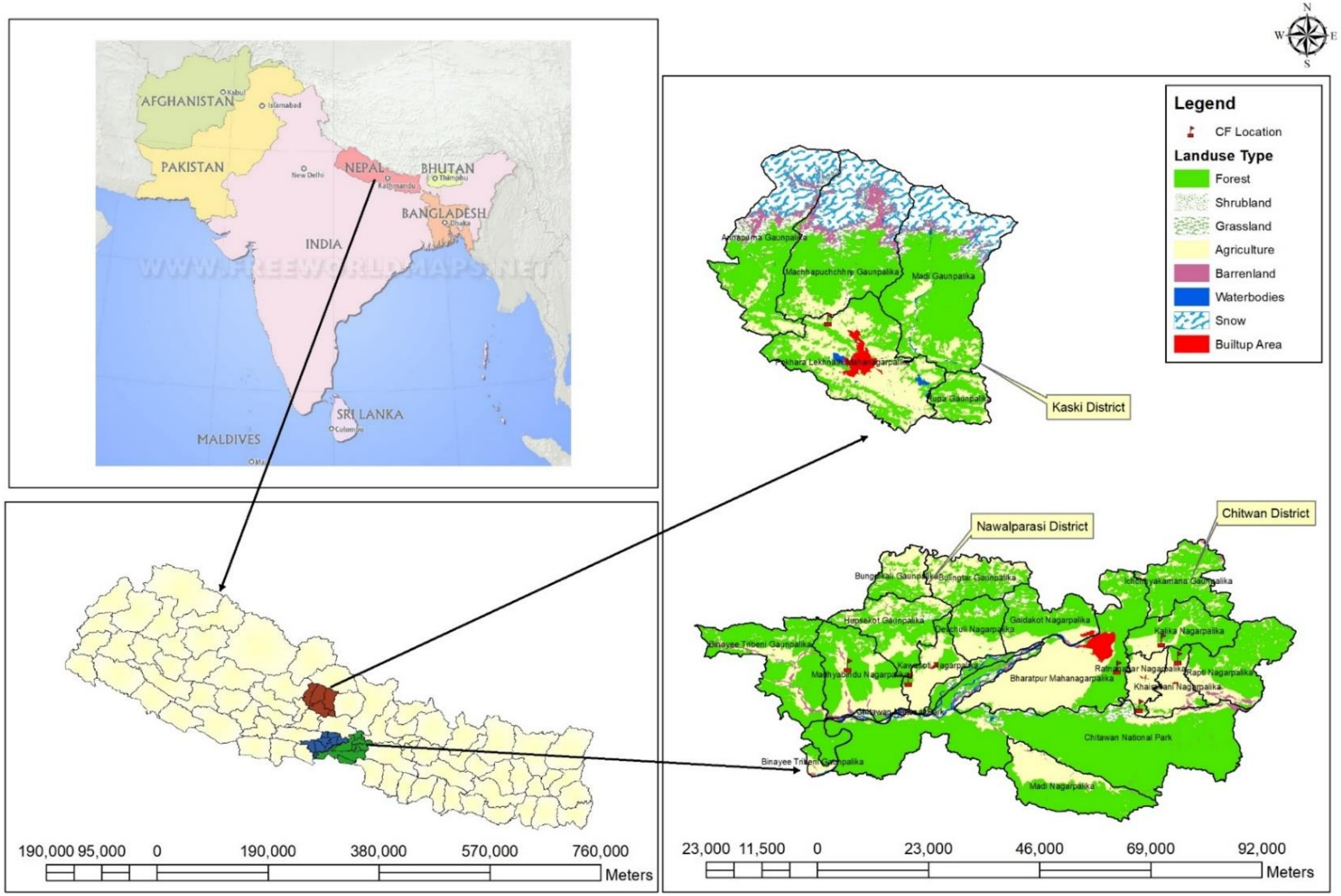
Table 3: General characteristics of the study site

Selected CMF	Attributes	Main forest types	Area (Ha)	HHs
Kankali CF	Multiple forest management	*Shorea robusta*	549.49	2065
Shree Janajagaran CF		*Shorea robusta*	232.87	400
Agingire CF	Scientific forest management	*Shorea robusta*	290	605
Dudhkoshi CF		*Shorea robusta*	498	881
Madyabindu ColF	Active forest management	*Shorea robusta*	588	3840
Tebrikot CF		*Schima castonopsis*	119.75	257
Akaladevi CF		*Shorea robusta*	199	102
Pipaltar Leasehold	Passive forest management	*Shorea robusta*	2.84	6
Mirgakunga Bufferzone Forest		*Shorea robusta*	3.33	3563
Total			**2483.28**	**11719**

Source: Field work and information collection from the management plan during 2016-2018

In addition, seven CMFs were selected from the two provinces, viz. 3 and 4 (Gandaki), for analysing the best forest management options from the green economy perspective. The study site was selected because I was working in the same sites and provinces for rest of the research questions since 2016.

Figure 3 : Location of study sites in Province 3 and Gandaki Province



For finding an answer to the research question V, the study focused from national to local level. Field investigations were carried out in Chitwan and Nawalparasi districts, where four forest management practices (passive, active, scientific, and multiple management) were available. Eight CMFs were selected two from each management practices, which cover about 2483.28 ha of forest area, of which 782.36 ha was covered by multiple management, 788 ha covered by scientific forest management, 906.75 ha by active forest, and 6.17 ha covered by passive forest management (Tables 3 and 4).

Table 4: Research questions and study sites

Research Questions	**Study sites**
How do regulatory instruments including FMPs, or forest bureaucrats, determine the harvesting practices in Nepal's CMFs?	Kankali CF, Khairani municipality, Chitwan district, Province 3, Ward 4
How do CMFs contribute to ecological & economic sustainability?	Kankali CF, Khairani municipality, Chitwan district, Province 3, Ward 4 Tebrikot CF, Pokhara metropolitan city, Kaski district, Province 4, Ward 25
How the income from CMFs is distributed and which well-being categories are benefiting?	Kankali CF, Khairani municipality, Chitwan district, Province 3, Ward 4 Tebrikot CF, Pokhara Lekhnath metropolitan city, Kaski district, Province 4, Ward 25
How socio-economic factors had affected on the amount of carbon emission?	Kankali CF, Khairani municipality, Chitwan district, Province 3, Ward 4
Which forest management approaches should now remain the priority?	Kankali CF, Khairani municipality, Chitwan district, Province 3, Ward 4 Shree Janajagaran CF, Madyabindu municipality, ward no 11 Kusunde, Nawalparasi, Province 4 Agingire CF, Khairhani Municipality, ward no 1,2, 3, 6, Chitwan, Province 3 Dudhkoshi CF, Bharatpur Municipality, ward no 8, Chitwan, Province 3 Madyabindu Collaborative forest, Kawasoti Municipality, 14 kodari, Nawalparasi, Province 4 Akaladevi CF, Kalika Municipality, Kaule 7, Chitwan, Province 3 Pipaltar Leasehold, Echyakamana VDC ward no 7, Chitwan, Province 3 Mirgakunga Bufferzone Forest, Ratnanagar municipality ward 6, Chitwan, Province 3

Source: Field work and information from the management plan during 2016-2018

4 RESEARCH METHODOLOGY

4.1 Research Design

The research followed the case study approach for holistic in-depth study (Collis & Hussey, 2009) as the researcher intended to carry out an intensive, detailed examination of the contemporary issues of CMF. Furthermore, the study deals with a technically distinct situation, which is based on multiple sources of evidence, and relies on the prior development of theoretical prepositions to guide data collection and analysis (Yin, 2003). Furthermore, the case study allowed for in-depth study of knowledge-related challenges from the perspective of participants (Gerring & McDermott, 2007). As described by Yin, (2014), I used both qualitative and quantitative approaches for data collection.

4.2 Study Approach

I carried out the fieldwork in two phases: the first from August 2016 to September 2017 and the second from June 2018 to March 2019. The first field study aimed at collecting information to answer research questions, which are: I) What are the regulatory provisions which control forest harvesting? The data for answering research question one is forest inventory, information from the minutes and financial records of CFUGs. II) How do CMFs contribute to resource sustainability? III) How is the income from CMFs distributed and which well-being categories are benefiting? For these research questions, local people's perceptions through household survey and focus group discussion (FGD) and records of minutes were analysed. The second fieldwork was done to collect information to answer research questions four and five, which are: IV) How socio-economic factors had affected on the amount of carbon emission? And V) What forest management approaches should now be prioritized?

I started fieldwork in consultation with academia at Institute of Forestry (IoF), Pokhara and forestry experts at national level. Similar consultation meetings were conducted with DFOs and CMF members in the studied districts. The consultations at national level and with the academia help to understand the policies of the nation and the sector priorities. Likewise, district level consultations help in selecting the CMF for the research and to understand the ground reality.

4.3 Data Collection Procedures and Methods

The study mainly relied on primary data, collected through both qualitative and quantitative methods (Table 5). The quantitative methods included forest inventory from the 109 sampled plots, including information analysis from CFUG records, a household survey of 377 households, and national, provincial and local level expert's consultation were carried out for multicriteria analysis. The qualitative methods included meetings, content analysis, key informant interviews (KIIs), and FGD.

Table 5: Various methodologies employed in the research

Areas of Enquiry	Inventory	Household survey	Record analysis	Multicriteria analysis	Written document analysis	Focus group discussion	Key informant interview
RS	*		*		*	*	*
HWB		*	*		*	*	*
LCE	*		*		*	*	*
AFMO				*		*	*

Notes: RS= resource sustainability, HWB= Human well-being, LCE= Low carbon emissions, AFMO= Appropriate forest management options

Ten enumerators were trained to carry out the forest inventory. They involved in the information collection for more than two months in the field. For the household survey, six enumerators were trained, and the researcher and the enumerators carried out a household survey with structured questionnaires. Questionnaires were first developed in English and translated into local language (Nepali). Although the study site and sampling procedures were common to all research questions, it was different for research question V; the sites, study designs and methods for data collection were different. I selected additional seven CMFs, including one studied previously for the research question and all of them are from terai regions.

4.3.1 Forest Inventory

Inventory data from permanent sample plots (of 2005, 2010 and 2013) were obtained from the IoF. The inventory of 2005 applied the 'coffee-house' design principle as the first plot was selected randomly and successive plots were laid to maximize the minimum distance to neighboring plots (Müller, 2001). Of the 68 plots laid in the terai forest, this study considered only 57, as data were missing for three plots and eight plots had been destroyed by infrastructure development and land conversions in 2010. Likewise, out of the 53 plots measured in the hills, information was missing for one plot; hence, only 52 plots were selected for the study.

In autumn 2016, a forest inventory was conducted in 109 plots by following the basic plot design of Meilby *et al.*, (2006), which includes three nested sub-plots. Trees with a diameter at breast height (DBH) of at least 10 cm were measured in a 20x25 m plot, trees with DBH of 4-9.9 cm were measured within an interior 10x15 m plot, and trees with DBH of 2-3.9 cm were measured within a 5x5 m interior plot. Furthermore, saplings were measured in 5x5 m plots, while seedlings were measured in 1x1 m plots. The parameters included species identification, positioning, DBH, and height of trees (***Annex IIa***).

4.3.2 Household Survey

For the household survey, first a list of households was obtained from the offices of the CFUGs. Participatory Rural Appraisal (PRA) tools were applied to disaggregate the users on the basis of wealth ranking. We followed three steps for assessing the well-being ranking: i) key informants, such as the village development committee secretary, teachers, local leaders, and those CFUG executives who had an idea of the social and economic status of each member household of the CFUG were identified. Snowball sampling methods were used where the respondents identified others to be included. ii) FGDs were held with the key informants in each settlement. During these, multidimensional aspects of well-being based on the Sustainable Livelihoods Framework of DFID and different livelihoods assets, such as physical, social, financial, natural, and human (Harbi *et al.*, 2018; Carney, 1998), were briefly explained to categorize households into different well-being categories. iii) After reaching consensus with the key informants on the well-being assessment indicators, a well-being ranking was carried out on the two groups separately (following checklist ***Annex IIg***). The participants of the groups separately classified the households into three different well-being categories: low, medium and affluent income households, which were further validated in joint plenary sessions between two groups. Table 6 presents the well-being assessment of two CFUGs.

Table 6: Number of households surveyed in the studied CFUGs (percent in the parenthesis)

Characteristics	Kankali	Tebrikot	Total
Low income	590 (28)	65 (25)	655
Middle income	1150 (56)	123 (48)	1273
Affluent income	325 (16)	69 (27)	394
Total CFUG member households	2,065	257	2,322
Sample size	217	160	377
Men	80 (37)	68 (42)	147
Women	137 (63)	92 (58)	230
Sample households' distribution			
Low income	60 (28)	40 (25)	100
Middle income	122 (56)	76 (48)	198
Affluent income	35(16)	44(27)	79

Source: Fieldwork 2016-2017

After the well-being ranking, a stratified random sampling technique was used to select households. Following Cochran (1977), I estimated sample sizes of 217 households from Kankali and 160 households from Tebrikot. I assumed a prevalence rate of 50% to allow maximum variability, with an allowable error of 5% at a 95% confidence interval. I divided the sample based on population probability of each well-being category; and households were selected randomly. Women respondents accounted for nearly half in both CFUGs.

Semi-structured questionnaire in the Nepali language was developed and pre-tested. Semi-structured interviews were conducted by following the questionnaires ***(Annex IIa),*** which covers key socio-economic elements, including household composition, education status, asset, sources of income, sales and consumption of crops, livestock, and forest products, membership/ representation in any organization in their village, and participation in training programs.

The enumerators (two males and one female in each site) were trained. The researcher, together with trained enumerators, carried out data collection between August 2016 and September 2017. To ensure the perspectives of a maximum number of household members, interviews were mostly undertaken either in the morning or in the evening at the convenience of the respondents; priority was given to household heads. The reason for ensuring the maximum number of household members was to extract in-depth information and allow self-triangulation. The interview commenced with giving overview of the study purpose so that the interviewers will understand the context and answer with limiting to the context.

4.3.3 Key Informant Interview

Key informant interviews were the main crux of the study to collect in-depth information about the primary issues prevailing in forest management through the past and present. Different levels of key informants were categorized based on the information being sought. The primary focus was given to the community level key informants- 10 (four female) from Tebrikot and 14 (six female) from Kankali. Based on prior knowledge about the study sites and scenarios, a list of personnel to be interviewed was prepared. Additional participants were further added through snowball sampling method to identify key informants. They were consulted for information on decision making and actual practices of tree harvesting. The key informants composed of the past and present executive committee members (4), forest guards (4), persons involved in harvesting operations (4), the CFUG staff and users (12). At the district level, 18-interviews were conducted with forest bureaucrats (9), school teachers (3), local political leaders (3) and women organization groups (3). Eight officials from the district forest offices-four from each study district- were interviewed to understand the role of policy provisions in CF in supporting reinvestment in the different taxonomies of goods and also to know which forest management practices can contribute to green economy with reference of the present scenarios of management. In addition, 16 community level key informants, one female and one male from each CMFs were interviewed to know the pros and cons of forest management approach for research question V. In total, 56 key informants were interviewed during the period of three years (2016-2019). A set of checklists (***Annex IIc, e***) was used to guide the follow of interview. It was developed differently for the community people and policy level actors. Almost all key informants were approached during the work period in their respective office or office canteen.

4.3.4 Focus Group Discussion

Focus group discussions (FGDs) are considered a very efficient way to gather information from different group dynamics in a short period of time. It is also used for data triangulation. FGDs were mainly conducted with communities' members to dig out the forest management information on the changing policy context and practices. Five FGDs were conducted in each CFUGs, particularly focusing on the marginalized group, women, the CFUGs executive members, occupational groups, and a mix group. Six to ten individuals, in each group, were invited for in-depth information collection and discussion. In total, 33 (13 female) users from

Kankali and 41 (16 female) from Tebrikot participated in the FGDs. Each FGD was began with giving the brief introduction of the researcher and overview of study to clarify the forest management goals and present scenarios, and how the forest can be managed from a green economy perspective. The discussion was carried out based on the guiding checklist (***Annex IId***). 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 noted during the FGDs. To maximise the available time for generating more information and make the discussion lively and participatory, each discussion was recorded a in a voice recorder with the permission of the group so that the researcher can engage totally in the discussion.

4.3.5 Content Analysis

A document review process was undertaken throughout my research process. An analytical and theoretical concept was drawn with reviewing the academic peer-reviewed papers and these developed addressing similar subject matter in the past. Written documents, minutes, and audit reports and records, especially those since 2005, were gathered. A content analysis of operational plans, community forest guidelines, plan and policy documents was done. In addition, I observed the general assembly and executive committee meetings of the CFUGs to understand how resources were allocated.

4.3.6 Multi-criteria Analysis

Multi-criteria-Analysis (MCA), is a well-known method used to reach consensus on the different alternatives. By taking one problem with the support of different alternatives, MCA measures the trade-offs between the different alternatives and come to the solution. The alternatives are broken down into a number of criteria and indicators to measure green economy pillars; resource sustainability, human well-being and social equity, low carbon emission, appropriate forest management. Integration of different stakeholders is the main challenges in doing stakeholders mapping and also the selection of right stakeholders for mapping is the most important section.

A total of 69 experts — CFUGs members (15), foresters (14), scientists (12), policymakers (16), and local government representatives (12) — were selected for MCA at the national, provincial and local levels. In total, I conducted four mini-workshops at the national level, four workshops at the provincial level, and eight consultation meetings, one each in eight CMFs, with the CMFs members (***Annex IIh***). In this study, two different methods for the elicitation of preferences for the green economy assessment were used: (i) scoring and (ii) pairwise comparisons.

The scoring technique was applied for the criteria and indicators (C&I) assessment at the field-level discussions, followed by repeated assessments at the provincial and national levels. I followed Mendoza *et al.*, (1999) and assigned a score to each criterion that reflected a perceived degree of importance. The participants were instructed to express their weights for each criterion by a 9-point scale (1=weakly important, 3=less important, 5=moderately important, 7=more important, and 9=extremely important, and 2, 4, 6, and 8 were used as intermediate level). The indicators were scored on a scale from 1 = least important to 100 = most important. Scoring was also used for exploring and judging the current condition of each indicator relative to the desired condition under each criterion, considering the performance of the selected forest management options. The assessment was done for each management option on a scale of 1-4 with regard to its potential for future improvements in relation to the current situation.

Furthermore, pairwise comparisons were done based on the ordinal input (from the scores provided by the stakeholder groups) according to every single indicator, and priorities were calculated using the Eigenvalue method (Saaty, 1977). In total, 36 pairwise comparisons were conducted, 12 at each level. Each participant had a chance to argue different opinions in their own group and in the plenary as well, and a consensus was reached on the different preferences of the members of the group. As a consequence, the individual judgments of each member within a group were used to formulate one single representative judgment for the entire group in the negotiation process.

4.4 Data Analysis

A large amount of quantitative and qualitative data was collected. The most important task was to organize the data (Yin, 2014). The information collection was carried out throughout the research period so that the analysis also took place in the multiple stages of research. Here, the data analysis took place as per the research questions.

4.4.1 Resource Sustainability

The inventory data were analysed by stratifying them based on species *S. robusta* versus other terai hardwood species (hereafter, other terai species) of the terai and Schima-castonopsis versus other hill hardwood species of the hills. In this report, *S. robusta* forest is abbreviated as SRF, other hardwood forest as OTHF, Schima-castonopsis forest as SCF, and other hill hardwood forest as OHF. The trees were further stratified based on diameter classes: seedlings, saplings, poles, and trees. Data were analysed focusing on the species, type and size of trees removed from the forest. Likewise, basal area growth (m^2/ha), differences in the frequency and occurrence of tree species were analysed by species type. Stand density/composition was analysed by comparing the distribution of tree diameter classes and canopy percentages. The canopy cover was grouped into three categories: poor density (10%–39.9%), moderate density (40%–69.9%) and high density (>70%). Furthermore, a relation between the canopy and regeneration was assessed (detail is in paper I).

The content analysis of FMPs and community forestry guidelines were carried out to calculate the prescribed harvesting amounts, while actual harvest was estimated based on the forest inventory results between two periods, i.e. 2010–2013 and 2013–2016. For the analysis of ecological and economic status of forest management, the Shannon & Weiner index (includes both abundance and evenness) was used. Margalef's index was used to measure the species richness. Pielou index was used to measure evenness within species. Shannon–Wiener diversity index (1963) was referred to know the diversity index. Margalef (1958) was used to measure the species richness and Pielou (1966) was used to measure the species evenness. Gini indexes were used to analyse the structure of a stand (Stöcker, 2002) and were calculated to assess inequalities within basal area distribution over the stand structure.

Stand density/composition was calculated by comparing the distribution of tree diameter classes. Relative density, relative frequency, and relative dominance were calculated for each species to determine the Importance Value Index (IVI) adopted by (Mueller–Dombois & Ellenberg, 1974). Major species from each forest type were selected to assess dominance and IVI, and the remaining species were grouped as other species. The total number of individual species per stratum was computed.

By following James *et al.*, (2012), the growth to removal (G/R) ratio was calculated. Growth is calculated as the increase in the growing stock volume in the forest and removal was considered as loss by mortality or harvesting of trees from plots. When the G/R ratio is greater than 1, growth outpaces the rate of removal, considering all other factors as constant. Growth is calculated by taking the difference of the two growing stock volume during the two inventory periods (V_2 -V_1) where V_2 is the standing growing stock volume in the recent inventory + ingrowth, and V_1 is the volume of the previous inventory which is also explained by Meilby *et al.*, (2014) studied in the same community forests of Nepal. Whereas, removal is the total harvested volume/quantity of trees in the recent inventory, which is computed based on the volume of trees removed/lost in comparison to previous inventory.

To evaluate the tree species diversity in different forest types of the hills and the terai, three species indices were calculated, and the derived indices of the species were statistically analysed by using one-way ANOVA with Welch's test using the post hoc test Turkey for multiple comparisons of unequal variance was performed at a significance level of $\alpha = 0.05$.

4.4.2 Human Well-being and Social Equity

I categorized CF goods into three groups: private goods, which are rivalrous (one person's consumption of a good necessarily diminishes another person's consumption of it) and excludable (those who have not paid for it can be prevented from using it, e.g. forest products and cash income); public goods that are neither rivalrous nor excludable (e.g. roads and schools); and common goods that are rivalrous but non-excludable (e.g. greenery promotion).

The pervasive role of economic factors in human well-being cannot be undermined as they have an indirect influence. As rural assets are distributed unequally between households, to minimize the effects of economic status on well-being (McKenzie, 2005), the economic indices

(*Ei*) were weighted following a principal component analysis (PCA) (detail in paper III). A PCA was first carried out to confound the economic dimensions and generate a controlling factor. In the second stage, I used a regression model to work out the relationship between well-being and benefits received from various taxonomies of goods derived from community forests. For this, I considered well-being as a dependent variable and the functions of public, private and common goods as independent variables (detail in paper III).

4.4.3 Low Carbon Emissions

Fuelwood consumption was considered the main sources of carbon emissions from the forests. The amount of fuelwood collection from the CMF was collected from the household survey and also from the CMF records and a descriptive analysis was done. Furthermore, the amount of fuelwood used from the CMF was analysed from the linear regression, in which nine variables were chosen, the result shows that various socio-economic factors are the underlying cause for the dependency on fuelwood use.

Carbon sequestration is calculated by taking the difference in the growing stock in a year. To estimate the carbon sequestration from the forest trees, which were classified into *Shorea robusta* forest and other terai hardwood forest. The difference in the growing stocks was analysed. The volume formula and density were derived by referring to Sharma & Pukla, (1990). Growing stocks of 2016 and 2013 were calculated and the difference in increment was determined.

Carbon consumption of a household was estimated from the annual household fuelwood consumption. To compute carbon dioxide (CO_2) emissions, I used conversion of fuelwood into CO_2 based on the Intergovernmental Panel on Climate Change (IPCC), 1996 revised report on the Guideline for National Greenhouse Gas Inventory. One *bhari* (backload) of fuelwood is equivalent to 40 kilograms. The total biomass of fuelwood is converted into carbon multiplying by *0.47* and to carbondioxie multiplying by 3.67. Similar was done for carbon sequestration as well.

4.4.4 Appropriate Options for Community-managed Forests

In Nepal, different CMF approaches are being practised: community forestry, leasehold forestry, buffer zone forestry, and collaborative forestry. In terms of intensity of management, the different approaches of management are categorized into four options: (i) close to nature, also known as passive management, has been practised in buffer zone forestry, (ii) active forest management (incremental felling), (iii) scientific forest management, and (iv) multiple forest management, mainly practised by community forestry and collaborative forestry. By using the three criteria and 10 indicators, the experts were asked to define forest management options which are capable of supporting development towards the green economy at national and provincial levels. Twelve experts from six different institutions (MoFE, DoF, NGOs, civil society, scientists, and local government representatives), who were directly or indirectly involved in decision making, policy reformulation and implementation of forest management, participated in the workshop at the national level. At provincial level, twelve experts from the provincial ministry of forest and tourism, local government representatives, DFOs, Federation of Community Forestry Users Nepal (FECOFUN), and CMF users were involved in the assessment of the management options (detail in paper V).

5 RESULTS

5.1 Resource Sustainability

The relationship between tree harvesting practices and the regulatory provisions, along with the persistent effects on the sustainability of community forestry in Nepal, was examined, taking the case of the terai community forestry. Panel inventory data, along with interactions with the key informants, was carried out to examine the effects of harvesting practices on stand structure and appraise what govern tree harvesting in the CF of Nepal.

The management plan does not govern the harvesting of forest products. CFUGs are required to prepare management plans for the harvesting of forest products, including estimates of harvesting amounts by species and block. However, harvesting is not carried out according to the plan (figure 4). Harvesting largely depends on the discretion of forest bureaucrats. The plan largely serves as a paper tool, where harvesting amount is mainly guided by administrative decisions, such as decrees. The average annual harvest (AAH) was arbitrarily reduced with an *ad hoc* circular of the DoF to limit the growing stock volume of 178 m^3/ha with the aim of reducing harvest quantity, where increment was assumed to be 1 percent and 60 percent of harvest. This raises a concern about defining the limit of sustainable harvest and the role of the inventory, both of which are the basis for sustainable harvesting.

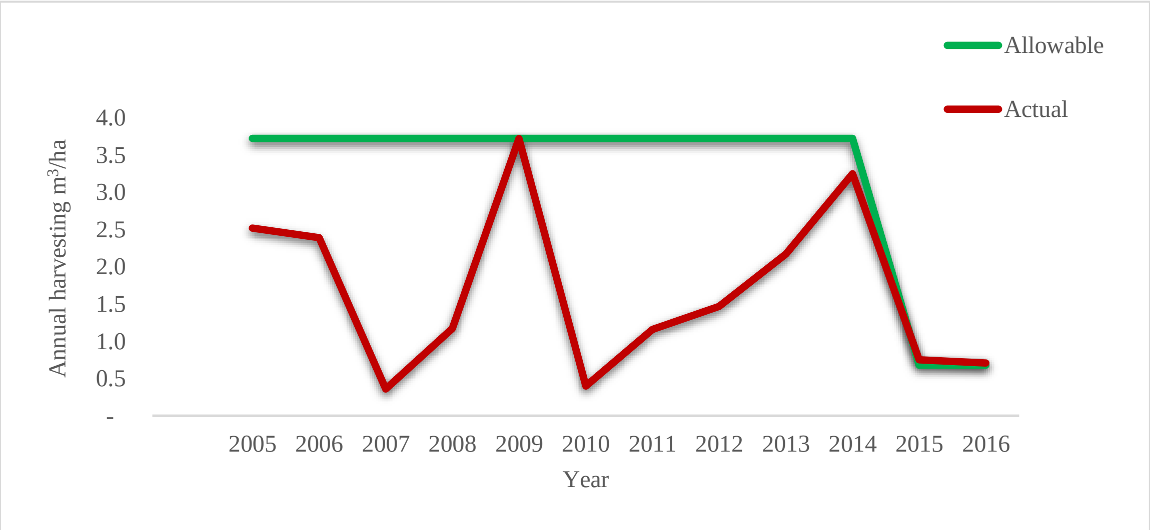


Figure 4: Allowable annual harvest and actual annual harvest in m^3/ha (2005-2016).

The users could not harvest according to the allowable amount: This mainly resulted from delays in obtaining permits from forest bureaucrats (in 2007) or by the *ad hoc* decision of celebrating timber holidays in 2010 and 2011. Users were only allowed to harvest one-third of the volume. However, the actual harvest was slightly higher than the prescribed amount due to damage of trees during harvesting operations and reliance on traditional harvesting practices. Moreover, forest bureaucrats had introduced different thumb rules, such as selecting only a poor-quality tree and fallen trees had also reduced the harvestable quantity.

When compared to stand conditions between the economically valuable tree species and other species, there was a slight increase in the number of pole and trees in both forests; however, the regeneration condition was declining (Table 7). According to the Scientific Forest Management Guidelines 2014, at least 15 to 25 mature trees per ha are needed for natural regeneration. However, the number of trees above 50 cm diameter is not only less than the prescribed number but had also declined during the three inventory periods and reached nearly one mature tree per ha. While, the number of poles was increasing, users were not carrying out any thinning practices as prescribed in the plan. As a result, resource competition between the poles was increasing, which might also affect forest productivity in the long run. Likewise, the basal area of poles and trees had decreased (details in the paper I).

Further, resource sustainability was assessed from forest stand condition, the extent of extraction of forest resources, especially timber, and maintenance of tree species diversity. For this study, two community forests each from two provinces (Province 3 and Gandaki Province) were selected based on long-term data from permanent measurement plots (details in paper II). The forest was divided into four categories, viz. SRF, OTHF, SCF, and OHF, to assess resource sustainability. The major findings are described below;

Table 7: Stand condition in the CF (n/ha) in different Inventory Period.

Species Type	***S. robusta***			**Others**		
Diameter Categories	**2010**	**2013**	**2016**	**2010**	**2013**	**2016**
Seedling (>2 cm)	26,842	12,982	13,421	6,930	12,456	6,316
Sapling (2–3.9 cm)	337	84	21	225	91	21
Est. sapling (4–9.9 cm)	675	504	323	486	336	215
Pole (10–30 cm)	410.2	482.5	487.0	191.6	224.2	226.0
Tree (30–50 cm)	8.8	7.4	11.9	7.0	8.4	9.5
Mature Tree (<50 cm)	7.4	4.2	1.1	1.4	4.6	1.1

Source: Inventory result of 2010, 2013 and 2016.

Resources are exploited only in a commercial forest. The number of trees was found declining in all four forest types, with a lot of variations in development stages. The stand structure resembled the reverse J-shaped distribution in all four time periods of the inventory, revealing that species are normally distributed in uneven-aged forests (details in paper II). There are variations in different forest types. For example, while the number of poles was found to have increased in SRF forests, there was no distinct trend of increase or decline of poles in other forest types. Such an uneven distribution reveals that stand structure does not support resource sustainability. Heterogeneity is supported by the Gini analysis, which showed that SCF was more heterogeneous than OHF. The transformation of both forests towards heterogeneity was seen between 2005 and 2010, during which period there was an increase in the Gini coefficient. In contrast, both SRF and OTHF were converting to homogeneous forests (Table 8). The transformation indicated that forests were converting into trees with the similar basal area.

Table 8: Mean and Standard error of Stand Density (no/ha) by forest type and tree stages

Forest Type	Stage	Year 2005	2010	2013	2016
SCF	Seedling	14444±3090	19111±3045	5444±1051	11111±1402
	Sapling	5140± 793	8954±1464	7377±1496	2362±528
	Pole	522±3082	465±31	424±31	415±31
	Tree	117±8	105±8	107±8	99±9
OHF	Seedling	8571±4040	7142±4738	1428±1428*	15714±2020
	Sapling	11466±3958	9942±3221	17647±6400	2019±792
	Pole	722±125	734±151	669±131	709±115
	Tree	82±37	88±36	97±34	114±33
SRF	Seedling	28709±5009	30645±5144	20000±3093	18548±2788
	Sapling	6668±1038	6098±1354	2715±471	673±169
	Pole	528±45	751±57	835±67	839±63
	Tree	20±5	18±5	17±5	23±5
OTHF	Seedling	25357±4317	32142±6168	26607±5352	16250±3563
	Sapling	8066±1515	4685±1497	2104±447	974±435
	Pole	297±35	391±41	381±42	403±62
	Tree	30±8	36±7	33±7	36±8

Source: Inventory result of 2005, 2010, 2013 & 2016
*Note: *Number of seedlings and standard error incase of OHF forest is same due to data in only one plot*
Note: SCF= Schima castaonopsis forest, OHF=other hill forest, SRF= Shorea robusta forest, OTHF=Other terai hardwood forests

The Importance Value Index (IVI) of economically important species is increasing in the terai, while it is declining in the hills. *S. robusta* in the terai and *S. wallichii* and *C. indica* in the hills had higher IVI than others. These are economically important species, largely used for construction and some for firewood purposes. However, the dominance of these species is in decreasing trend, revealing that forests are either economically exploited or extraction of mature trees is high, thus changing the IVI value. In SCF, the IVI of *S. wallichii* had slightly decreased from 141.95 in 2005 to 136.80 in 2016, the IVI of the same species increased from 93.14 in 2005 to 111 in 2016 in the OHF. On the contrary, the IVI of *S. robusta* in SRFs increased from 229.4 to 238.2 and that of OTHF increased from 83.6 to 104.1 during the eleven-year period. The increased dominance of Sal timber is mostly because of restriction on harvesting, including administrative and bureaucratic hassles.

Forest was under-harvested in both terai forests, while it was over-harvested in SCF and in OHF. The finding shows that removal was higher than growth throughout the four periods in SCF, while growth exceeded removal in OHF in all but period II (2010-2013). In SRF and OTHF, growth was higher than removal throughout all periods. The table 9 showed the terai forests are under-harvested, except in period II (2010-2013).

Table 9: Average growth and removal (m^3/ha/year) over the last 11 years

Forest type	**Period I (2005-2010)**			**Period II (2010-2013)**			**Period III ((2013-2016)**		
	Growth	**Removal**	**Ratio**	**Growth**	**Removal**	**Ratio**	**Growth**	**Removal**	**Ratio**
SCF	-3.61	0.49	-7.4	-0.71	2.54	-0.28	-2	0.8761	-2.3
OHF	1.43	0.63	2.3	-0.55	1.93	-0.28	5.5	1.2512	4.4
SRF	8.03	2.16	3.7	6.3	1.76	3.57	5.5	0.5827	9.5
OTHF	3.04	1.1	2.8	3.68	1.89	1.95	4.6	0.7182	6.3

5.2 Human Well-being and Social Equity

Human well-being and social equity were assessed for enhancing the well-being of local communities by investing in three different taxonomies of goods: private, common and public goods. This research question focuses to answer how the income from CMFs is being distributed and which well-being categories were benefiting.

CFUGs' resource investment in taxonomies of goods: Almost half of the investments made by the CFUGs were directed toward private goods and the rest was directed towards common goods and public goods. Of the different types of private goods, the highest investment was in forest product collection, followed by forest-based employment creation, alternative energy, and skill development training. Regarding public goods, though the highest investment was in roads and other infrastructure, the investment was 10% of the total. Among low-income households, common goods investment was the highest (14%). Priority was given to common goods over other goods, primarily due to the high demand for community development activities among the members.

Benefits from private goods were mostly enjoyed by affluent households. More than 70 percent of the affluent households had benefited from CFUGs' investments in private goods, while less than 50 percent of the low-income households had benefited from investments in private goods. Nevertheless, more than 60 percent of the households of all income levels had benefited from investments in public goods.

CFUGs' contribution to the household well-being: All positive values of correlation coefficients indicate that affluent households benefited more from private goods. Among public goods, with the exception of education facilities and awareness of operational plans, other remaining categories were found to be non-significant, indicating that investment in public goods does not necessarily support well-being. However, awareness of operational plans and education facilities were positively correlated with well-being at 5 percent and 10 percent levels (p = 0.0103 and 0.0863 respectively) of significance (Table 10).

Table 10: Realization of benefits from different taxonomies of goods on human well-being

Variables	Coefficient	Std. Error	t-Statistic
Constant/intercepts			
Well-being (lower/medium)	7.8851**	1.3470	5.8539
Well-being (medium/ better-off)	11.6226 ***	1.4489	8.0216
Private forest goods			
Creating forest-based employment (CFBE)	2.0444***	0.2604	7.8500
Income-generating activities (IGA)	0.7135***	0.2327	3.0650
Forest product collection (FPC)	0.1403*	0.0978	1.1435
Access to skill development training (SDT)	0.4962**	0.2266	2.1890
Alternative energy (AE)	1.0211***	0.2417	4.2238
Public forest goods			
Educational facilities (EF)	0.3526*	0.2581	1.3661
Health facilities (HF)	-0.0839	0.1404	-0.5981
Roads and other infrastructure (RI)	-0.1436	0.3290	0.4367
Market facilities improvement and construction (MF)	0.2699	0.2483	1.0870
Awareness of forest management plan (AOP)	0.5409**	0.2326	2.3247
Common forest goods			
Special provision to women and low-income households (capacity building) (SP)	-0.1510	0.2355	-0.6410
Disaster risk reduction (DRR)	-0.6146***	0.2448	-2.5103
Water source conservation (WS)	0.4782**	0.2474	1.9326
Green promotion (GP)	-0.3089	0.2481	-1.2448
Economic Index (Ei)	-2.6095***	0.4536	-5.7521

Note: Significance at 10%, ** 5%, ***1%, N=377, Ei as a control factor*

Two variables, special provision and greenery promotion, are non-significant. The significant and positive relation of the economic index with well-being shows that affluent households realize benefits from the investment in general.

This further suggests that direct benefits from these two categories of goods, i.e. private and public, were realized more by affluent households, whereas benefits from investments in health facilities, roads, market facilities, and other infrastructure were realized by all income categories. In the case of common goods, community investments in disaster risk reduction (DRR) and water source conservation were significant at 1 percent and 5 percent levels (p=0.0062 and 0.0270 respectively). The negative coefficient of DRR implies that the low-income households realized more benefits from DRR compared to the affluent households, while it is the reverse for water source conservation. This study reveals that low-income households are also likely to benefit from common goods as they live on the fringes of rivers.

5.3 Low Carbon Emissions

The majority of households (more than 60 percent) still depend on fuelwood for cooking and heating. The regression analysis further shows that family size has strong and positive relation with fuelwood consumption at 5% confidence level. This means that households with a higher number of family member use more fuelwood. This could be because those households can spare time for collection of firewood from the CF. Likewise, the analysis shows that the households possessing a greater number of livestock consume a higher amount of fuelwood ($p = 0.005$). This could be because households having a greater number of livestock need more fuelwood to cook food for their livestock. Furthermore, the relation between per capita income and fuelwood consumption is opposite and significant at 10% confidence level. This shows that the consumption of fuelwood reduces as income increases. This could be because people switch to other alternative energy sources, particularly Liquefied Petroleum Gas (LPG), when they start earning more. A similar case is true for the relation between literacy and fuelwood consumption. Educated households use less fuelwood. This could be because better-educated households know the health impact of indoor pollution of fuelwood burning and they know more about alternative energy, which could have motivated them to switch to LPG. The CF is sequestering carbon, which balances the extent of carbon emitted from fuelwood. However, other sources of wood and carbon emissions are not included; so, still this study contends that until and unless households shift to clean energy, the likelihood of the CF contributing low carbon emission is less likely in the future.

5.4 Appropriate Forest Management Options

Four options of forest management practices, guided by the green economy principles, were selected and defined following the existing practices, which included passive management, active management, scientific management, and multiple management. Resource sustainability was ranked as the most important criterion for managing forests from the green economy perspective, followed by human well-being and social equity and low carbon emission in that order (Table 11). Biotic influences, employment through forestry and alternative energy are the major indicators. Almost all stakeholders rated biotic influences as the highest priority for management.

Table 11: Relative weight of criteria and indicators based on geometric mean of the synthesized stakeholder group judgments

Criteria & Indicators	Synthesized priorities of stakeholders					
	Forester	scientist	Policy-makers	CFUGs	Local government representatives	Overall
C1. Resource Sustainability	**0.308**	**0.298**	**0.300**	**0.298**	**0.300**	**0.301**
I1. Forest condition	0.241	0.187	0.195	0.240	0.191	0.210
I2. Maintenance of tree species diversity	0.324	0.301	0.309	0.404	0.305	0.327
13. Forest growth and harvest	0.353	0.324	0.358	0.406	0.344	0.356
14. Biotic influences	0.517	0.462	0.466	0.529	0.462	0.486
C2. Human well-being and social equity	**0.244**	**0.241**	**0.245**	**0.245**	**0.250**	**0.244**
I5. Employment through Forestry	0.298	0.302	0.298	0.298	0.304	0.299
I6. Capacity building programmes	0.226	0.236	0.230	0.228	0.244	0.230
I7. Inclusion of poor & marginalized communities	0.162	0.173	0.162	0.164	0.182	0.165
C3. Low carbon emission	**0.190**	**0.170**	**0.157**	**0.167**	**0.174**	**0.171**
I8. Alternatives energy	0.297	0.306	0.328	0.339	0.332	0.317
I9. Use of timber in other purpose	0.238	0.233	0.239	0.265	0.279	0.243
I10. Energy saving device	0.340	0.265	0.287	0.286	0.291	0.293

Regarding management options, the multiple forest management option is preferred by the majority of the stakeholders and was ranked as the best performing management option, whereas scientific forest management was ranked as the second option, followed by active and passive forest management options (Table 12).

Table 12: Overall priorities of management options with respect to all stakeholder groups

Management Options	**Forester**		**Scientists**		**Policymakers**		**CFUGs**		**Local government representatives**		**Overall**	
	Rank	Priority	Rank	Priority	Rank	Priority	Rank	Priority	Rank	Priority	Rank	Priority
Multiple forest management	1	0.568	1	0.551	2	0.627	1	0.553	1	0.584	1	0.576
Scientific forest management	2	0.472	3	0.437	1	0.635	2	0.483	2	0.502	2	0.501
Active forest management	3	0.394	2	0.443	3	0.504	3	0.383	3	0.407	3	0.424
Passive forest management	4	0.232	4	0.252	4	0.266	4	0.224	4	0.233	4	0.241

6 DISCUSSION

The contribution of CMF to the green economy were assessed focusing on four aspects with the three pillars of green economy, viz. (a) tree harvesting and resource sustainability, (b) human well-being and social equity, (c) low carbon emission, and (d) appropriate forest management options.

In both CMFs selected for this study has spacing and diameter classes were not considered during harvesting the forest stand is unbalanced. The findings further reveal that forests are currently under-harvested, which outcompete in different stages, and do not support the realization of sustainable forest management (Basnyat *et al.*, 2018b; Subedi *et al.*, 2014). Similar observations have also been found elsewhere in Nepal which are supportive of SDG goal 15. I further found that trees selection does not consider silvicultural characteristics which result in species competitions, a fact that was also argued by Gilmour, (2018) studied in Nepal. This means that forest harvesting, and silvicultural practices are still conceptualized as technical aspects of forestry, often neglecting the engagement of community and stakeholders, and this was also evident in our studied areas.

CFs' harvesting operations are paradoxically managed by administrative officials and guided by political interests rather than by science. Apparently, it is also observed that quantity of harvest is mainly governed by regulatory instruments, which limits communities to take appropriate decisions (Basnyat *et al*., 2018b; Toft *et al.*, 2015; Ojha *et al.*, 2007; Pokharel and Ojha 2005). For instance, a circular issued by MFSC on 2 December 2011, orders harvesting of only 4Ds and fallen trees within the AAH limits. Another circular issued by the MFSC, on 6 March 2012, directs that while estimating AAH from the forest, the growing stock volume of the forest should not exceed 178 m^3 per ha or that specified in the FMP, whichever is lower. Harvesting between 1 and 2 m^3per ha of the forest is allowed, depending on forest condition (approximately 1% of the growing stock volume). Kern, *et al.*, (2017) and Mielby *et al.*, (2006) also pointed out quantity harvested is far below the growth observed in Nepal and in Cameroon Cerutti *et al.*,(2008), a similar situation in Nepal, where harvesting was carried not according to the plan.

In recent years, the AAH has been reduced substantially, albeit without a clear rationale, which seemingly raises concern whether or not the FMP can support harvesting practices. This resonates with Shrestha & Amatya (2000) who observe that inventory results are seldom used in preparing FMPs and implementing management activities. Communities are compelled to harvest 4D trees, which led to pole size-dominated forests, which was also noted in Picard & Gaspartto (2016) and Sapkota *et al.*, (2009). This practice led to an imbalance in forest management; however, the quality of remaining trees seems improving due to harvesting of only 4D trees.

The study found that local communities prefer the economically valuable species and hence emphasize protection of those species, Baral *et al.*, 2019b; Sapkota *et al.*, (2009) also identifies economical valuable species is highly preferred species. As a result, the dominance (basal area volume) and the number of stems per ha of economically valuable species are increasing more than those of other species. A similar observation was made by Tian *et al.*, (2018). *S. robusta* is preferred even in the mixed *S. robusta* forest and priority is given to convert *S. robusta* mixed forest into pure *S. robusta* forest. The government's *ad hoc* policy decisions, for instance the blanket ban on timber harvest, compelled bureaucrats to enforce rules to control harvesting of valuable trees, like *S. robusta*, a finding also observed by Basnyat *et al.*, (2018b). This management focus on economically important species may have adverse consequences on resource sustainability, which may influence the realization of the green economy objectives.

Tree harvesting appeared to have a positive impact on the growing stock volume both in the terai and in the hills. Our results show community harvesting practices focused on maintaining a constant growing stock over time, with only parts of the annual increment being harvested. This study echoes with Toft *et al.*, (2015), who conclude that management practices of the community forest have led to a constant growing stock volume and low harvest rates of the annual increment in the mid-hill region of western Nepal. Seemingly, removal of annual increment was consistently less than the prescribed amount in the management plans for terai forests but was high in Hill forests (especially in SCF in all periods ie; 2005 to 2016), Subedi *et al.*, (2014) studied in overall Nepal's also has drawn the same findings. This pattern had two exceptions –i) forests were found to be relatively over-harvested in the hills and that favoured forest regeneration, and (ii) forest were found to be under harvested in terai and regeneration couldn't establish into saplings. Harvesting appeared to have a positive impact on tree species diversity and stand structure as well as in enhancing growing stock volume. Although users are allowed to harvest 60% of the annual growth (assumed to be 1% by Department of Forests (DFRS, 2015), the MFSC in 2011 initiated a provision called 'Plant Holiday' to decrease the harvest in the terai but such a provision was not implied in the hills. Similarly, a circular issued in October 2012 also forced the communities to reduce harvesting. The disenabling regulatory environment is the main causes of over and under harvest in hills and terai respectively. Baral *et al.*, (2019c); Gritten *et al.*, (2015) also has same findings that regulatory environment effects on the harvesting.

Despite several studies on the role of community forests in contributing to local income (Rasolofoson *et al.*, 2016; Adhikari *et al.*, 2004), its role in maintaining and improving well-being has not been studied so far. Scholarly works largely focus on investigating the contributions of CFUGs to livelihoods and community development (Pokharel, 2009; Adhikari *et al.*, 2004). In theory, community forest decisions in Nepal are guided by the principle of equitable distribution of resources. However, a detailed analysis is currently lacking on how diverse investments from CF contribute to human well-being. There is a need to explore which goods directly contributed to human well-being.

CMFs are investing in different goods. Investing in private goods has positively contributed towards well-being, which is also reflected by Rasolofoson *et al.*, (2016) and Bhandari *et al.*, (2019) in Madagascar and Nepal, respectively. Households which were benefiting from private goods became affluent and enhanced their status. The level of investment was higher in private goods, targeting low-income households, such as the creation of forest-based employment opportunities, income-generating activities, and forest product collection. Scholars (Walelign & Jiao, 2017, Charlery & Waleligh, 2015; Chhetri *et al.*, 2012; Adhikari *et al.*, 2004) argue that affluent households gained more income and upgraded their living conditions compared to low-income households who strongly depend on forest resources, and similar results were observed by (ibid); however, our findings demonstrate that low-income groups did, in fact, shift to the affluent group, which resonates with the findings of Waleligh (2016) and Gauli & Hauser (2011), because low-income households generated more income from forests. Moreover, Meilby *et al.* (2014:9) contend that benefits may vary across different physiographic regions of Nepal; however, private goods, such as forest wages and involvement in forest management activities always seem to have had high relevance irrespective of the region.

Forest associated benefits such as forest product collection, skill development training and promoting its use are quite supportive for realization of the green economy objective which ultimately contributes to SDGs goals 1,2, 3 and 6. Those CFUGs that are investing in private goods can improve the conditions of low-income groups. It was observed that investments in one of the five different types of public goods were almost non-existent. For instance, benefits from investments in roads and other infrastructure such as market facilities cannot be exclusively realized by poor households, as CFUGs cannot exclude outsiders from enjoying benefits. Although Lund *et al*., (2013), who studied 45 CFUGs in Nepal, indicate that affluent households benefit more from investments in the construction of infrastructure and from capacity development training, this does not hold true, primarily because of the non-exclusionary nature of these goods. Nonetheless, the significant and positive correlation of educational facilities suggests that affluent households had realized benefits from investments in educational facilities, as the majority (85%) of these households were educated.

Low-income households cannot enjoy the benefits of educational facilities, as their children seldom get the opportunity to go to school. Our findings are consistent with those of Nagendra (2011), whose study in Nepal and Tanzania demonstrates that CFUGs invest more in building schools. However, such investments do not necessarily benefit low income households who cannot afford to send their children to school (Schreckenberg & Luttrell, 2009).

Household energy consumption basically reflects the welfare of the households and also reflect the national economic development. Our findings also show that more than one-third of households are using fuelwood as the main source of energy in which low-income households with large size and illiterate households use more fuelwood in comparison to affluent households. Biomass, especially fuelwood, still constitutes a primary energy source in rural areas of developing countries (Nepal, 2008) in which Nepalese people dependency is still high (Suwal, 2013). Further, from our regression analysis it shows that there are various underlying factors that determine the use of the fuelwood as the source of energy.

The relationship between income and fuelwood consumption has been widely studied in Africa (Uhunamure, *et al*., 2017; Kgathi and Zhou 1995) where it shows that higher the income less is the fuelwood consumption. Our study also resembles to the findings as of African context. Along with the increase in income, the use of alternative energy sources, such as LPG, is gaining ground in Nepal and is reducing the need for fuelwood (Heltberg *et al*., 2000). This tends to low carbon emissions and contribute to SDG goal 13. Similarly, the family size is also one of the underlying factors which force to use more fuelwood as energy. In our cases the low economic household has a greater family size which also use more fuelwoods. The study by

Maih *et al.*, (2009) showed that family size, income, amount cooked and burning hours significantly affected the amount of fuelwood used annually by a family. Taking into account different family sizes, the study observed that 4.24 tonnes of firewood were consumed per family per year. This further contracts with Bhattarai, (2013), as household size increase the per capita fuelwood use decreases which is because of the economics of scale increases in this case.

The forest management practices in the studied sites still focused on conservation and subsistence need. The management practice has paid less attention to resource sustainability, human well-being and low carbon emissions in Nepal (Karki, 2013). It is because management decisions are being dominated by forestry bureaucrats with limited involvement of other actors. The forestry sector plays a major role in translating green economic opportunities into concrete livelihood and environmental gains, ecotourism, forest-based livelihoods, and renewable energy solutions—bio-gas, bio-briquettes and micro-hydro energy—to fuel the green growth practices for sustainable development (ibid). For instance, Subedi *et al.*, (2014) estimate that forestry sector has a potential to generate 1.4 million full-time equivalent jobs in Nepal compared to the current employment of 145,000 full-time jobs. Human well-being is highly preferred criterion for national level stakeholders whereas resource sustainability is the highest preferred criterion for provincial stakeholders. The reason for the high preference for resource sustainability given by provincial stakeholders could be that the stakeholders still give high priority to biophysical condition improvements. In the context of federalization, majority of forests land have brought under provincial government, conservation approach seems to lead the forest management in years to come.

7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

When harvesting was not governed by management plans, the disenabling regulatory environment along with forest bureaucracy discretion were the prime reasons. The quantity of sustainable harvest was arbitrarily reduced, largely to comply with departmental circulations. Sustainable harvest or sustainable management leads to green economy development, which has been often compromised in the case of CMF in Nepal. Despite this, the conditions of forests have improved. The improvement of conditions of forests does not necessarily lead to green economy development. There is a need to focus on active management rather than current practices. Plans should be implemented according to the spirit of the green economy so that the green economic objective may be realized.

It was found that the studied forests appeared to be managed in an ecologically sustainable way, where biodiversity was maintained, yet harvesting was far below the growth potential. An inverse J shape curve of harvesting was maintained, and economic benefits were compromised. In order to manage the forest sustainably, harvesting should be according to the growth of the forest. However, as an increase in the growing stock volume was observed in the community forests, this may contribute to ecological benefits. However, it does not ensure economic sustainability. Moreover, future economic value of the forest might be compromised due to an increase in the number of the over matured trees, which lose the quality. Hence, the forests should be managed on both ecologically and economically sustainable course to frame the CMFs in the green economic pathway. Unfortunately, current CMFs miss this opportunity. Holding more trees and increasing forest cover does not necessarily contribute towards the green economy; rather sustainable management and re-investment in forestry is necessary.

The study reveals that CMFs are investing in goods of a different nature; in particular, investment in public goods is quite high compared to others. However, investment in private goods had positive effects on the realization of the green economy. Many low-income households improved their economic conditions because of the benefits they had realized from CMF. The current community forestry policy of investing in livelihoods improvement targeting poor and marginalized goods had positive effects on improving the well-being and, thereby, on the realization of the green economy. The investment priority of community forests should be shifted towards private goods if the green economic objectives are to be realized.

Dependency of households on fuelwood is quite high, resulting in high carbon dioxide emission. As a result of limited timber harvesting, carbon sequestration is high compared to emission. In order to promote CMF towards low carbon emission, there is a need to shift energy consumption behaviour towards clean energy, along with improving the economic conditions of households. Here, the role of CFUGs come, which can invest in low carbon emission technologies and improve the economic condition of their users.

Large majority of the stakeholders, especially the policy makers and researchers argue to promote multiple forest management towards realization of green economy. However, the forest management still is timber centric and protection oriented. There is a need to shift forest management approach from timber centric to multiple forest management to achieve green economy for catering the need of different segments of society. National policies and perspective of national level stakeholders have shifted towards human well-being and social equity; however, provincial level bureaucrats, who are the key implementers of the forest policies and rules, still prefer resource conservation in forest management.

Currently, CMF are contributing towards the green economy, however the contribution is very minimal. There is a need of systematic assessment of CMF to overhaul the CMF. Current forest management practice might be supportive but not instrumental in ushering in the green economy objective. Hence, the study argues to revisit current management practices of CMFs, from protection oriented to multiple forest management to maximise contribution towards all the pillars of the green economy by devising appropriate forest management modalities.

7.2 Recommendations

Despite CMFs having a huge potential to contribute on the green economy, they do not seem to do so, largely because the priority has been given to the ecological aspects of forest management rather than the economic aspects. Though sustainable forest management is crucial to achieving the green economy, appropriate policy options, a sustainable supply of resources for human well-being, are equally important. Considering this, the following recommendations are made for policymakers, planners, CMFs, and researchers to maximize the contribution of CMFs in the green economy.

7.2.1 Policy Makers and Planners

As the country is embarking towards federalization, policy discourse and debates should lead CMF management towards meeting the goal of a green economy. Which ultimately support the national and local economy and Nepal's SDG targets related to the goal 1- reducing poverty, goal 13 - carbon capture and storage and goal 15- biodiversity conservation and indirectly goal 3- healthy life and promote well-being, goal 7- ensure affordable and sustainable energy, goal 8- inclusive and sustainable economic growth through employment, and goal 12-ensure sustainable consumption and production. With more than one-third of the forests being managed under the CMF, their role towards the green economy should be enhanced through the involvement in policy-making processes at all levels of the government.

Long-term management prescriptions and plans are needed to retain and manage forests instead of random approaches to harvesting. Seemingly, there is a need for multidimensional approaches in forest management to achieve sustainable development. I argue for an appropriate forest management plan focusing on ecological, economic and social sustainability. What is needed is the "conservation through use" principle, especially focusing on (a) developing simple and doable management prescriptions, (b) following systematic harvesting practices (c) revision of the FMPs while considering productive capacity of the forest, (d) maintaining all age class tree species, and (e) considering the economic potential of the forests while developing plans and policies. Moreover, the long-term effects of government decrees on forest sustainability need to be monitored periodically.

Furthermore, Nepal's policy provisions should go towards carbon neutral. As carbon emission from fuelwood is high, policies should emphasise in using alternative energy technologies that minimize fuelwood consumption.

7.2.2 Community Managed Forest

The CFUGs should give priority to investment in private goods to maximize contribution to economic well-being. Though the policy had provisions to spend at least 35 percent of income on pro-poor activities, such provisions are not implemented adequately; and whatever the investment made is not enough to promote low-income households to affluent. Thus, policy provisions should not only be enforced but continuous monitoring should also be carried out so that the contribution to green economic development in general and community well-being, in particular, can be enhanced. Furthermore, harvesting practices need to be tailored in such a way that they help to enhance the value of forest resources and provide regular benefits to local communities. There is a need for identifying appropriate forest management options, where diverse interests of stakeholders can be addressed without compromising the goal of a green economy.

7.2.3 Further Research

This study recommends the establishment of long-term standard research plots for forest management such that future scenario of forest management can be well predicted. Furthermore, it ensures the authenticity and reliability of research data and results. Data collected over a longer period of time can help to explore the effects of harvesting on undergrowth of forests, including growth performance of those species.

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Appendixes

Annex-I: Papers

Paper I

What governs tree harvesting in community forestry—regulatory instruments or forest bureaucrats' discretion?

forests

Article

What Governs Tree Harvesting in Community Forestry—Regulatory Instruments or Forest Bureaucrats' Discretion?

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Abstract: Community forestry is required to follow a forest management plan (FMP) to ensure sustainable tree harvesting. However, the role of FMPs or forest bureaucrats' discretion in guiding harvesting decisions and the resultant effects has not been explored. This paper investigates tree harvesting practices in community forests (CF) and its effects on forest sustainability, using the forest inventory panel dataset for three consecutive periods (2010, 2013 and 2016), together with qualitative information obtained by key informant interviews and a review of records of the community forest users' group. Harvesting decisions in the CF are largely guided by the decrees or schematic instructions of forest bureaucrats, where the role of the FMP remains highly contested. Whether harvesting decisions should be guided by the prescriptions of the FMP or should be regulated through decrees is a matter of discourse. Forest bureaucrats are arbitrarily reducing harvesting quantities and rarely referring to the prescriptions of the FMP. Consequently, users are compelled to harvest less than half the quantity of trees prescribed in the FMP. Furthermore, they are only allowed to harvest poor quality and dead trees. As a result, the number of good quality trees has increased, while the number of seedlings and saplings has decreased significantly. Although harvesting of saplings and seedlings is a common practice, it is against the provisions of the FMP. Though the current bureaucratic discretion has shown quick short-term effects on the forest stand conditions, the long-term impacts should not be undermined. Our findings will be useful to implementors and policy makers in Nepal and other developing countries with similar circumstances for deciding the tree harvesting. We argue for a rational approach in designing harvesting prescriptions and complying with them rather than regulating harvesting practices through guidelines, circulars and bureaucratic discretion.

Keywords: harvesting; forest management plan; sustainability; regulatory instruments; forest condition

1. Introduction

After the nationalization of forests in the 1950s, a sort of anarchy prevailed in the forestry sector in Nepal, which encouraged illegal logging, deforestation and forest encroachment, particularly in the Terai region [1]. The failure of nationalization of forests led to massive deforestation during the second half of the twentieth century and paved the way for community forestry in the country [2,3]. Under the concept of community forestry, the government transferred the responsibility for forest management to local communities through participatory forestry approaches [4]. Nepal is the first country devolving forest management from the authorities to local communities for conserving forest resources, which has attracted worldwide attention [5]. Over four decades, community forest user groups (CFUGs) in Nepal have made intensive efforts to improve degraded forests [6–8] and provide benefits to nearly 2.5 million households, which comprise more than 35% of the country's population. Approximately 27.5% of the country's total forest area is managed by CFUGs [9] and a national survey indicates that the overall forest area has reached 44% of the country's area [10], a 20% increase over the previous two decades [9]. Although forest cover has increased [6,8,11], the long-term aspects of forest sustainability have received little attention. The oft-quoted slogan, "*rukh ropaun ban jogaun*" (let's plant trees, and conserve forests), has successfully contributed to the conservation of forests, but it has completely jeopardized the potential economic utilization of forest resources [12].

According to the Federation of Forest Based Industry and Trade Nepal, around 29.3 million cubic feet of timber was imported into the country from East Asian and other countries in 2015, while 37.6 million cubic feet of timber decayed or were not utilized in the country's forests [13]. The forest bureaucrats responsible for forest management prescriptions are reluctant to allow the harvesting of trees, due to the mandatory requirement for complying with various policies and regulations. The Community Forest Directives 1995 (revised 2014) and Community Forestry Inventory Guidelines 2004, adopted by the Ministry of Forests and Soil Conservation (MFSC), made it mandatory for CFUGs to prepare forest management plans (FMP). CFUGs prepare the FMPs with the support of forest technicians, where forest bureaucrats define management prescriptions, including the allowable annual harvest quantity [14]. The FMP, in essence, is a vehicle to regulate management activities [15,16] and assure the implementation of regulatory instruments on the ground [15]. However, inventory data and analysis results are often misinterpreted in preparing the FMPs according to bureaucratic requirements [16]. Consequently, forest management practices in community forests (CFs) are being dominated by forest bureaucrats [15].

With the existing FMPs, regulating sustainable harvest in uneven-aged forests is difficult and challenging, as they also do not examine the contextual role of management planning adequately. Gurung et al. [17] studied the role of FMP in improving forest conditions and found that forest management activities were rarely carried out according to FMP. Additionally, the formulated rules of the FMP restricted the access to forest products. There are several indications that the conditions of the forest resources in CFs are improving [18,19], but the role of forest management prescriptions is not well known [16]. Though several researchers question the role of FMPs in implementing harvest decisions [15,16,20,21], the short- to mid-term effects on forest stand conditions are poorly understood. For example, preventing the felling of good quality green trees and promoting the extraction of 4D (dead, dying, diseased and decayed) trees only might have improved the condition of the forests but negatively affected the benefits of CFUGs [22]. However, there is a lack of periodic data from permanent plots in CFs to estimate the long-term effects of such harvesting practices [23].

Many of the problems in the management of uneven-aged forests in Nepal are also related to the fact that only the stand volume has been considered in the regulation of uneven-aged stands for years, ignoring changes in diameter classes. Natural regeneration is largely ignored, and harvesting is confined to the extraction of logs, ignoring the recent stand development. Recent statistics even show that forest conditions are not improving significantly [10]. DFRS [10] indicates that, although the forest cover has increased in Nepal, the growing stock of forests has declined from 178 m^3/ha in 1996 to 164.76 m^3/ha in 2015 [10]. This apparently raises a question: do regulatory instruments including FMPs, or forest bureaucrats, determine the harvesting practices in Nepal's CFs? We hypothesize that discretion of forest bureaucrats overshadows the role of FMP in tree harvesting. Therefore, this paper analyses the effect of tree harvesting practices in the context of existing formal and informal instruments of CF management in Nepal. More specifically, we:

- investigate the tree harvesting practices in selected case studies, focusing on the compliance of regulatory instruments, including FMP, and on what guides harvesting decisions;
- compare the quantity of harvest of economically valuable species (*Shorea robusta* Gaertn. f. hereafter *S. robusta*) with that of other species;
- quantify the effects of harvesting practices on tree quality, health, regeneration and stand composition and appraise the reasons for the observed changes; and

- appraise whether it is the FMP or forest bureaucrats who determine the number of trees to be harvested.

2. Regulatory Instruments Render Tree Harvesting: An Analysis

After the restoration of democracy in Nepal in 1990, the Forest Act 1993, as the first democratic movement was enacted as a principal legal instrument to promote community forestry in the country. This law established local people's rights over forest resources [18] and was regarded as a landmark instrument in Nepal's forest management. Thereafter, the inventory-based FMP was introduced in the early 2000s, where a certain portion of increment was allowed to be harvested by type of species (see Community Forestry Inventory Guidelines 2000). This type of harvesting existed until the amendment of the guidelines in 2004, which addressed the shortcomings in traditional forest management. During the same time period, Community Forest Guideline 1995 was amended in 2001, which institutionalized inventory-based management plan. The guidelines further expanded the role of forest technicians in the CFs and prescribed the templates of FMP. The plan consists of the technical aspects of forestry such as growing stock, block divisions, biomass, timber volume, and annual harvesting yields along with the harvesting and sale procedures [21]. The Forest Inventory Guidelines 2004 introduced annual increment of forest stand by forest condition and species, and it ranges between 1% and 5% of the growing stock volume. This resulted in the harvesting of economically valuable green trees, leading to deforestation [1]. Consequently, the government banned green harvesting of timber all over the country in 2011 for about a year, aiming to control forest deforestation. In 2012, the government issued a decree for green harvesting with restrictive provisions. According to this provision, the growing stock should be aligned within the threshold of a national average of 178 m^3 per ha and the harvested amount should be between 1 and 2 m^3 per ha irrespective of the forest condition (Table 1). This decision seemingly led to a reduction in tree harvesting quantity [21,22]. The main reason for reducing the quantity of harvest was sporadic cases of illegal timber harvesting across the country [24]. In addition, the government issued the Community Forest Product Collection and Sale Directives 2014 [25], which expanded the bureaucratic involvement in CFs. The regulatory instruments introduced were often not understandable by CFUGs and the local technical personnel [20]. In addition, a Silviculture-based Forest Management emphasis was introduced when the Scientific Forest Management Guideline was introduced in 2014.

Table 1. Key features and implications for harvesting found in major regulatory policy documents in Nepal.

<table>
<tr><th>Policy Document(s)</th><th>Key Features</th><th>Implications</th></tr>
<tr><td>Forest Act 1993 & Forest Regulation 1995</td><td>A national forest handed over to a local community for conservation, utilization & management according to the forest management plan (FMP) prepared by community forest user group (CFUG) and approved by the District Forest Officer (DFO)</td><td>The users can sustainably harvest forest products within the quantity specified in the FMP</td></tr>
<tr><td>Forest Products (Timber/Fuelwood) Collection, Sale and Distribution Directives 2000</td><td>It prescribed for harvesting</td><td>The user can follow prescribed procedures to be followed during harvesting</td></tr>
<tr><td>Community Forestry Guidelines, 2000</td><td>Estimating growing stock and allowable annual harvest (AAH)</td><td rowspan="2">Provisions for tree harvesting in relation to increment. It remains silent on the quality of tree to harvest.
The inventory-based provisions were enforced at the FMP preparation stage only</td></tr>
<tr><td>Community Forest Inventory Guideline, 2004</td><td>Inventory based FMP institutionalized. Harvesting as the % of annual increment of growing stock volume</td></tr>
</table>

Table 1. *Cont.*

Policy Document(s)	Key Features	Implications
"Plant Holiday" declared-MFSC, (21 May 2010)	Restriction on the harvesting of timber throughout the country especially in Terai	The forest could not be harvested according to FMP. The quantity of the harvest reduced substantially
Circular-MFSC, 2 December 2011	The decision to harvest fallen trees only within the AAH	Discouraged harvesting of green trees, & promote the 4D collection, causes improvement in forest quality
Circular-MFSC, 6 March 2012	While estimating AAH, growing stock volume of the forest should not exceed 178 m^3 per ha	The blanket approach undermines the provisions of continuous harvesting in uneven-aged forests, & encourages manipulation of the growing stock volume to align with the national average
	Annual harvesting is limited between 1 to 2 m^3 per ha of the forest, which is nearly 1% of growing stock volume (assuming 178 m^3 per ha)	
	Except fallen, harvesting restricted for a year from FMP approval	It undermines the guidelines; inventory remains silent on species to be harvested but encourages harvesting "4D"
	The decision to grant approval to CFUG for harvesting a maximum of 85% of the approved AAH for internal use only, and 60% in the case it is also for external sale	
Community Forest Product Collection and Sale Guideline 2014	Elaborates on processes and procedures to be followed for harvesting timber from CFs and sale of it on the market	The guideline expanded bureaucratic control over harvesting decisions; involvement of forest bureaucrats is required on all decisions, i.e., harvesting and distribution
Scientific Forest Management Guideline, 2014	Forest management planning and harvesting decisions with the active involvement of forest bureaucrats	It encourages retaining mother tree (seed tree) to promote regeneration by an opening canopy

Source: [26] Government of Nepal (GoN),1993; [27] GoN, 1995; [28] Department of Forests (DoF), 2000; [29] DoF, 2004, [30] DoF, 2012, [31] DoF, 2014 and [25] GoN, 2014.

3. Materials and Methods

3.1. Study Area

Kankali CF, a natural forest located in Khairani Municipality, Chitwan District, in the low-lying Terai plains in Province 3 of Nepal (Figure 1) was selected for this study. The forest lies at 27.65° N, 84.57° E and between 220 and 580 m above mean sea level. It is dominated by tropical *S. robusta*, *Semecarpus anacardium* L.f., *Holarrhena pubescens* Wall., *Terminalia alata* Heyne ex Roth., and *Dalbergia sissoo* Roxb. ex DC. For the management purpose, the forest is divided into five blocks, each between 99.8 ha and 191.4 ha in size.

The site was selected based on the existence of panel forest inventory data for 2010 and 2013, and a similar protocol was used to collect data in 2016.

The community comprising 2065 households residing in 546.7 ha of land manages the 749.2 ha of forest with both long- and short-term objectives. The long-term objectives (generally realized beyond the FMP) are to fulfill the needs of the community regarding forest products, maintain the forest ecosystem, enhance biodiversity through scientific forest management, and improve the livelihoods of users [32]. Likewise, the short-term objectives (to be achieved within the FMP duration) are to ensure a continuous supply of forest products, control forest encroachment, erosion, and grazing, and promote income generation activities [32]. The forest was handed over to the local communities in 1995.

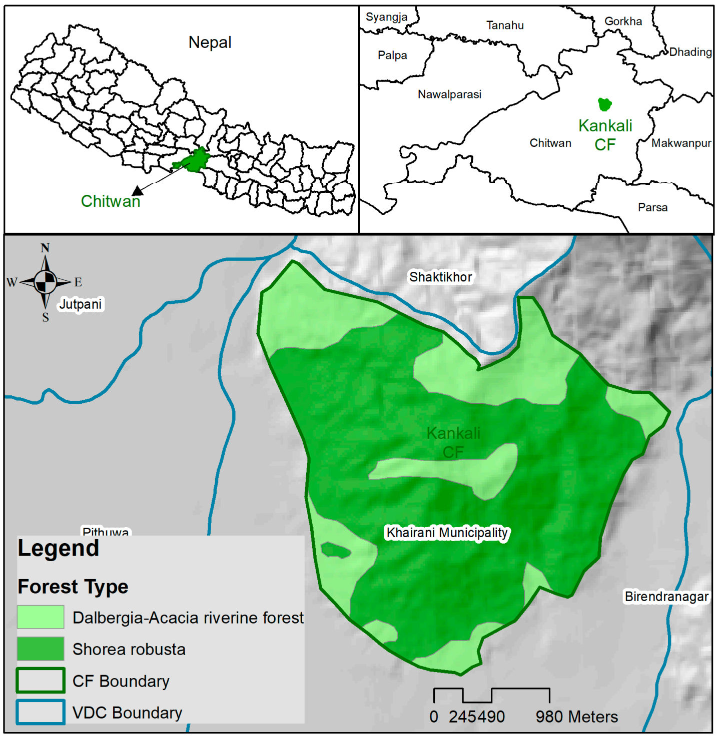

Figure 1. Study area in central Nepal showing different forest types and Village Development Committee boundary.

3.2. Data Collection

The study used a case study approach to understand the harvesting practices and their effects on forest management. Field data were collected between August 2016 and June 2018. The policy documents related to harvesting, since the initiation of community forestry, was also thoroughly reviewed.

Permanent plots were laid according to the stratified random sampling method described by Meilby et al. [23] using the coffee-house approach suggested by Müller [33] where the first plot was selected randomly, and the successive plots were laid to maximize the minimum distance to neighbouring plots [34]. The inventory data were collected from 57 permanent plots, established by "The Community Based Natural Forest Management in the Himalaya (ComForM) project", jointly implemented by Institute of Forestry, Tribhuvan University, Department of Forest Research and Survey, Government of Nepal, and Danish Centre for Forest, Landscape and Planning, University of Copenhagen from 2003 to 2014. The study collated existing inventory data of 2010 and 2013, and conducted an additional inventory in 2016, following the same protocol. The forest inventory in autumn 2016 followed the plot design of [23] including three nested subplots. Table 2 shows the size of the plots for the different tree categories measured. Parameters measured included tree diameter at breast height, height, canopy, health, quality and regeneration condition.

Table 2. Categories of trees and plot size used.

Category	Diameter	Plot Size
Seedlings	<2.0 cm	(1×1) m^2
Saplings	2.0–3.9 cm	(5×5) m^2
Established Saplings	4.0–9.9 cm	(10×15) m^2
Trees	≥10 cm	(20×25) m^2

Source: ComForM Manual.

In addition, we used snowball sampling method to identify key informants (altogether 21) who were consulted for information on decision making and actual practices tree harvesting. The key informants constituted of past and present executive committee members (4), forest guards (4), forest bureaucrats (4), persons involved in harvesting operations (4) and the CFUG staff (5). The aim of such consultations was to understand the actual harvesting practices in compliance with the prescriptions of the FMP, and the role of forest bureaucrats. Similarly, the criteria (four D trees, deformed trees, canopy opening, species competition, economic importance and diameter size) for selection of trees to be harvested were developed prior to executing the ranking exercises jointly with key informants. The key informants for the ranking constituted of (nine) DFO staff and (11) users. They were asked individually to rank each criterion on a scale of 1 to 7, where is 1 is the least preference and 7 is the highest preference. The information collected was validated and triangulated through interactions with the different groups of key informants to get an in-depth understanding of the context.

3.3. Data Analysis

The inventory data were analyzed by stratifying them based on species *S. robusta* versus other Terai hardwood species (hereafter, other species). Furthermore, trees were stratified based on diameter in classes: seedlings, saplings, poles, and trees. Data were analyzed focusing on the species, type and size of the trees removed from the forest. Prescribed harvest amounts were computed from the FMP and official records of the CFUG, while actual harvest was estimated based on the forest inventory results between the two periods 2010–2013 and 2013–2016. Basal area (m^2/ha) differences in the frequency and occurrence of tree species were analyzed by species type. Stand density/composition was analyzed by comparing the distribution of tree diameter classes and canopy percentages. The canopy cover was grouped into three categories: poor density (10%–39.9%), moderate density (40%–69.9%) and high density (>70%). A correlation test was done to assess the relationship between canopy closure and regeneration number.

All measured trees were further classified based on their health and quality. According to their health, trees were grouped into three categories: (i) healthy (live trees with no sign of reduced vigour), (ii) weak (live trees showing signs of reduced vigour) and (iii) dying (live trees showing clear signs of dying). Similarly, trees were classified into three categories based on quality: (i) high quality trees (live trees with good form, high probability for a saw log with a length of at least six meters, <4% of cull volume in the section from the stump to the upper limit of saw log of merchantable quality), (ii) sawn timber (a log is considered merchantable when $\geq$50% is perfectly straight) and (iii) cull trees (live trees with poor form, indications of injury or decay). The grouped data of quality and health were analyzed in percentage and presented in a histogram.

In addition, content analysis was also performed for reviewing written documents such as: forest records and minutes, forest inventory results, the FMP, forest products extraction records from the user committee and the Community Forest Inventory Guidelines, 2004. The analysis mostly focused on indications for deviations of the recorded and actual harvesting. The review of the FMP allowed identifying provisions given for harvesting and the basis for prescriptions. The content analysis together with the findings of the interviews of the key informants supported the overall comparison of the differences between the prescriptions and the actual practices.

4. Results

4.1. Harvesting Practices

The forest is divided into five blocks for its management. Harvesting is carried out based on the annual increment of the growing stock volume. The FMP has a provision for harvesting forest products, especially timber and fuelwood (Table 3). According to the FMP, users can harvest "4D" tree throughout the forest and the prescribed volume of green trees from a specified block. However, information on where and how to harvest is missing in the FMP. One of the CF executive members explained about the harvesting of timber in practices:

> *"The decision on the harvesting of the tree is taken by forest bureaucrats. The harvesting team (forest guards and crew) mainly focuses on finishing the task and doesn't take any precautions for protecting seedlings and saplings. Every other year, new forest bureaucrats come up with their own ideas and impose them based on their own interests or government's ad hoc decisions. This creates confusions and delays in harvesting operations"* (Field note, 2017).

Table 3. Observed deviations of forest management practices with reference to the FMP.

FMP Allowable Prescriptions	Actual Practice
Forest divided into 5 blocks & collection of fallen trees allowed throughout the year; not exceeding growing stock volume of particular blocks	Timber and firewood collection allowed to harvest according to the growing stock volume of the block
	Harvesting of the trees are taking place only in the few blocks
Fixing the % of annual increment, allowed to cut on the basis of species types and forest condition	The annual increment is fixed based on the growing stocks
AAH is estimated and green felling (harvesting) will be carried out	Harvesting amount fixed by the administrative rules such as circulars irrespective of the AAH
	AAH estimation is conservative; the users are compromising with the potential volume of harvest
	No harvesting since fallen trees already reach AAH
Harvesting of trees within the block carried out on a periodic basis according to AAH	No such practices are being carried out, harvesting as per the forest guard judgment while cleaning forest or inspecting forest
Trees should be selected for harvesting	DFO staff select tree and hallmark for harvesting considering the "4D" quality
	The basis for selection not known, depend on DFO staff judgment
Harvesting of the timber and fuelwood during November–February	Harvesting in practice taking place from February to May
Users are only allowed to harvest trees	Users also collecting pole from forests especially "4D"
Number of harvesting in a year	Annually
Selective harvesting system prescribed in the FMP	Selective harvesting in practice, however, users are only considering "4D" trees

Source: Reviewing of FMP and discussion with the committee members during field work from 2016–2017.

Harvesting is regarded as a major activity in forest management. The CFUG was involved in management activities before the "Community Forest Product Collection and Trade Directive 2014" was enforced [22]. After the directive came into force, the responsibility of forest management decision rested on the Forest bureaucrats. In the usual practice, the CFUGs collect information regarding the amount of required timber and submitted a request to the DFO office. The forest bureaucrats decide where to harvest (see Table 3) and users mark the trees to be harvested. Some of the users informed us that they were not in a condition to take harvest decisions themselves; so, they followed the instruction of the DFO office. Users, however, are not satisfied with the decisions and procedures, as often they are only allowed to harvest "4D" trees. The users of the studied CF presented similar views, and thus our inventory results had a minor role in decision making.

The AAH is estimated based on the inventory results, but green trees, especially small pole-sized trees, are also harvested as needed, although the FMP has restricted this kind of harvesting. The FMP mentions that trees should be selected considering tree competition, diameter class, and tree conditions. But these criteria are not considered while selecting trees for harvesting. The amount to be harvested is mainly guided by administrative rules such as circulars. Moreover, the amount of fallen trees often exceeds the AAH. A past executive member of the CFUG, who was involved in harvesting operations for nearly two decades said:

Harvesting is guided not by the FMP, but by the discretion of the forest bureaucrats', FMP is like an "elephant's tusk" only an adornment but not of use (Field note, 2017).

The FMP prescribes that harvesting operations should be conducted during November–February; however, such activities do not take place as prescribed. The FMP states that the general assembly of users should submit an application to the DFO to harvest a prescribed quantity of timber and fuel wood. The approval of the application and the marking of trees takes a considerably long time. As a result, trees are harvested during February and March, mainly because of the complicated and lengthy administrative procedures of getting a permit. For example, the community studied in this research submitted an application to the DFO in January 2015 but the harvesting took place several weeks later, in March 2015.

Based on the prescriptions in the FMP a number of harvesting activities are to be carried out within selected blocks. However, the activities couldn't take place due to new decrees and policies. Therefore, the recommendations in the FMP on harvesting practices are inadequate.

During our inventory, we asked some forest users and newly recruited forest bureaucrats "how decisions concerning harvesting were taken". The forest users instead asked us to enquire with the forest bureaucrats, one of whom responded that,

"*the government allows harvesting of the annual increment of 1% of the growing stock volume, where only 60% of the increment can be harvested for external use and 80% for internal use. Only 4D trees can be harvested. As this CF had a lot of fallen trees, harvesting covered only the collection of fallen trees that got distributed to users within the volume allowed by a decree*".

When asked further about the use of the FMP on harvesting decisions, he answered:

"*I don't believe in the inventory results of this CF, especially the growing stock volume. We are bound to follow many regulations on harvesting; so, the FMP has little role in harvesting.*" (Field note, 2017).

According to the FMP, trees should be selected considering the 4D criterion; however, species competition and other silvicultural characteristics remain of less priority. Figure 2 shows that both DFO and users equally prefer harvesting 4D trees. In addition, users give high preference to diameter size and deformation of trees. They are not aware of technical considerations, such as economic importance, species competition, canopy opening, that district forest bureaucrats consider. From field observations, we found that the management focused on producing lumber which can be used for fuelwood in the future. The individual crop trees face a high competition in the forest and there is no intention to reduce the competition. One of the users admitted that the provisions in the FMP and its approval are merely for authentication and have nothing to do with forest inventory results. A user involved in harvesting operations said:

"*During harvesting, we generally select standing dead trees as DFO staff does not allow us to harvest green trees while 4D trees are in the forest.*" (Field note, 2017).

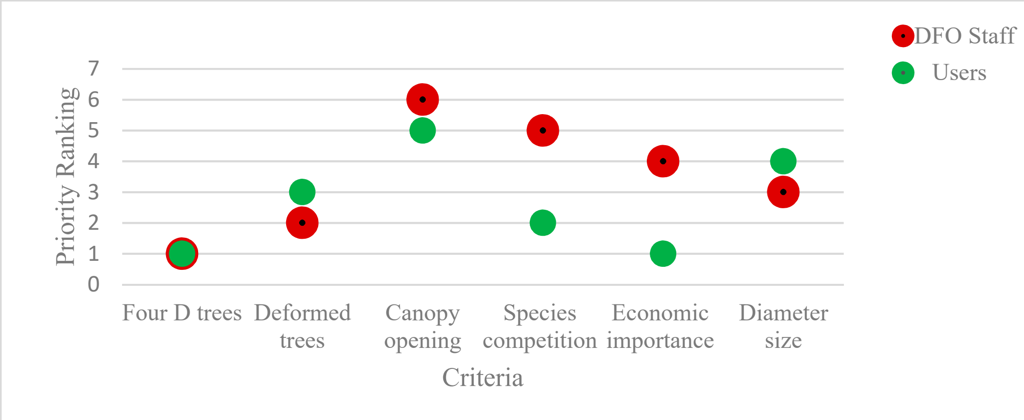

Figure 2. Priority ranking of DFO staff and users in selecting trees for harvesting. Source: Users and DFO officials of Kankali CFUG, Chitwan (2017).

4.2. Comparing Actual and Allowable Harvesting Quantities

From a review of the last two periods, I (2010–2013) and II (2013–2016) of the FMP, it was found that the growing stock of the forest in the previous FMP (2010–2013) was 146 m^3/ha, while it increased to 170 m^3/ha in the current FMP (2013–2016). In the previous FMP, the increment of the growing stock was estimated to be 3.0%, while the current FMP estimates 1%. The recent provision contradicts the Community Forestry Inventory Guidelines of 2004. According to the guidelines, the annual increment in the growing stock of the forest ranges from 1% to 5% depending on the nature of species (fast, medium and slow growing) and forest conditions (poor, medium and good). Out of the growing stocks 85% can be harvested. However, the AAH was arbitrarily reduced by the ad hoc circular of the Department of Forests to 178 m^3/ha with an aim of reducing harvest quantity. The circular limits annual growth of forest to maximum 1%, and 60% of the increment could be harvested. This raises concerns about defining the limit of sustainable harvesting and the role of inventory. For instance, the chairperson of the CF stated:

> "*We could hardly distinguish any difference between the harvesting practices during two periods, but the prescribed amount has reduced drastically between the two FMPs; the only difference we observed was in the quantity*" (Field note, 2018).

Figure 3 presents the AAH of the growing stock and the actual harvest, suggesting that the users were not harvesting what they were actually allowed in the FMP. The low harvest rates were often caused by delays in obtaining permits from forest bureaucrats (in 2007) or by the ad hoc decisions of celebrating timber holidays, in 2010 and 2011.

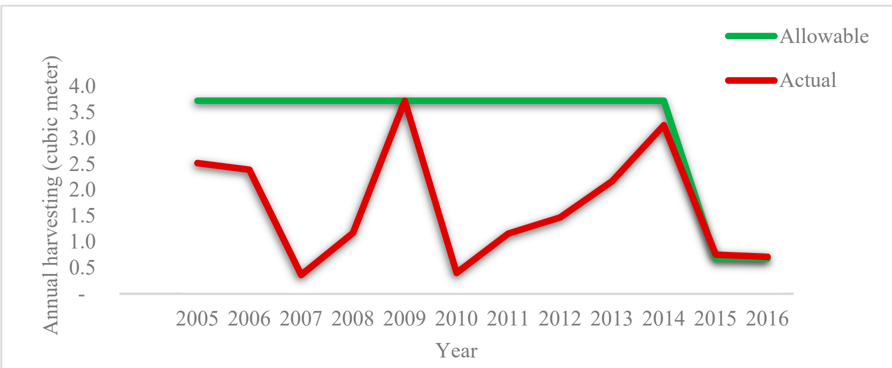

Figure 3. Allowable annual harvest and actual annual harvest in m^3/ha (2005–2016). Source: Data collected from two consecutive FMPs and CFUG records.

Table 4 shows the recommended harvest rates in the FMP and the actual harvest quantity for the periods I (2010–2013) and II (2013–2016). In the period I, the actual harvest is below the allowable harvest in all blocks while in period II, there exits variation by the blocks. The data indicate that the actual harvest is higher than the allowable harvest in blocks I, II and V while it is lower than allowable in block III and IV in the period II.

Table 4. Block wise allowable harvest in FMP and actual harvest from inventory.

Block	Harvest (m^3/ha per/year) Period I: (2011–2013)			Harvest (m^3/ha per/year) Period II: (2013–2016)		
	Allowable (Plan)	Actual (Inventory)	Δ Change	Allowable (Plan)	Actual (Inventory)	Δ Change
I	2.0	0.8	(0.6)	1.0	2.0	1.0
II	3.3	1.9	(0.4)	1.6	5.0	2.1
III	3.6	1.5	(0.6)	1.8	1.4	(0.2)
IV	2.3	1.1	(0.5)	1.1	1.1	(0.0)
V	1.9	1.4	(0.2)	0.9	1.2	0.3

Source: FMP of Kankali CFUG, Chitwan (2016) & from the inventory of 2016 & 2017.

Overall, it was found that the actual harvest (from inventory results) in the CF is higher than the reported harvest (CF records), (see Figure 4), but in recent periods the allowable harvest (prescribed in FMP) almost matches the actual harvest. This is mainly because of strict monitoring and supervision of harvesting decisions by forest bureaucrats. Moreover, forest bureaucrats had introduced different thumb rules, such as selecting a poor quality and fallen trees and had also reduced the proportion of annual harvest.

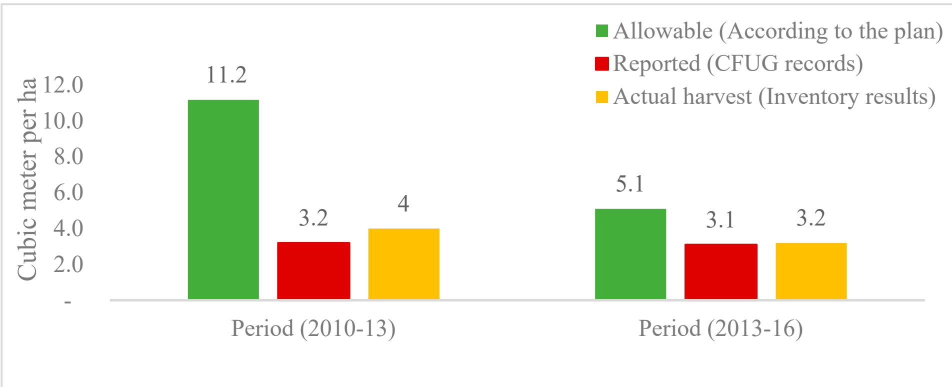

Figure 4. Reported and actual harvest compared to the allowable harvest. Source: Inventory result of 2010, 2013 and 2016, FMP and Inventory recorded.

4.3. Effect on Forest Condition

The effects on forest structure were analyzed focusing on (a) changes of regeneration and tree condition and species composition, (b) changes of tree basal area, and (c) changes in tree health and quality.

4.3.1. Stand Condition and Tree Species Composition

Table 5 presents a comparison of the stand condition of economically valuable tree species with the other tree species. The results indicate that the number of seedlings had declined from 26,842 in 2010 to 13,421 in 2016 in the case of *S. robusta*, while that of other species was 6930 in 2010, doubled in 2013 and decreased (9%) to 6316 in 2016. However, the number of both saplings and established saplings of all species had declined during the same period. This result also coincides with the correlation of the canopy closure and the total number of natural regenerations. It shows a positive relation (0.48) in 2010 and a negative relation (−0.10) and (−0.31) in 2013 and 2016 respectively. Similarly, in the case of saplings, the result shows a weak and negative relation between the canopy cover and the sapling ratio: (−0.02) in 2010, (−0.03) in 2013 and (−0.02) in 2016. However, the correlation is very weak.

Table 5. Stand condition in the CF (n/ha) in different Inventory Period.

Species Type	*S. robusta*			Others		
Diameter Categories	**2010**	**2013**	**2016**	**2010**	**2013**	**2016**
Seedling (>2 cm)	26,842	12,982	13,421	6930	12,456	6316
Sapling (2–3.9 cm)	337	84	21	225	91	21
Est. sapling (4–9.9 cm)	675	504	323	486	336	215
Pole (10–30 cm)	410.2	482.5	487.0	191.6	224.2	226.0
Tree (30–50 cm)	8.8	7.4	11.9	7.0	8.4	9.5
Mature Tree (<50 cm)	7.4	4.2	1.1	1.4	4.6	1.1

Source: Inventory result of 2010, 2013 and 2016.

Table 5 shows that the number of pole-sized trees increased, while that of mature trees decreased between 2013 and 2016. According to the Scientific Forest Management Guidelines, 2014, at least 15 to 25 mature trees per ha are needed for facilitating natural regeneration. However, the number of trees above 50 cm diameter is not only less than prescribed but also declined during the three inventory periods and reached nearly one mature tree per ha. While the number of pole trees is increasing, the users are not carrying out any thinning practices prescribed in the FMP. As a result, competition between the poles is increasing, which might affect forest productivity and the capacity for seed production in the long run.

4.3.2. Tree Basal Area Variation

Aside from differences in the frequency and occurrence of tree species (Table 5), the basal area (m^2/ha) varied by plots and study sites (Figure 5). The basal area of poles decreased from 9.1 to 3.8 m^2/ha for *S. robusta* and from 4.2 to 2.8 m^2/ha for other species. In the case of mature trees, the basal area decreased from 2.9 to 2.6 for *S. robusta* and remained similar with 0.6 m^2/ha for other species.

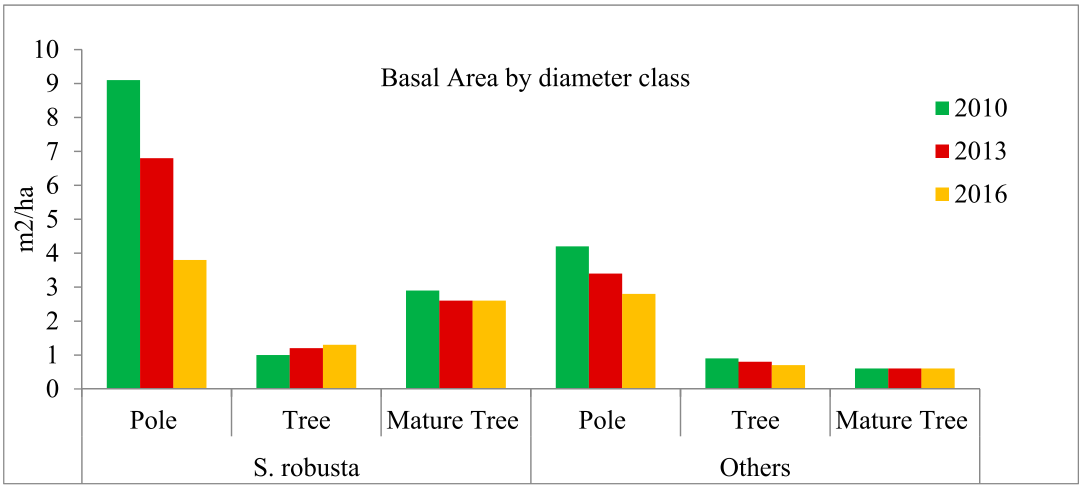

Figure 5. Basal area per ha by species types (m^2/ha). Source: Inventory of 2010, 2013 and 2016.

4.3.3. Changes in Tree Health and Quality

The analysis of the tree health and quality categories (Figure 6) showed that the number of healthy trees increased between 2010 and 2016, i.e., an increment of stems from 85% to 95% of stems per hectare. In the case of declining categories, a decrease has been noticed ranging between 3% to 10% for both forest types (*S. robusta* and other categories). Similarly, the quality of log and cull trees improved, while that of sawn trees was decreasing for both forest types.

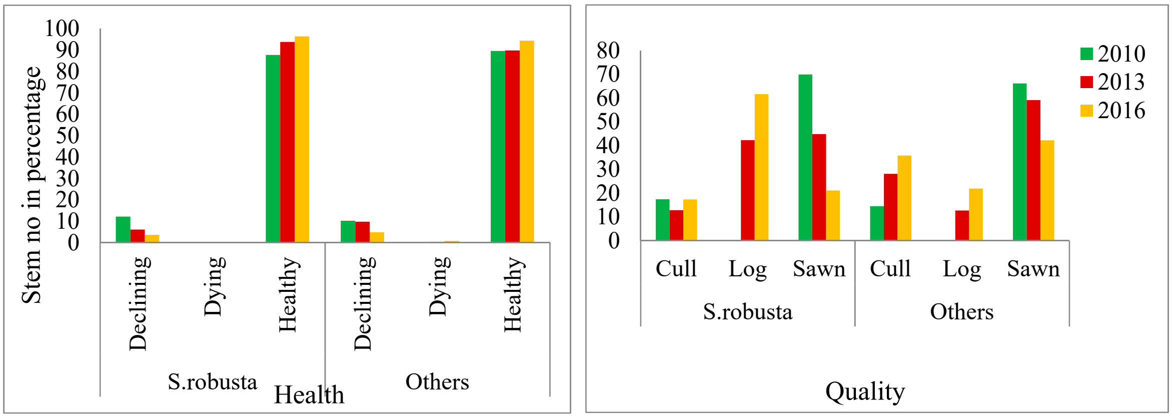

Figure 6. Tree health and quality of *S. robusta* and other species in percentage.

5. Discussion

5.1. Tree Harvesting Practices—Are They in Compliance with FMPs?

While investigating the role of the FMP in guiding harvesting practices, the prescribed management practices were found not matching the local practices. The FMP prescriptions rarely guide harvesting; rather, verbal instructions of district forest bureaucrats, such as DFO and rangers, followed by administrative decrees, dictate harvesting decisions; which is also corroborated by [35]. In addition, developing an FMP is quite onerous for the users [36]. Though Nightangle, Ojha et al. [37,38] argued that the technical knowledge of FMP application is important for the management of forest resources in Nepal's CFs, we observed that the FMP has become merely a paper tool to fulfill the criterion of handing over the forest. In recent years, the AAH has been reduced substantially, but without a clear rationale. This apparently raises concern whether the FMP can support harvesting practices of CFUGs. This resonates with the findings of Toft et al. [16], who observe that inventory results are seldom used in preparing FMPs and implementing management activities. A study by Bhattacharya and Basnyat [39], in the western Terai of Nepal, concludes that the prescribed allowable harvesting operations in the FMPs are complex and not specified in detail, which makes it difficult for the users to follow them. Furthermore, Gautam et al. [19] conclude under similar conditions that silvicultural operations are not being practiced according to the FMP. Similarly, the rationale of the block divisions is questionable since users simply collect the AAH volume from the entire forest irrespective of the blocks. Similar findings were reflected in the study of Toft et al. [16], who states that block division is done merely for administrative purposes.

The harvesting prescriptions in the FMP are simply a list of activities appended to the FMP which are to be carried out in a block every year, but the FMP is silent on what, how and where the activities should be carried out. This apparently raises concerns on the usefulness of the described harvesting practices, driven by the aim of opening the forest for penetration of light and providing a favorable environment for regeneration. The reasons for this mismatch can be attributed to the absence of specific knowledge of appropriate harvesting practices of the local communities among the forest bureaucrats, which is also identified by [20], and studies conducted in Nepal, Cambodia, and Vietnam [20,40]. It appears that harvesting operations are one of the basic components of forest management, where the FMP works as a tool to enforce what forest bureaucrats are supposed to classify as correct. Similar findings were presented by Rutt et al. and Toft et al. [15,16] in their studies in the mid-hills of Nepal, and by [41] in Cameroon, where the government continued carrying out timber production, and the management rules and FMP were ignored.

Improvement in the conditions of forest stands are not a result of the implementation of the FMP, but a consequence of other practices within the CF and changes in the economic status of local communities. The current harvesting practices are protection-oriented and conservative, where users remove fallen and over-mature trees. While selecting trees, silvicultural characteristics such as species competition are not taken into consideration. Moreover, Subedi et al. [42] conceptualize forest harvesting and silvicultural practices as technical aspects of forestry, often neglecting the engagement of community and stakeholders. This has also impacted the adoption of improved harvesting practices [43].

5.2. Tree Harvesting Quantity—What Governs It?

Harvesting of timber is highly unpredictable for long planning periods and the quantity of harvest can vary from year to year. However, the amount of timber harvested in the studied CF has been reduced, despite an increment in the growing stock volume. Our observations reflected that "non-systematic and uneven harvesting of trees resulted in an increment in the growing stock of the forest. Trees are like straight boles without or very less tapering, which is a sign of stiff competition among species, which may retard their growth in the future. Adoption of "protective forest management based on limited use by the MFSC" has resulted in the promulgation of harvesting prescriptions resembling the one size fits all approach, which was also observed in the study of [44], where the FMP and prescriptions are identical.

It seems from the CF records that the total AAH is more than the reported harvest and the actual harvest estimated from the inventory in periods I and II. The reason behind this is that forest bureaucrats enforced a number of decrees published. Harvesting doesn't correspond with the FMP prescriptions. There is no other specific consideration for tree selection for harvesting, and hence tree selection is often guided by national decrees. There were a series of decrees which changed or limited harvesting in period I, such as the Plant Holiday" declared-by the MFSC on 21 May 2010, which limited green harvesting. Moreover, a circular issued by MFSC on 2 December 2011, allows harvesting of only fallen trees within the AAH limit. Another circular, issued by the MFSC, on 6 March 2012, directs that, while estimating AAH from the forest, the growing stock of the forest should not exceed 178 m^3 per ha or that specified in the FMP, whichever lower. The studied case is of Chure (fragile hill); so only 1% growing stock increment is indicated in the guidelines including FMP. Out of the growing stock 40% is allowed to be harvested each year, which is a key factor in differentiating the reported and actual harvesting. The main reason for the limited harvesting was the forest officials' discretion rather than the prescriptions of the FMP [20]. The rationale for this recommendation is based on the assumption that Chure, being fragile land mostly of gravel and boulders, where tree growth is low and the land is highly prone to landslides, conservation of forest helps in stabilizing the land. Hence, the quantity of harvest was reduced to be on the safe side. Consequently, Baral et al. [21,22] in studies in Terai and Mid-hills forests of Nepal, conclude that the harvested quantity is far below the annual yield. Cerutti et al. [41] observed a similar situation in a study in Cameroon, where the harvesting was carried out without referring to the FMP. Contrary to our findings, the forest was largely overharvested to maximize revenues, as the benefits of the timber harvest remained largely with the local communities.

5.3. How Tree Harvesting Decision Affect Tree Quality?

We observed that local communities preferred economically valuable species and hence emphasized protection of those species. As a result, the dominance (basal area volume) and the number of stems per ha of economically valuable species increased more than those of other species. A similar observation was made by Ojha and Bhattarai [45] in their study in mid-hills of Nepal. Yet another study, Sapkota et al. [46], carried out in the Terai region, concludes that *S. robusta* is preferred even in the mixed *S. robusta* forest and priority is given to convert *S. robusta* mixed forest into pure *S. robusta* forest. The forest is also gradually converting into an *S. robusta* dominated forest, moving towards a single species forest from a mixed one. This is due to the preference given to the conservation of economically valuable species and discarding low-value species. It shows that management interventions are guided by social preferences. Sapkota et al. [46] had similar findings from the Terai region of Nepal, where social preferences guide the species composition and management of the forest.

Generally, we observed that there were no strict rules on harvesting tree species except *S. robusta*. Government's ad hoc policy decisions, for instance, the blanket ban on timber harvest, oblige bureaucrats to enforce rules to control harvesting of valuable trees, like *S. robusta*. Our findings resonate with a growing body of literature indicating a high priority given to the conservation of *S. robusta* in Nepal [11,45,46]. Though one of the main objectives of forest management mentioned in the FMP is maintaining forest tree diversity, the dominance of economically valuable species is increasing in the study sites. This is confirmed by a study of six CFUGs in the mid-hills of Nepal [44]. The authors conclude that the current harvesting practices pose a threat to species diversity. Harvesting interventions are difficult without considering the current forest stand structure. In our study, the tree health has improved while the quality has decreased due to high competition between trees, which resonates with the finding of [9], carried out in the western Terai.

5.4. How Harvesting Practices Affect Stand Condition?

The number of seedlings, saplings and established saplings of *S. robusta* is decreasing gradually over time, whereas the number of pole trees is increasing. This can be partly caused by the continuous growth of saplings inducing a closed canopy and obstructing the penetration of sunlight [11,40,46]. Based on a study in a few Terai districts, Awasthi et al. [11] conclude that canopy opening can improve the regeneration condition in the forest. In addition, the regeneration of the forest in our study is poor because of unrestricted grass collection throughout the year. This might reduce the number of seedlings and saplings despite the presence of open canopy. In theory, the canopy opening should lead to higher regeneration, but biotic influence has a higher role in our case. Harvesting practices also destroyed under-growth due to poor handling of harvested logs while dragging from forests to the log yard.

6. Conclusions

We observed a large gap between the allowable and actual tree harvesting practices in the studied CF. Ideally, harvesting should be carried out according to the FMP; however, the FMP doesn't support harvesting decisions. Harvesting rules are guided by forest bureaucrats' discretions which are based on political coercions rather than economic considerations. The current level of harvest is far below the sustainable amount (as specified in the FMP) which could be harvested from forests. Conservative harvesting practices deteriorate the forest conditions.

On a positive note, current harvesting practices have improved the overall forest conditions, quality and health but at the same time have decreased the number of seedlings and saplings, which is a matter of concern. Although economically valuable species like *S. robusta* and others had harvesting rates lower than their growth rates, this does not necessarily contribute to sustainable management. Controlled harvesting does not imply the right approach to forest management, rather, harvesting should be guided by management objectives. In recent years, priority has been given to harvesting of poor-quality trees, which has increased the number of quality trees in forests.

Heavily regulated harvesting not only affects the future productive potential of forests but also increases the risk of holding a large number of standing trees in the forest. This may be a serious issue in the long run, which may skew forest population dynamics. Regulatory instruments are important in shaping the boundaries, however, they do not provide sufficient conditions for supporting timber harvesting. Thus, long-term management prescriptions are needed to retain and manage forests. Within CFs, management and harvesting operations are guided by political interests rather than by science; hence, forest management governance is missing. Legally, harvesting following FMP does not necessarily mean "sustainably produced" or "sustainably managed". While the current harvesting practices have generated limited social benefits to the community, the ecological and economic prospects of forestry have been undermined. The optimal level of harvest is not being practiced, which is reducing the contribution of forests to economic development. As argued by Baral et al., Hara and Gersond [22,47], the CF has been ecologically sustainable but not economically. Jong et al. [2] concluded that harvesting should ensue all three dimensions of forest sustainability, which is largely ignored in the studied cases.

We conclude that there are inappropriate policy instruments to regulate tree harvesting. There is a need for multidimensional forest management approach to achieve sustainable development. We argue that FMPs should be developed considering the forest conditions and requirements of the CFUGs. They should be simple and applicable rather than adopting them as a ritual. Further, tree harvesting should not be influenced by bureaucratic discretion. Hence, we recommend to follow a pragmatic approach in developing FMPs and complying with them rather than regulating forest management through guidelines or discretion, specially focus should be on (a) building the capacity of CFUGs, (b) developing simple and doable management prescriptions, (c) reducing impact logging, (d) avoiding blanket and ad hoc policy, and (e) developing FMPs considering forest productivity. Moreover, the long-term effects of government circulars on forest sustainability need to be monitored periodically.

Author Contributions: The study was originally designed by S.B. and H.V. S.B. collected primary and secondary data and collated and analyzed them in consultation with H.V. The draft manuscript was developed by S.B. and H.V. contributed to the finalization of the manuscript.

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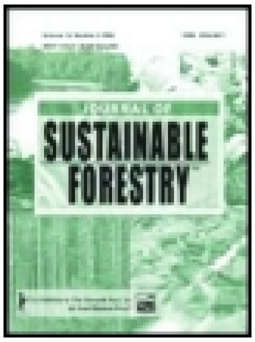
Paper II

Ecological and economical sustainability assessment of community forest management in Nepal: a reality check



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Ecological and economical sustainability assessment of community forest management in Nepal: A reality check

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ABSTRACT

This study analyzes the sustainability of community forest management, representing four forest types of two physiographic region Hills and Terai of Nepal. We assess the sustainability based on species composition, stand density, growing stock volume, and growth-to-removal ratio using inventory data of 109 permanent forest plots from four consecutive intervals of three to five years. In addition, forest users, forest committee members, and forest officials were consulted. We observed increment on the representation of economically valuable tree species in all forest types of both regions. The pole-size tree dominates in all forest types with declining number of trees and regeneration. In case of Hills forests, they were over-harvested until 2013 but were under-harvested in the recent period. In contrary, forests were under-harvested in the Terai. We found that ecological objectives of sustainable management are fully achieved while economic benefits remained unharnessed where harvesting is far below the growth. We conclude that maintaining a large number of trees may contribute to ecological but not on economical sustainability. We argue to rationalize annual harvest in all categories of the forest to enhance resource conditions together with regular benefits to the local communities.

KEYWORDS

Community forests; diversity; growing stock; forest management; sustainability; Nepal

Introduction

Arresting the continuous dwindling and degradation of tropical forest remains a major challenge for governments and other stakeholders around the world (Laurance, 1999; Zhai, Cannon, Dai, Zhang, & Xu, 2015). They are facing unprecedented pressure for making resources available (Liu & Diamond, 2005). This worldwide challenge led to the decentralization of forest management in the late 1980s (Essmann, Andrian, Pattenella, & Vantomme, 2007). Consequently, various participatory forest management strategies were being adopted in different parts of the world, especially in developing countries (Gurung et al., 2013).

In Nepal, the first participatory forest management approach, known as “community forestry,” was initiated in the late 1970s with the twin goals of restoring forest and enhancing the supply of subsistence forest products. The forests were handed over to the local communities, after forming local institutions, where the Forest Management Plans (FMPs) are a precondition for handing over forests to communities (Toft, Adeyeye, & Lund, 2015). The Forest Act 1993-Article 25 and the Forest Regulations 1995-Rules 28

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requires Community Forest User Groups (CFUGs) to prepare or renew their FMPs in every five or ten years. The FMPs define forest conditions, regulate management activities, and prescribe Allowable Annual Harvests (AAH). The FMPs are aimed at promoting sustainable forest management where sustainable harvesting is crucial for the improvement of forest conditions.

Over the past four decades of community forestry programme in Nepal, the country has made relentless efforts to revive degraded forests (Gilmour, 2016; Poudel, Fuwa, & Otsuka, 2015). It considers community forestry as one of its successful programmes for improving forest cover (Poudel et al., 2015). A recent national-wide survey of forest resources by the DFRS (2015) showed an increase in the average number of tree stems in the country in between 1998 and 2014 (from 408/ha in 1987–98 to 430/ha in 2010–2014).

Several studies have confirmed that over the years, forest coverage has improved in community forests (Gurung et al., 2013; and Poudel et al., 2015). However, the prevailing management practice in community forests is selective harvesting which focuses on the removal of low commercial value species and protection of high commercial value species (Pandey, Maraseni, Cockfield, & Gerhard, 2014). The impact of such management practices on species richness and diversity may result in the development of less structured forests in the long run (Awasthi, Bhandari, & Khanal, 2015). Despite the fact that community forestry is considered a highly successful programme for reclaiming the degraded forests of Nepal by improving the forest cover, the growing stock has still not improved (DFRS, 2015). The mean stem volume per hectare is found to be less in the recent survey, (164.76 m^3/ha in 2014) compared to earlier inventory, (178 m^3/ha in 1998) (ibid). This apparently pleads a question whether forests are being managed sustainably or not. However, several studies (Sapkota, Tigabu, & Odén, 2009; and Pandey et al., 2014) have focused on assessing the contribution of community forest either to livelihoods or to ecological aspects. Measuring forest sustainability requires assessment of both ecological and economic benefits (Seydack, 1995). However, both ecological and economical aspects of community forest (CF) management based on forest resource condition is yet to be explored.

Researchers argue that an understanding of the forest dynamics is fundamental to develop sound management systems (Charnley & Poe, 2007). This flags a need for in-depth study of the effects of forest management on the forest condition and the supply of resources. However, only a few studies have taken into consideration these effects on forest growth (Liang, Buongiorno, Monserud, Kruger, & Zhou, 2007) and uncertainties still exist in quantifying these relationships. Moreover, Poudel et al. (2015) conclude that changes in forest volume and tree size, as well as species composition over time, remain unclear in community forest management. Long-term forest data are required for assessing the current state of forests, which is less obvious in the tropics, especially in less developed countries like Nepal. This research attempts to fill this research gap by analyzing permanent plot data for eleven years.

Owing to this, much remains to be done in order to understand the contribution of CFs management to ecological (forest stand structure, diversity) and economic (forest stock growth and removal) sustainability. This paper aims to assess whether the CFs representing four different forest types from two physiographic regions are sustainably managed by analyzing forest inventory data of permanent sample plots. We have used sustainability indicators and verifiers to evaluate sustainability, focusing on forest stand conditions, tree species diversity and harvesting intensity on four forest types from two community forests to draw an examine sustainability prospects of community forests in Nepal.

Theoretical framework: Forest sustainability

Brundtland et al. (1987) defined sustainability as meeting the needs of the present generation without compromising on the livelihoods of future generations. In case of forestry, sustainability includes balancing the societal needs while maintaining natural resources (Costanza et al., 2007; Sample, 2004). This can be achieved either by regulating consumption at the societal level or by regulating management at the forest level. Consequently, sustainable forest management remains one of the primary priorities of global development goals (Prabhu, Colfer, & Dudley, 1999; and Sample, 2004), wherein integrated approaches with ecological assessment and optimal utilization are indispensable for appropriate measurement of overall sustainability (Khadka & Vacik, 2012).

Several international organizations such as the Regional Initiative for Dry Forest in Asia (RIDFA) and the International Tropical Timber Organizations (ITTO) have developed different criteria and indicators for measuring forest sustainability which are in line with the tropical context. For instance, ITTO proposed seven criteria[1] and 66 indicators (ITTO, 2005) that focus on social, economic, and ecological aspects of forest management (Prabhu et al., 1999). For this study, however, we considered three indicators based on the ITTO framework - (a) forest stand conditions (b) maintenance of forest diversity and (c) the extent of extraction of forest resources, especially timber, to assess the ecological and economical sustainability of forests. Table 1 presents the indicators used for this study and their reference to the ITTO respective indicators 4.2, 4.3, and 5.2. A detailed description of each indicator and the methods for measuring and calculating are discussed in depth in the Data Analysis Section. Many of these indicators also indirectly contribute to Criteria 2 (forest resource security) and Criteria 7 (cultural, social, and economic importance).

Table 1. Indicators used for assessing forest sustainability.

Indicators	Verifiers	Reference to ITTO indicators
Forest stand condition	Stand structure Regeneration condition Standing growing stock volume	Indicator 4.2 Current level of sustainable harvest for wood and non-wood forest product
Extent of extraction of forest resource especially timber	Growth to removal (G/R) ratio	Indicator 4.3 Quantity of wood and important non-wood forest product harvested by forest type
Maintenance of tree species diversity	Species composition Species richness Species evenness	Indicator 5.2 Number of rare, endangered and threatened forest depend on species

Source: Adapted from ITTO (2005).

[1]Enabling Conditions for Sustainable Forest Management, 2. Forest Resource Security, 3. Forest Ecosystem, Health and Condition, 4. Flow of forest produce, 5. Biological Diversity 6. Soil and Water, 7. Economic, Social and Cultural Aspects (*Source*: ITTO, 2005).

Indicator 1: Forest stand condition: is characterized by species composition, mean diameter, diameter distribution, stand height, and stand density (Brodbeck, 2004). With the help of distribution of the forest population, it is possible to predict the proportion of individuals within certain size limits (Freese, 1984) needed to ensure sustainable future harvesting and forest management (Seydack, 1995). Likewise, the density of the remaining trees after harvesting is an equally important measurement of sustainability (Pinard, Putz, & Tay, 2000). However, management interventions alter forest stand structure and regeneration capacity (Djomo Njepang, 2015). Taking this into account, we used three verifiers, namely: (a) stand structure (b) regeneration condition and (c) Standing growing stock volume for the analysis of forest stand condition.

- **Stand structure**: describes the horizontal or vertical distribution of species (Hara & Gersonde, 2004). We used tree diameter to describe the forest stand structure (Bourdier et al., 2016) and basal area to calculate Gini indexes to quantify the conditions.
- **Regeneration condition**: measured by seedlings and saplings per unit area.
- **Growing stock volume**: measured by a standing volume of timber per unit area.

Indicator 2: Extent of extraction of forest resources, especially timber: The intensity, periodicity, and kind of thinning has a strong effect on the total yield of forests (e.g., Kramer, 1988) Hence, harvest rates should be at least equal to growth or forest growing stock should remain constant over a period of time if we intend to ensure the future sustainability of the forest.

- **Growth to removal (G/R)**: Ratio is used to examine future resource sustainability (Morin & Liknes, 2012). It should be at least close to one to be ecologically and economically sustainable, where constant resource volume is maintained over a period (Seydack, 1995).

Indicator 3: Maintenance of tree species diversity: Tree species diversity can be maintained by managing the structural diversity of stands (Buongiorno, Dahir, Lu, & Lin, 1994; and Franklin et al., 2002). Structural diversity is an important part of biological diversity and affects other components of biodiversity, i.e., compositional and functional diversity, and, consequently, economic, ecological, and social values of forest management practices (Lexerød & Eid, 2006). Maintaining compositional, structural, and functional attributes of the forest ecosystem is an important approach to biodiversity conservation (Franklin et al., 2002). We used species composition, richness, and evenness to assess tree diversity.

- **Species composition** allows us to quantify the distribution of tree species (McElhinny, Gibbons, Brack, & Bauhus, 2005) where the Importance Value Index (IVI) was used as a proxy (Mueller-Dombois & Ellenberg, 1974).
- **Species richness** refers to the number of species recorded in each plot is calculated following Shannon and Weiner (1963).
- **Species evenness** indicates how evenly the species are distributed in the forest with a value ranging from 0 to 1, where 1 means an equal distribution and values

approaching 0 indicate unequal distribution. Species evenness was calculated following Margalef (1958).

Material and methods

Study area

Table 2. General characteristics of the study area.

Attributes	Kankali CFUG	Tebrikot CFUG
Forest category	Terai	Hills
Forest handover to local communities	1995	2003
Operational plan revised	2013	2014
Altitudinal range of the forest	220–580 msl	1200 msl
Aspect	South-East	East-North
Forest area	749.13 ha	119.75 ha
Main forest type	*Shorea robusta* Gaertn f. (Sal)	*Schima wallichii* (DC.) Korth. *Castanopsis indica* Roxb.ex Lindl.
Forest development stage	Pole	Pole and Tree
Number of management blocks	5	5

Source: Management Plan of Kankali CFUG and Tebrikot CFUG; 2016

The study areas were selected based on the availability of long-term forest inventory data representing two community forests—Kankali Community Forest representing the Terai forest, and Tebrikot Community Forest representing Hills forest. Table 2 presents the general characteristics of each study area.

The Kankali CF (27.65°N, 84.57°E) is located in Khairani Municipality, Chitwan district of Province 3 and covers 749.18 ha in Chitwan District. Tebrikot CF (28.29°N, 83.93°E) is located in Pokhara Lekhnath metropolitan city of Kaski District of Province 4 and covers 119.75 ha area (Figure 1). The dominant vegetation types represented are tropical *S. robusta* forest in Kankali and subtropical *S. wallichii* and *C. indica* forest in Tebrikot. The CFUGs, comprising 1967 and 257 households, respectively, in Kankali and Tebrikot are managing the forest.

Data collection

Forest inventory data of the permanent sample plots collected in 2005, 2010 and 2013 were obtained from the Institute of Forestry. The first inventory of 2005 applied the 'coffee-house' design principle as the first plot was selected randomly and the successive plots were laid to maximize the minimum distance to neighboring plots (Müller, 2001). Of the 68 plots laid out in the Terai forest, this study considered only 57, as data were missing for the three plots and eight plots were destroyed by infrastructure development and land conversions in 2010. Likewise, out of the 53 plots measured in the Hills forest, information was missing for one plot, and only 52 plots were selected for this study.

The first author conducted a forest inventory in autumn 2016 following a basic plot design of Meilby, Puri, Christensen, and Rayamajhi (2006) that includes three nested subplots. Trees with a diameter at breast height (DBH) of at least 10 cm were measured in a

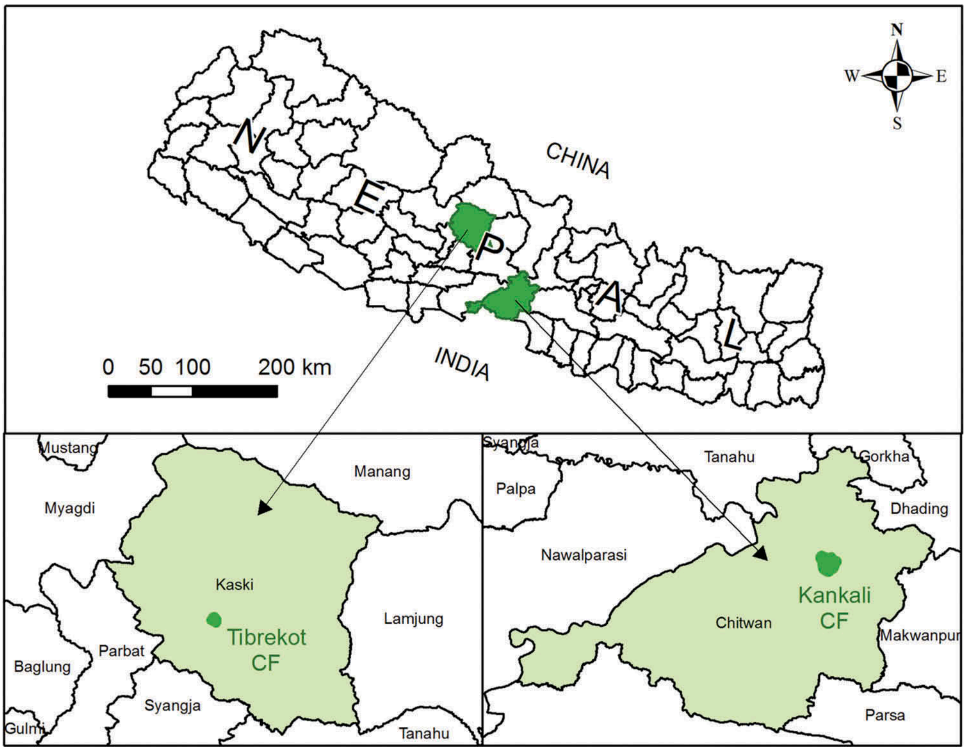

Figure 1. Study area.

20 × 25 m plot, trees with DBH 4–9.9 cm were measured within an interior 10 × 15 m plot, and trees with DBH 2–3.9 cm were measured within an interior 5 x 5 m plot. Furthermore, saplings were measured in 5 × 5 m plots while seedlings were measured in 1 × 1 m plots. The parameters included species identification, positioning, DBH, and height of trees. Additional information was derived from CFUGs documents such as management plans, forest product extraction records, and meeting minutes. Eighteen committee members (ten in the Terai and eight in the Hills) who were involved in the management of community forests were consulted during the field survey in late 2016 to gather additional qualitative information about the current management practices.

Data analysis

For data analysis, both descriptive and inferential statistics were used. The inventory data were analyzed by establishing four distinct forest types. A nomenclature of the plots was based on the proportion of species present. Referring to Pandey et al. (2014) and Miehe et al. (2015), in Terai, plots with more than 50% of trees belonging to the *S. robusta* were categorized as *S. robusta* forest (SRF) and those with the majority (above 50%) of species other than *S. robusta* were categorized as other Terai hardwood forest (OTHF). Similarly, plots in the Hills with more than 50% *S. wallichii* and *C. indica* were categorized as *Schima-Castanopsis* forest (SCF) and the plots with mixed trees were named as other Hills forest (OHF). The samples were stratified based on the mean diameter of the occurring species: seedlings (< 1 cm), saplings (2-10 cm), pole trees

(10-30 cm) and trees (> 30 cm). Our study followed a nested plot design in order to consider tree size and plot size while analyzing data by using different equations and indices.

Shannon & Weiner index was used to account for species composition (includes both abundance and evenness), and Margalef's index was used to measure the species richness. Likewise, Pielou index was used to measure evenness within species. Evenness indicates how even the species in the forest are distributed with values ranging from 0 to 1, where 1 means an equal distribution and values approaching 0 means unequal distribution.

Measurement of diversity

The type of diversity used here is α- diversity, which is the composition of species within a community. The diversity index was calculated by using the Shannon–Wiener diversity index (1963).

$$\text{Diversity index} = \text{H} = -\sum(\text{Pi})\ (\text{In Pi}) \tag{1}$$

where Pi = S/N
S = number of individuals of one species
N = total number of all individuals in the sample

Measurement of species richness

Margalef's index was used as a simple measure of species richness (Margalef, 1958).

$$\text{Margalef's index} = (\text{S} - 1)/\text{In N}) \tag{2}$$

S = total number of species
N = total number of individuals in the sample

Measurement of evenness

For calculating the evenness of species, the Pielou's Evenness Index (e) was used (Pielou, 1966).

$$\text{e} = \text{H}/\text{InS}) \tag{3}$$

H = Shannon – Wiener diversity index
S = total number of species in the sample
Gini indices are used to analyze the structure of a stand (Stöcker, 2002) and are calculated to assess inequality within basal area distribution over the stand structure. Bourdier et al. (2016) explain that, for the natural uneven aged forest, it is more productive and sustainable than the stands of the same size if the basal area distribution is heterogeneous with diverse sizes. Gini coefficient is a measurement of heterogeneity and quantifies the deviation from perfect equality. It has a minimum value of zero when all trees are of equal size and a theoretical maximum of one when all trees, but one has a value of zero. Therefore, higher values indicate the greater size of diversity. In our study, it was calculated by taking the basal area.

Gini coefficient is calculated using the following formula;

$$G\,1 = 1 - \sum_{k=1}^{n} (X_k - X_{k-1})\,(Y_k + Y_{k-1}) \tag{4}$$

Where

X_k is the cumulated proportion of the tree population variable, for k = 0,..., with $X_0 = 0$, $X_{n = 1}$.

Y_k is the cumulated proportion of the basal area variable, for k = 0,. . .,n, with $Y_0 = 0$, $Y_{n = 1}$.

Y_k is indexed in non-decreasing order ($Y_k > Y_{k-1}$).

Stand density and composition were analyzed by comparing the distribution of tree diameter classes. Relative density, relative frequency, and relative dominance were calculated for each species to determine the Importance Value Index (IVI) adopted by Mueller-Dombois and Ellenberg (1974). Five major species from each forest type were selected to assess dominance and IVI, and the remaining species were grouped as other species. The total number of individual species per stratum was computed.

IVI was calculated by using following formula proposed by the Zobel, Jha, Behan, and Yadav (1987), where

$$\mathrm{IVI} = \mathrm{Relative\ Frequency(RF)} + \mathrm{Relative\ Density(RD)} + \mathrm{Relative\ Dominance(RDo)} \tag{5}$$

Whereas relative frequency is the frequency of a species relative to that of all species:

$$Relative\ Frequency\ \% = \frac{Frequency\ of\ a\ Species}{Total\ Frequency\ of\ all\ the\ Species} * 100$$

Relative density is the density of a species with respect to the total density of all species.

$$Relative\ Density\ \% = \frac{Density\ of\ individual\ species}{Total\ density\ of\ all\ the\ species} * 100$$

$$Relative\ Dominance\ \% = \frac{Basal\ area\ of\ species}{Basal\ area\ of\ all\ species} * 100$$

Four regression equations were derived from the reference tree height values of the main tree species of the 2016 inventory for estimating the tree height in all forest types. The number of trees, mean tree height, mean diameter, basal area, and stand volume per unit area were calculated. We estimated the growing stock volume using the volume equations developed by Sharma and Pukkala (1990) for different categories of species. This calculation was conducted for different diameter classes and forest types.

$$\ln(v) = a + b\ln(d) + c\ln(h) \tag{6}$$

where v is the total stem volume with bark, and a,b,c are the constants for the different tree species Sharma and Pukkala (1990).

The growth to removal (G/R) ratio was calculated following James, Abt, Abt, Sheffield, and Cubbage (2012). Growth was calculated as the increase in the growing stock volume in the forest, and removal was considered as a loss by mortality or harvesting of trees from plots. When the G/R ratio is greater than 1, growth outpaces the rate of removal, considering all other factors as constant. This ratio is often used as a reference point to forecast future resource sustainability. Growth is considered as the difference in the growing stock volume during two inventory periods (i.e. V2-V1, where V2 is the standing growing stock volume in the recent inventory + ingrowth, and V1 is the volume in the previous inventory) (Meilby et al., 2014). Removal is the total harvested volume/quantity of trees in the recent inventory, which is computed based on the volume of trees removed or lost in comparison to previous inventory, and thus includes both lost and harvested trees from the plots in two consecutive inventories.

Results

Forest stand condition

The findings indicate that the number of trees is declining in all development stages and there is a lot of variation (Figure 2 and Table 3) in all forest types except for OHF. The number of seedlings and saplings in all forest types were in decreasing trend between 2005 and 2016. However, in OHF, there was a net increase in the number of saplings despite the fluctuations that were prevalent in that time period. For instance,

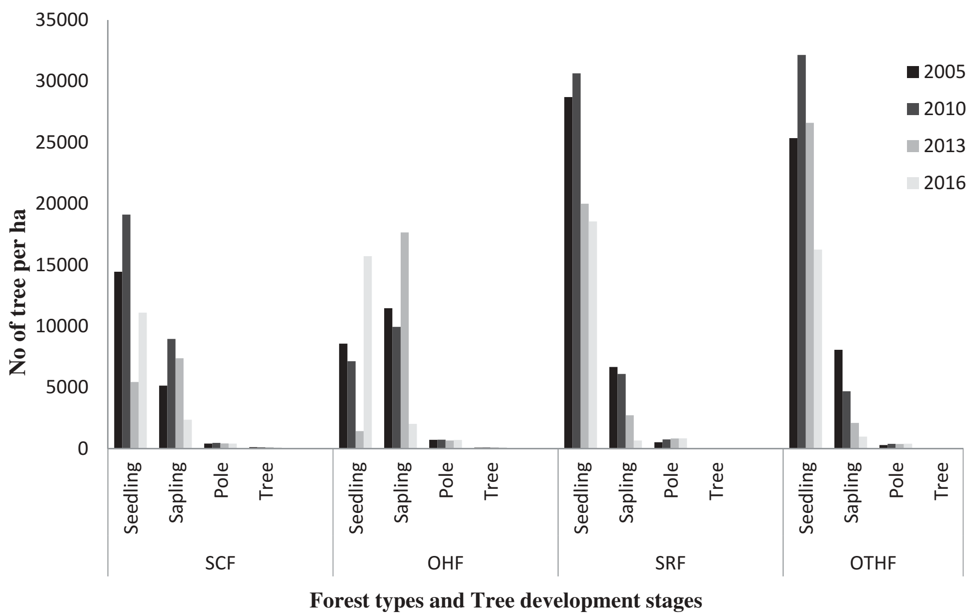

Figure 2. Stand structure by forest types *Source: Inventory data 2005, 2010, 2013 & 2016.*

Table 3. Mean and standard error of stand density (no/ha) by forest type and tree stages.

Forest Type	Stage	2005	2010	2013	2016
SCF	Seedling	14444 ± 3090	19111 ± 3045	5444 ± 1051	11111 ± 1402
	Sapling	5140 ± 793	8954 ± 1464	7377 ± 1496	2362 ± 528
	Pole	522 ± 3082	465 ± 31	424 ± 31	415 ± 31
	Tree	117 ± 8	105 ± 8	107 ± 8	99 ± 9
OHF	Seedling	8571 ± 4040	7142 ± 4738	1428 ± 1428*	15714 ± 2020
	Sapling	11466 ± 3958	9942 ± 3221	17647 ± 6400	2019 ± 792
	Pole	722 ± 125	734 ± 151	669 ± 131	709 ± 115
	Tree	82 ± 37	88 ± 36	97 ± 34	114 ± 33
SRF	Seedling	28709 ± 5009	30645 ± 5144	20000 ± 3093	18548 ± 2788
	Sapling	6668 ± 1038	6098 ± 1354	2715 ± 471	673 ± 169
	Pole	528 ± 45	751 ± 57	835 ± 67	839 ± 63
	Tree	20 ± 5	18 ± 5	17 ± 5	23 ± 5
OTHF	Seedling	25357 ± 4317	32142 ± 6168	26607 ± 5352	16250 ± 3563
	Sapling	8066 ± 1515	4685 ± 1497	2104 ± 447	974 ± 435
	Pole	297 ± 35	391 ± 41	381 ± 42	403 ± 62
	Tree	30 ± 8	36 ± 7	33 ± 7	36 ± 8

(Columns 2005–2016 are under the spanning header "Year".)

Source: Inventory result of 2005, 2010, 2013 & 2016
*Note: *Number of seedlings and standard error in case of OHF forest is same due to data in only one plot*

the number of seedlings per ha in the SCF declined from 14,444 in 2005 to 11,111 in 2016 while in SRF it reached 18,548 from 28,710 during the same period. The rate of decline of saplings was quite high when compared to that of seedlings, indicating that natural regeneration was high in the initial stages. Interestingly, the number of poles increases in SRF and of trees increases in both SRF and OHF, whereas number of poles in SCF, OHF, and OTHF remained almost equal throughout the inventory period. Likewise, numbers of trees in SCF is in decreasing trend and that in OTHF remained almost constant. The stand structure resembled the reverse J-shaped distribution in all four periods of the inventory with some fluctuations in between, except in OHF (Figure 2 and Table 3).

Tree species diversity

We identified 28 tree species in the Hills forest and 41 in the Terai forest. Based on the 2005 inventory results, we identified five major tree species based on their density. In both SCF and OHF, the species were *C. indica, Engelhardia spicata* Lesch ex Blume, *Myrica esculanta* Buch.-Ham. ex D.Don, *Myrsine capitellata* Wall, and *S. wallichii*. Likewise, in OTHF, the five dominating species were *S. robusta, Lagerstroemia parviflora* Roxb., *Holarrhena pubescens* Wall., *Cleistocalyx operculatus* Roxb. and *Dalbergia sissoo* Roxb. ex DC while in SRF, they were *S. robusta, L.parviflora, Sapium insigne* Royle Benth. ex Hook. f, *C. operculatus*, and *Casearia graveolens* Dalz.

The IVI in Figure 3 indicates changes in IVI across the four inventories in the Hills forest. In SCF, the IVI of *S. wallichii*, which is an economically important species has slightly decreased from 141.95 in 2005 to 136.80 in 2016 (with fluctuation in between), whereas it increased from 93.14 in 2005 to 111 in 2016 in the OHF. The IVI of *C. indica* increased in both categories of the Hill forest between 2005 and 2016, which was 114.6 to 121.3 in SCF and 29.5 to 36.09 in OHF. The IVI value of *M. esculanta* and *E.spicata* decreased in both Hills forests whereas that of *M. capitellata* increased. Figure 3 shows

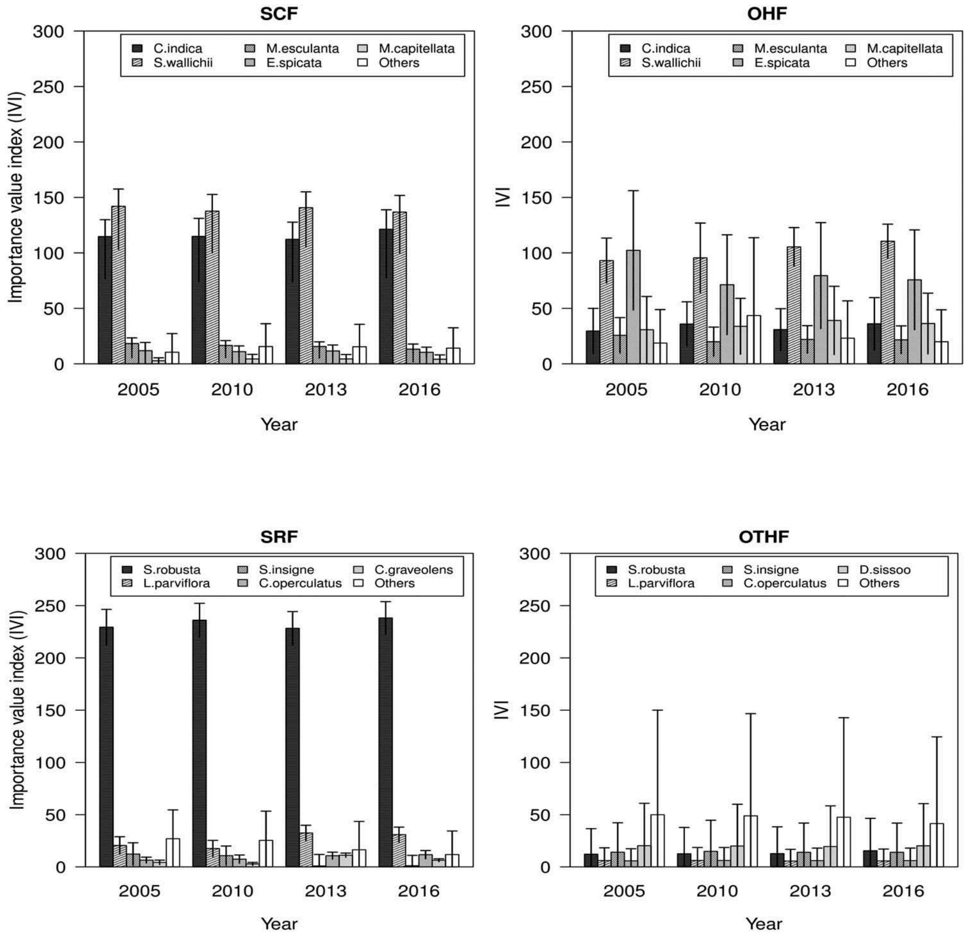

Figure 3. Importance Value Index (IVI) of major tree species in the Hills & Terai Forests.

that IVI of *S. robusta* in SRFs increased from 229.4 to 238.2 and that of OTHF increased from 83.6 to 104.1 during the eleven-year time period, whereas that of *D. sissoo* in OTHFs remained the same during the same period (Figure 3). However, the proportion of some other species had slightly increased and that of other species had gradually decreased in both cases. Among these species, *S. robusta in* the Terai and *S. wallichii* and *C. indica* in the Hills had higher IVI than others.

According to Shannon index, the tree species diversity increased in both categories of the Hills forests over the last eleven years, from 1.23 to 1.52 in OHF and from 0.97 to 1.05 in SCF. On the contrary, it decreased over the same period of time in both types of Terai forests, with some variation by forest type. Species diversity is low in SRF, and it dropped down from 0.75 in 2005 to 0.62 in 2016, although the species density was higher in the OTHF forest (1.28), but it decreased to 1.24 over the same period of time (Figure 4). Overall, indices show that species density had improved in the Hills forest in the last decade, while it had decreased in the Terai forest. However, such a difference is not statistically significant. Similarly, Margalef's Species Richness Index decreased in SRF (from 1.98 in 2005 to 1.67 in 2016) with fluctuation in between, while it marginally increased in OTHF (from 0.98 in 2005 to 1.06 in 2016) and in

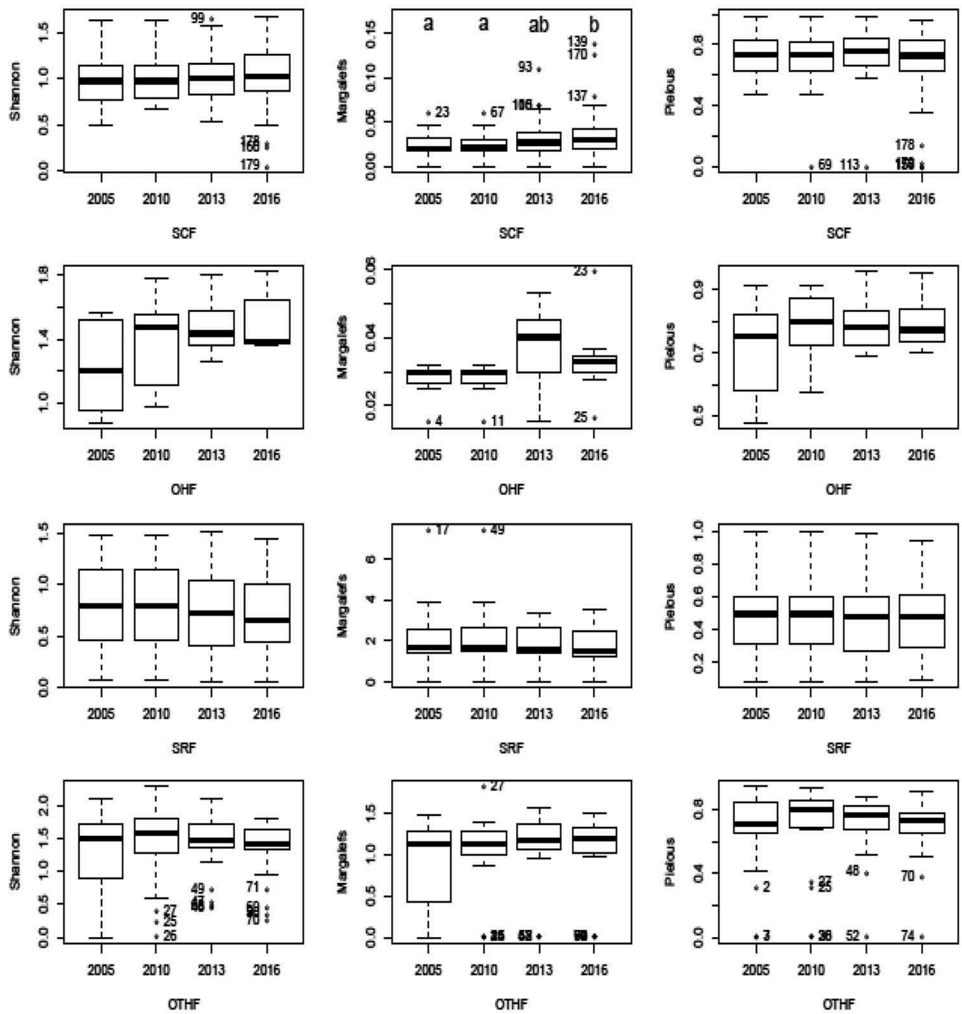

Figure 4. Box plots with mean and standard errors of species diversity, evenness and richness indices.

SCF (from 0.02 in 2005 to 0.04 in 2016), but it remained almost the same in OHF (0.03). During the eleven years, the Equitability or Evenness Pielous Index almost remained the same in SCF and SRF forests, while it decreased in OTHF Terai and slightly increased with fluctuation in between in OHF.

To evaluate the tree species diversity in different forest types of the Hills and Terai, three species indices were calculated and the derived indices of the species were statistically analyzed. A one-way ANOVA with Welch's test using the post hoc test Turkey for multiple comparisons of unequal variance was performed at a significance level of α = 0.05. Results are illustrated in Figure 4 and show a range for the four different types of forests for each index. Statistically significant differences for the years and indices are highlighted by different letters. According to Figure 4, significant differences were evident for the Margalefs analysis for comparison for the periods 2005–2016 and

Table 4. Gini coefficient of the tree basal area in the observed plots.

	Hills (n = 52)		Terai (n = 57)	
Year	SCF (45)	OHF (7)	SRF (34)	OTHF (23)
2005	0.59 ± 0.008	0.54 ± 0.011	0.61 ± 0.006	0.71 ± 0.008
2010	0.61 ± 0.008	0.56 ± 0.012	0.54 ± 0.006	0.67 ± 0.008
2013	0.61 ± 0.009	0.56 ± 0.012	0.50 ± 0.005	0.62 ± 0.008
2016	0.61 ± 0.008	0.56 ± 0.214	0.47 ± 0.007	0.59 ± 0.009

Source: Inventory data 2005, 2010, 2013 & 2016

2010–2016; however, no variation was found in 2013 in SCF. In contrast, it shows a variation in the mean in OHF and OTHF in the figure that was not statistically significant.

Because of the sensitivity of the Shannon–Wiener index and its uncertainty to changes in the class width, the Gini coefficient was also used to calculate the inequality distribution of the basal area of different forest types. It performs better structural diversity measurements in forest management planning and does not require arbitrarily classified basal area (Lexerød & Eid, 2006). The Gini analysis (Table 4) showed that SCF was more heterogeneous than OHF. The transformation of both forests towards heterogeneity was seen between 2005 and 2010, during which there was an increase in Gini coefficient. The Gini coefficient, thereafter, remained the same throughout the study period, implying that there was no change in the homogeneity or heterogeneity of the forests. In contrast, both SRF and OTHF were converting to homogeneous forests. The transformation indicated that forests were converting into trees with similar basal area.

Growing stock volume

The growing stock volume in the Hills forest, especially in SCFs, had decreased in the last eleven years (200.3 m^3/ha in 2005 and 168.6 m^3/ha in 2016), whereas that in OHF had increased, with some fluctuations between the years (153.6 m^3/ha in 2005 and 185.6 m^3/ha in 2016). In the Terai, the standing growing stock volume in both SRF and OTHF increased during the same period (Table 5). The increase in the growing stock in SRF is very high with almost 100% (from 101.4 m^3/ha in 2005 and 200.8 m^3/ha in 2016). In OTHF it was almost 57% (98.5 m^3/ha in 2005 and 154.8 m^3/ha in 2016).

Table 5. Mean growing stock volume (m^3/ha) and standard error of the four forest types.

	Hills (n = 52)		Terai (n = 57)	
Year	SCF(n = 45)*	OHF (n = 7)	SRF (n = 34)	OTHF (n = 23)
2005	200.3 ± 23.7	153.6 ± 10.1	101.4 ± 15.3	98.5 ± 17.1
2010	182.3 ± 10.8	160.7 ± 23.9	141.6 ± 15.4	113.7 ± 17.1
2013	178.8 ± 11.1	157.9 ± 23.2	173.0 ± 19.2	132.0 ± 17.2
2016	168.6 ± 12.7	185.6 ± 23	200.8 ± 21.3	154.8 ± 18.2

Source: Inventory data 2005, 2010, 2013 & 2016
**No of plots*

Table 6. Average growth and removal (m^3/ha/year) over the last 11 years.

Forest type	Period I (2005–2010)			Period I I (2010–2013)			Period III ((2013–2016)		
	Growth	Removal	Ratio	Growth	Removal	Ratio	Growth	Removal	Ratio
SCF	−3.61	0.49	−7.4	−0.71	2.54	−0.28	−2	0.8761	−2.3
OHF	1.43	0.63	2.3	−0.55	1.93	−0.28	5.5	1.2512	4.4
SRF	8.03	2.16	3.7	6.3	1.76	3.57	5.5	0.5827	9.5
OTHF	3.04	1.1	2.8	3.68	1.89	1.95	4.6	0.7182	6.3

**The standing stock/growth in 2010, 2013, 2016 was calculated as the mean of the volume per year per hectare of live trees and ingrowth. Whereas the increment in period I, II, III is the change in volume of trees alive both in 2005 to 2010, 2010 to 2013, 2013 to 2016, plus the volume of ingrowth* (Meilby et al., 2014).

Extent of extraction

It can be assumed that the growth-to-removal ratio should be ≥ 1, indicating strong economic sustainability of the forest (James et al., 2012). The growth- to-removal rate was estimated for three periods: period I (2005–2010), period II (2010–2013), and period III (2013–2016) (Table 6). In SCF, removal was higher than growth throughout the period, while growth exceeded removal in OHF, except in period II. In SRF and OTHF, growth was higher than removal throughout all periods. This indicated that the forest was under-harvested in both Terai forests while it was over-harvested in SCF and in OHF, except in period II.

Discussion

Forest management practices influence forest stand structure and species diversity, and this influence is important to understand and recognize for the creation and maintenance of ecologically sustainable forest management (Liang et al., 2007). The standing growing stock volume, the growth to removal ratio, and harvesting intensity are important aspects to address the economic dimensions of sustainable forest management (James et al., 2012). Referring to the ITTO's framework, three indicators and seven verifiers were used to assess whether the community forests are managed in an ecologically and/or economically sustainable manner by collating the forest inventory data of two CFUGs which represent four different forest types. The current research relies on inventory design from the previous research (2005) and subsequent data collected during 2010, 2013 and 2016. Though inventory design was very comprehensive and robust many important parameters required to estimate growth of the forest, such as species competition and mortality were not collected. As a result, we computed growth of the forest based on changes in the growing stock volume between two periods (cf above). In addition, we had to discard nearly 10% of the permanent sample plots since they were permanently destroyed. Moreover, we focused our analysis focusing on ecological and economic aspects of the forest sustainability, where we have selected only a few indicators. This study did not look after social aspects and governance issues related to the forest sustainability.

Ecological aspects of tree harvesting for sustainable forest management

We observed tree harvesting practices have an effect on the proportion of seedlings, saplings, poles, and trees in the forest. The forest stands' structure and regeneration status of the all tree species indicated a high share of seedlings, followed by saplings and poles. Moreover, the results indicate that the proportion of seedlings compared to saplings is up to five times higher in all four inventories except OHF. The share (seedling and sapling) of Terai forests was quite high which is consistent with the results of Giri et al. (1999) who found the highest number of seedlings (9205/ha) and saplings (321/ha) of *S. robusta* in *Shorea-Terminalia* forests in the western Terai region of Nepal. Shrestha (2015) made similar observations in the Kankali community forest where seedling density was almost double than that of saplings (seedling density 11,858/ha and sapling density 5,999/ha). In case of Terai forest, our findings are consistent with West et al. (1981) cited in Acharya and Shrestha (2011) who suggest that the density of seedlings should be higher than the density of saplings when the strategic management goal is to ecologically enrich the forests. Likewise, various experimental studies have shown that the balanced structure of an uneven-aged forest can be approximately characterized by de Lincourt's rule wherein the number of trees in successive diameter classes at the stand level can be represented as a decreasing geometric progression or a reverse J-shape curve (Meyer, 1943; and Picard & Gasparotto, 2016). Our inventory results of three forest types except OHF for all-time series show a similar pattern, which favors ecological oriented management when compared to other management strategies. However, the time series data also demonstrates a fluctuation with a decrease in the number of seedlings and saplings. Interestingly, despite the good regeneration, many of the seedlings and saplings did not survive especially in Terai forests due to resource competition (e.g., light, water, and nutrients) or poor management interventions (e.g., harvest of forage and grass for cattle). Though regeneration of SRF was better compared to other species, its further survival and establishment was poor. The dense pole-sized forests obstruct sunlight from reaching the forest ground, and consequently, the number of seedlings and sapling of SRF forest decreased gradually over the period, whereas that of pole increased gradually. A closed canopy and the resultant limited sunlight conditions are described as a hindrance to natural regeneration in the Terai forest of Nepal (Oli & Subedi, 2015 P $_{(101)}$ and Awasthi et al., 2015). In response to the significant cutting of saplings for grass growth, local communities stated that "*the regeneration condition of the forest was deteriorating because of unrestricted grass collection throughout the year.*"

Pandey et al. (2014) reported that community forests generally have pole-sized trees because of the community forest guidelines allowing selective cutting of mature trees. This is similar to our study, where numbers of poles remained consistent expect in the SRF where the number of trees increased. Although the pole density of this study appears to be consistent with the findings of Shrestha (2015), it was found to be in contrast with the findings of Timilsina, Ross, and Heinen (2007), who reported a density of poles with only 220 stems/ha in the western Terai of Nepal. Similarly, Paudel and Sah (2015) accounted for 227 stems/ha in lowland Terai. It can be assumed that the number of poles was relatively high in our case because as expressed by community members "*communities do not harvest small-sized trees.*" In addition, the community has had managed Terai forest since 1995 and the community has consistently given high priority to forest protection over the last decade (Puri et al., 2013). The increasing numbers of poles particularly towards the enhancement of *S. robusta* species echoes the findings of Sapkota and Odén (2008). In discussion with an executive committee member of Terai, it was stated that "*they prefer to harvest other species as much as possible and conserve economically valuable species such as S. robusta.*". Further, it was stated that *"harvesting of S. robusta is a cumbersome process* *where they had to comply with several government requirements*". Surprisingly, pole stand density had decreased in both Hill forests. In a key informant interview, the CFUG chairperson revealed that *"there is high demand for poles in the communities for construction material and fuelwood. Hence, harvesting of the pole-sized tree takes place regularly"*.

Hara and Gersonde (2004) and Bennett (2013) reported that the distribution of the diameter classes could be used to describe the sustainability conditions of the forest. A high number of individuals in the low diameter classes can help maintain forest structure and productivity in long run. Our findings showed diameter distribution followed a reverse J-shaped curve with low densities of large diameter trees consistently over four inventories, all four forest types are in a continuous regeneration process. However, there are imbalances in the diameter class distribution. This is likely due to older trees/pole of particularly *S. robusta*, being less harvested in Terai forests. This finding is similar to Sapkota et al. (2009) and Picard and Gasparotto (2016), who found that Terai forests are mainly dominated by pole-sized trees. Further, this is due to community forest utilization guidelines (2014) which prohibit the harvesting of pole size trees (GoN, 2014).

Huang et al. (2003) explained that species diversity is significantly influenced by forest structure and species composition. Moreover, Naidu and Kumar (2016) concluded that high species diversity is often connected to a more complex vertical structure. The number of tree species recorded in our study sites was lower than the number of species reported by several authors under similar tropical forest conditions (ibid) 129 species (with diameter ≥ 15 cm) were recorded in northern Andhra Pradesh, Tenzin and Hasenauer (2016) recorded 124 species in east Dagana, Bhutan and Sapkota et al. (2009) recorded 67 species in Western Terai of Nepal. The low species richness is likely attributed to the selective thinning of tree species with low economic value, and the increased management and protection of economically valuable species (Chaudhary, Burivalova, Koh, & Hellweg, 2016). Although species richness in Terai forests has decreased, the total species richness was still higher compared to estimation by Dallakoti and Kleinn (2008) in the same Terai forest. However, species evenness and dominance have increased compared to the past, especially in the Hills. This is mainly caused by the subsistence use of resources for which people do not have preferences for any particular species.

The IVI of preferred species like *S. robusta* in the Terai and *Schima and Castanopsis* (in aggregate) in the Hill forests had increased over the period of time, while that of other species had decreased. This confirms the finding that management interventions are guided by social preferences and interests (e.g., Sapkota & Odén, 2008). Although there was no strict rule for harvesting tree species other than *S. robusta* in Terai forest, protection measures for *S. robusta* still remained a high priority (Awasthi et al., 2015; and Paudel & Sah, 2015).

The Gini coefficient of the observed tree basal area shows that the heterogeneity remained almost similar in the Hills forests over the four inventories, while both forests in the Terai were transformed into more homogeneous forests in the same period. Despite conservation history of nearly three decades in both study sites, the proportion of mature trees was slightly increased in the OHF in the Hills and the SRF in the Terai while that of pole trees had remained almost constant. Communities have been compelled to harvest 4Ds trees (dead, dying, infected by diseases and deformed) led to pole size dominated forests which was noted in Sapkota et al. (2009); Picard and Gasparotto (2016), and Baral, Vacik, Khanal Chhetri, & Gauli, (2018). From a study of six CFUGs in the Mid-Hills of

Nepal, also Oli and Subedi (2015) concluded that the current harvesting practices pose a threat to species diversity, and future interventions should focus on multiple products and services when designing management strategies.

Economic aspects of timber harvesting practices

Timber harvesting appeared to have a positive impact on the growing stock volume both in Terai and Hills which is also supported by the findings of Bufum, Gratzer, and Tenzin (2008) in Bhutan. Community harvesting practices we focused on maintaining a constant growing stock over time, with only parts of the annual increment harvested. Our findings resemble those of Toft et al. (2015), studied in the western mid-Hills region of Nepal and concluded that the management practices of the community forest lead to a constant growing stock volume and low harvest rates of the annual increment. The removal of annual increment was consistently less than the prescribed amount in the management plans for Terai forests whereas high in hill forest especially in SCF in all periods. This pattern had two exceptions —Forests were often over-harvested in the Hills and under-harvested in the Terai, which mainly favored forest regeneration in the Hills. Timber harvesting appeared to have a positive impact on tree species diversity and stand structure as well as in enhancing growing stock volume. However, in the absence of long-term data, informing forest management and providing a sound prediction of the annual yield assessments on forest sustainability may not be possible. Nevertheless, harvesting decisions were carried out in a judicious way by maintaining at least a constant growing stock volume over time and giving preference on the protection of mature trees. However, this implies fewer income opportunities from selling timber for the communities and consequently they were giving more preference towards the harvesting of small-sized trees for fuelwood.

This study further revealed that biophysical parameters are poorly considered in management decisions by forest managers. Decisions are largely based on administrative orders which have previously undermined harvesting practices. Recent reports from the Department of Forests (DoF) assumes the annual growth of the forests as being 1%, where users are allowed to harvest 60% of the growth (DFRS, 2015). On the other hand, the CFUG inventory guidelines (2004) assume that if the growth rate is between 3% and 5% in a medium quality forest, 85% of the annual growth could be harvested (DoF, 2004). As a result, the amount of harvested timber is far below the annual growth rates independently from the considered guidelines as indicated by our study. A series of decrees are issued by the DoF, which sneak the liberty the Forest Act 1993 to CFUGs. For instance, in September 1999, the MoFSC decided to ban harvesting of green trees from government and community managed forests. This was strongly enforced with a follow-up circular issued in the same month of the year, instructing District Forest Officers (DFOs) to stop tree harvesting (Devkota, 2010). To reduce harvesting rates, the MoFSC declared the year 2011 as a "Plant Holiday," resulting in lower harvest in the Terai forests; however, this is not implied for the Hills. Similarly, a circular issued in October 2012 mentions that the national average growing stock volume is below 178 m^3/ha and with an increment rate of 1%, which is low and forces the communities to reduce harvesting. However, the prescribed growing stock volume is high relatively on the ground.

Our findings reveal that the forests at both study sites are managed sustainable, as the forest stand conditions are at least comparable with the results of the 2005 inventory. However, the management has focused on maintaining important economic species and giving emphasis on the protection of larger trees. The forest appears to be sustainable from an ecological point of view as species diversity is maintained. But the conditions of the natural regeneration are very poor either due to unfavorable light conditions or caused by human interventions like collecting grass. This might affect forest conditions in the future. However, the management practices do not necessarily contribute towards the economic sustainability. The current level of annual harvesting is far below the total growth of the forest, partially due to the recent policy reforms in the community forest. In addition, the conservation attitudes of the local communities further support this trend. Hence, we can argue that both ecological and economic objectives of sustainability have to be considered in the community forests in order to meet the ecological and economic benefits simultaneously.

Conclusions

Resurgence of community forests in Hills and Terai forests of Nepal have the potential to contribute to the ecological and economic sustainability of forests. However, forests are largely managed from the ecological perspective guided by limited harvesting with less attention to optimal utilization. The current management practices have been predominately focused on enhancing the growing stock over time, giving priority to ecological sustainability. Government directives are partially responsible for this situation. Increasing the growing stock volume may contribute to ecological benefits but may not contribute to the future economic value of the forest. Furthermore, the preference for protecting economically valuable species has adversely affected species diversity, structure, and productivity of the forests in the long run.

Forests in the study sites are in the stage of recovery from degradation. However, the current management practices might not ensure future economic sustainability as the economic value of the forests is decreasing due to the limited promotion of timber production. Forest management is very generic and conducted without considering the site and stand conditions in making harvesting decisions. Unless the forest management strikes a balance between ecological and optimal utilization, it is not possible to meet overall forest sustainability. This study suggests for improving current management approaches to balance both ecological and economic aspects of the forest and thereby ensuring forest sustainability. Maintaining existing trees or growing more trees does not necessarily ensure forest sustainability. Harvesting practices need to be tailored in such a way that they help to enhance the value of the forest resources and provide regular benefits to the local communities, for ensuring both ecological and economic sustainability.

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Paper III

Investments in different taxonomies of goods: what should Nepal's community forest user groups prioritize?

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Investments in different taxonomies of goods: What should Nepal's community forest user groups prioritize?

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ABSTRACT

Community forestry was initiated four decades ago in Nepal, with the aim of conserving forests and providing basic forest products to proximate households for subsistence use. Many resources were invested in improving the well-being of local communities, especially through the selling of forest products. However, there is limited knowledge of how this investment contributes to well-being. Following the concept of economic goods, this paper elucidates how community forest investment in different taxonomies of goods contributes to households' well-being. A statistically representative (n = 377) household survey was carried out in the Terai and mid-hills, representing different income groups (low, middle and affluent), along with focus group discussions and key informant interviews in two community forests. The data collection was supplemented with an analysis of community forest-user groups' records and their interactions with stakeholders. Two-stage statistical models were developed to explain the effect of the investment in different taxonomies of goods to household well-being, where economic factors were confounded in the first stage, followed by multinomial regression. Investment in private goods, especially in income and employment-generating activities, positively contributes to household well-being. In contrast, investment in public and common goods may not necessarily contribute to well-being, emphasizing the need to identify goods that positively contribute to the household well-being. We argue that appropriate policy reforms should be made to prioritize investment in private goods by the community forest user groups that maximize the contribution of community forestry to human well-being, especially that of low-income households.

1. Introduction

Local communities manage some 732 million hectares, around 28% of the world's forests, in 62 countries through different participatory management programs (Gilmour, 2016). Community forestry (CF) is one of the uniting approaches to landscape restoration, although its success varies across the world (Shrestha et al., 2010). Nevertheless, conserving forests converges on enhancing the well-being of the communities' living close to forests (Harbi et al., 2018). Moreover, it contributes to poverty reduction in developing countries (Rasmussen et al., 2017). Agrawal et al. (2013) in their study contend that the value of CF is US$250 billion per year, which is more than twice the value of total development assistance in the world. In recent years, the priority of CF has shifted toward livelihood improvement, while recognizing the importance of conservation (Charlery and Walelign, 2015). This creates a space for local communities to obtain benefits from conservation.

The CF program in Nepal was initiated during second half of the twentieth century (1970s) in an attempt to restore degraded forest to provide basic forest products and services. However, up to 2000, subsequent forest policies, for instance the Master Plan for Forestry Sector, 1989, undermined the potential of CF to enhance human well-being. The Tenth Plan 2002–07 (GoN, 2002) shifted the priority of CF from conservation to poverty reduction for the first time. Two consecutive periodic plans (2010–2012 and 2013/14–2015/16) highlighted the significance of increasing the productivity of community forests, which was indirectly linked with the livelihood concept (GoN, 2014, 2010). Likewise, the Forest Sector Strategy 2014, highlighted "community-based forest management" as an integrated approach to improving livelihoods and conserving biodiversity, which ultimately contribute to the well-being of rural communities (Baral et al., 2018; MoFSC, 2014).

A community forest is a patch of government forest land handed over to the proximate communities under the name of community

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forest-user group (CFUG), for management and use of forest products. CFUGs are autonomous institutions for conservation, management, and utilization of forest products from their forests within or beyond the CFUGs. The Community Forest Development Guidelines, (2014) direct each CFUG to develop its own constitution and management plan, including a few mandatory provisions for each, such as at least 35% of its income should be invested on pro-poor activities and community forest development, and 25% in conservation and management activities (MoFSC, 2009). For instance, CFUGs have made efforts to support the local community in allocating community forest land to low-income users for income-generating activities or providing soft loans and forest products free of charge or at subsidized rates (Walelign, 2016; Pokharel, 2009). Additionally, various community development activities, such as the construction of school buildings, irrigation systems, drinking water, roads, and other infrastructure, are supported through CFUG funds. This kind of support enhances communities' well-being, both directly and indirectly (Foster and Rosenzweig, 2001).

Community forests contribute to the well-being of forest users (Harbi et al., 2018; Ludvig et al., 2018; Gauli and Hauser, 2011) by creating local-level employment opportunities. However, this varies by socio-economic group (Bocci et al., 2018; Pokharel, 2009) and is affected by several factors, such as location, species composition, and nature of the forest (Baral et al., 2018; Meilby et al., 2014). Some authors show that the distribution of benefits from taxation of forest products in CF is unequal, and disadvantaged groups are poorly placed to claim a larger share of the benefits (Lund et al., 2013). Nevertheless, inequalities can be dealt with through affirmative strategies, such as focusing on pro-poor activities. With appropriate utilization of resources, the income from community forest can be increased tenfold, which ultimately supports nationwide poverty reduction (Wunder et al., 2014). However, Pokharel (2009) contends that such benefits do not necessarily reach everyone; some low-income households cannot send their children to school; so, are unable to benefit from such investment. Hence, inclusive benefit distribution in CFUGs is questionable. In fact, the actual relationship between the benefit from forest goods and households' well-being needs to be better understood.

Despite several studies on the role of community forests in contributing to local income (Rasolofoson et al., 2016; Adhikari et al., 2004), its role in maintaining and improving well-being has not been studied so far. Scholarly works largely focus on investigating the contributions of CFUGs to livelihoods and community development (Pokharel, 2009; Adhikari et al., 2004). In theory, community forest decisions in Nepal are guided by the principle of equitable distribution of resources. However, a detailed analysis is currently lacking on how diverse investments from CF contribute to human well-being. Likewise, well-being itself is an area of research which has received less attention, since the concept is complex and difficult to unpack (Melnykovych and Soloviy, 2014). The extent to which individual households benefit from the flow of goods without discrimination remains unexplored in the general discussion on overall community well-being.

Hence, this study focused on the options for enhancing the well-being of local communities by investing in different taxonomies of goods. In our analysis, we consider how the income from community forest is distributed and which well-being categories are benefiting. These are important aspects for the future success and sustainability of decentralized resource management units. More specifically we:

i) establish a community economic (well-being) index, using well-being categories;
ii) assess community forests' resource flows to different taxonomies of goods, including the extent of investment; and
iii) examine the effects of different goods' investments in households' well-being.

2. Methodology

2.1. Study area

The main criteria for selecting CFUGs were that community forests had a long history of management (more than five years) and generating income by selling forest products. In addition, these sites had been closely observed for a decade (because they were permanent research sites of the Institute of Forestry, Nepal) and represented similar contexts (location from the city center, forest management practice, objective of forest management, communities' dependence on forest products), even though community forests represented two distinct physiographic regions (see Table 1 and Fig. 1): Terai (where economically valuable forests exist) and mid-hills (where the evolution of the CF program could be observed).

Both CFUGs maintain community funds, which are utilized according to their constitutions and management plans for forest conservation, community development, and other livelihood improvement activities. The CFUGs harvest forest products, such as timber, fuelwood, and fodder in certain months of the year, usually between November and March. The users are allowed to take fuelwood and fodder free of charge, whereas they need to pay a royalty to their CFUGs for timber, as specified in the management plans. Nevertheless, timber is provided free of charge to the victims of natural disasters in the CFUGs to construct their houses. The CFUGs invest their income in pro-poor activities, targeting the poor and women's groups, and community development activities, such as the construction of roads, temples, and school buildings.

The CFUGs consist of 2065 households in Kankali and 257 households in Tebrikot, and include Brahmin, Chettri, Gurung, Magar, Newar, and a few occupational castes (see Table 1). Their long-term objectives are to fulfill the community's subsistence need for forest products, maintain the forest ecosystem, enhance biodiversity through scientific forest management, and improve the livelihoods of forest users. The short-term objectives are to maintain a continuous supply of forest products without degrading the condition of the forest, to control forest encroachment, erosion, and open grazing, to promote income-generating activities, etc.

2.2. Data collection and compilation

The study mainly relied on primary data. Our unit of analysis is the household. According to Vyamana (2009), determining the economic status of the households is key to participatory well-being ranking. For the well-being ranking, we followed three steps;

i) Key informants, such as the Village Development Committee secretary, teachers, local leaders, and those CFUG executives who had an idea of the social and economic status of each member household of the CFUG were identified. Snowball sampling methods were used where the respondents identified others to be included.
ii) Focus group discussions (FGDs) in each settlement with the key informants. During these, multidimensional aspects of well-being based on the Sustainable Livelihoods Framework of UK's Department for International Development (DFID) and different livelihoods assets, such as physical, social, financial, natural, and human (Harbi et al., 2018; Carney, 1998), were briefly explained to categorize households into different well-being categories.
iii) After reaching a consensus with the key informants on the well-being assessment indicators, a well-being ranking was carried out on the two groups separately. The participants in the groups separately classified the households into three different well-being categories low, medium, and affluent income households[1] which were

[1] Affluent households include those households whose living standard is

Table 1
General attributes of selected community forests and CFUGs.

Attributes	Kankali CFUG	Tebrikot CFUG
Location	Khairani municipality, Chitwan district, Province 3, Ward 4	Pokhara Lekhnath metropolitan city, Kaski district, Province 4, Ward 25
Ethnic composition	Brahmin, Chhetri, Magar, Gurung and other occupational group	Brahmin, Chhetri, Magar, Gurung and other occupational group
Distance from road	50 m	20 m
Number of households (HH) in CFUG	2065	257
Population within CFUG	11,802	1008
Forest handed over	1995	2003
Management plan revised	2013	2014
Altitudinal range	220–580 msl	900-–1200 msl
Aspect	South-east	North-east
Location	27.65°N, 84.57°E	28.29°N; 83.93°E
Forest area	749.13 ha	119.75 ha
Settlement area	518.5 ha	744.5 ha
Main forest type	*Shorea robusta* Gaertn f. (Sal)	*Schima wallichii* (DC.) Korth. *Castanopsis indica* Roxb.ex Lindl.
Main occupation	Vegetable and rice farming & non-farm employment	Vegetable and rice farming & non-farm employment
Forest development stage	Pole	Pole and tree
Number of management blocks	5	5
Use of forest	Wood, fuelwood, fodder, recreational value	Wood, fuelwood, fodder, recreational value

Source: Fieldwork 2016–2017.

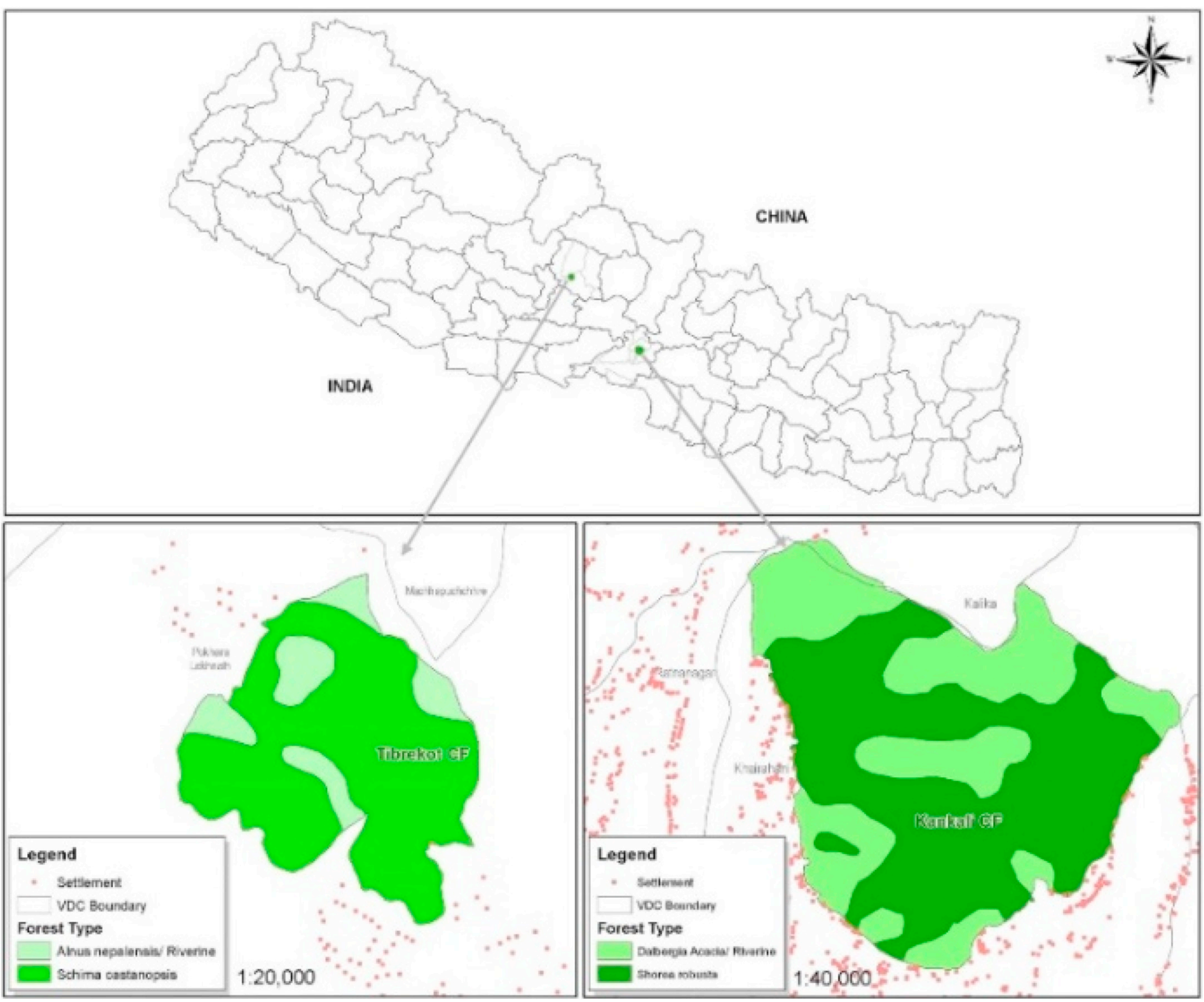

Fig. 1. Location of study sites in Kaski (Tebrikot CF in left) and Chitwan (Kankali CF in right) districts in Central Nepal.

Table 2
Categorization of households and number of households surveyed in the studied CFUGs with percentage in the bracket.

Characteristics	Kankali	Tebrikot	Total
Low income	590 (28)	65 (25)	655
Middle income	1150 (56)	123 (48)	1273
Affluent income	325 (16)	69 (27)	394
Total CFUG member households	2065	257	2322
Sample size	217	160	377
Men	80 (37)	68 (42)	147
Women	137 (63)	92 (58)	230
Sample households' distribution			
Low income	60 (28)	40 (25)	100
Middle income	122 (56)	76 (48)	198
Affluent income	35(16)	44(27)	79

Source: Fieldwork 2016–2017.

further validated in joint plenary sessions between two groups. Table 2 below presents the well-being assessment of two CFUGs.

After the well-being ranking, a stratified random sampling technique was used to select households. Following Cochran (1977), we estimated sample sizes of 217 households from Kankali and 160 households from Tebrikot. We assumed a prevalence rate of 50% to allow maximum variability, with an allowable error of 5% at a 95% confidence interval. We divided the sample based on population probability of each well-being category; and households were selected randomly. Women respondents accounted for more than half of the respondents in both CFUGs. A list of selected households representing each well-being class is shown in Table 2.

Respondents were interviewed following a semi-structured pretested questionnaire in the Nepali language. The questionnaire was prepared to collect information on key socio-economic elements, including household composition, education status, asset ownership, sources of income, sales and consumption of crops, livestock, and forest products, membership/representation in any organization in their village, and participation in training and extension programs.

Before mobilizing the enumerators for the household survey, the first author trained them (two males and one female in each site) on data collection using the questionnaire. The first author, together with trained enumerators, carried out data collection between August 2016 and September 2017. To ensure the perspectives of a maximum number of household members, interviews were mostly undertaken either in the morning or in the evening at the convenience of the respondents; priority was given to household heads. The reason for ensuring a maximum number of household members was to extract in-depth information and allow self-triangulation.

Apart from the household survey, three FGDs were organized in each CFUG with low, medium and affluent income households in separate groups to understand the role of community forests in improving their livelihoods. In total, 33 (13 female) users from Kankali and 41 (16 female) from Tebrikot participated in the FGDs.

Key informants, such as political leaders, school teachers, business people, and executive committee members totaling 24 informants were interviewed: 10 (four female) from Tebrikot and 14 (six female) from Kankali. We also interviewed eight officials from the district forest offices, four from each study district, to understand the role of policy provisions in CF in supporting reinvestment in the different taxonomies of goods. Secondary data were gathered from the audit reports and meeting minutes of each CFUG for the last 5 years. In addition, the first author observed the general assembly and executive committee meetings of the CFUGs to understand how resources were allocated to the different taxonomies of goods.

After completing the survey, information was cross-checked and verified with randomly selected households in each settlement to avoid discrepancies and inconsistencies in the data. The open-ended questions were then coded before data were entered into Excel, edited, and thoroughly checked to remove entry errors and inconsistencies.

2.3. Model specifications

Before delving into the investment of community forest goods into well-being, we need to unpack the meaning of well-being, which conflates the complex and synergistic functions of several components (Russell et al., 2013). Rath and Harter (2010) broadly categorize well-being into a career, financial, social, community, and physical types, which agrees with the DFID framework (Carney, 1998). Furthermore, income and employment rates are often used to categorize well-being (Melnykovych and Soloviy, 2014). Guided by these concepts, and following Strumpel (1974), we defined well-being as a combination of socio-economic conditions of individual households and other multidimensional aspects. We hypothesized that household well-being results from the investment of funds derived from community forest resources into the different taxonomies of goods. Veenhoven (2000) emphasized that the terms welfare and well-being are bracketed together, especially in the case of well-being and state of welfare. The level of well-being is alleged to be higher in welfare states and its distribution more equitable (ibid). Considering this, we used a welfare approach to understand how investment from community forests contributed to human well-being, especially in relation to investment in different taxonomies of goods.

Paudyal et al. (2016) and Costanza (2008) classify economic goods into four taxonomies: private, public, common, and club goods. For this study, based on consumption, we categorized CF goods into: private goods, which are rivalous (one person's consumption of a good necessarily diminishes another person's consumption of it) and excludable (those who have not paid for it can be prevented from using it, e.g. forest products and cash income); public goods that are neither rivalrous nor excludable (e.g. roads and schools); and common goods that are rivalrous, but non-excludable (e.g. greenery promotion). However, we did not consider club goods, since there are no natural monopolies in delivering such goods. All local households were members of the CFUGs and could benefit from CF resources. Moreover, we compared the contributions of CFs to the well-being of members of the groups, whereas club goods are more relevant for analysis between the groups, e.g. members versus non-members.

Fig. 2 presents a framework linking the taxonomies of goods and household well-being through causal pathways. Through conservation of forests, CFUGs invest in goods of different natures to improve community well-being.

We hypothesized that investment in private goods may result in

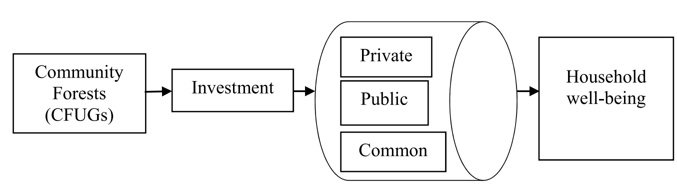

Fig. 2. Framework illustrating the linkages between CFUGs investment in the household well-being.

(*footnote continued*)
above average with food sufficiency of 9 months or above from own farm production and a permanent source of income such as services, business, and physical assets (permanent houses, size of land holding, and vehicles). However, this excludes temporary income such as wages and remittances. Likewise, middle-income households have sufficient food for 5–9 months from their own production and permanent services or assets and a minimum level of vehicle. While, low-income households have up to 4 months food sufficiency and have temporary sources of income or lower levels of permanent services, wages or family member outside country for earning.

Table 3
Confounding variables and associated descriptions.

Variables	Description
Family size	Number of household members
Education	Number of educated household members above 5 years
Income	Total household income (salaried or cash-in-hand/ad-hoc) across all family members
Landholding	The total area of land owned by the household, including renting out and barren land, measured in hectares
Livestock value	Total monetary value of livestock owned by the family
House type	The type of house owned by the family (i.e. permanent or temporary)

greater well-being than investment in public or common goods. Nevertheless, the pervasive role of economic factors in human well-being cannot be undermined as they have an indirect influence. Hence, it is necessary to analyse individual households' economic conditions to understand the role forest goods play in household well-being. To analyse economic status, referring to previous works, land ownership (Filmer and Pritchett, 2001), literacy (number of educated family members), income (Charlery and Walelign, 2015), livestock value (Schellenberg et al., 2003), and house type (Charlery and Walelign, 2015) were considered for a principal component analysis (PCA). PCA is a multivariate statistical technique which reduces the number of variables in a dataset into a smaller number of dimensions. As rural assets are distributed unequally between households, to minimize the effects of economic status on well-being (McKenzie, 2005), the economic indices (*Ei*) were weighted. Of the six variables, family size, education, total household income, landholding, and livestock values are continuous variables, while house type is a binary variable (see Table 3).

A PCA was first carried out to confound the economic dimensions and generate a control factor. We predicted the confounding control, *Ei* on the left-hand side, by taking the right-hand side influencing variables as Eq. (1). This equation estimated the diverse levels of individual household's economic characteristics by confounding the number of controlling factors.

$$(Ei_{i=}a_1 familysize_i + a_2 literacy_i + a_3 householdincome + a_4 landholding_s + a_5 livestock\ value_i + a_6 housingtype + e_i) \quad (1)$$

This economic factor was a combination of six variables, with factor load, which gave individual household economic indices for low-income to affluent households. Finally, a PCA was carried out to confound the economic dimensions as one factor. In our case, we found that PCA 1 included 95% of the overall variance (see Table 4); as such, we selected PCA 1 as an economic index (*Ei*) factor for regression analysis.

In the second stage, we used a regression model to work out the relationship between well-being and benefits received from various taxonomies of goods derived from community forests. For this, we considered well-being as a dependent variable and the functions of public, private, and common goods as independent variables.

The multinominal regression model was constructed, in which well-being is the categorical variable (0 represents low income, 1 middle income, and 2 affluent income) and goods are either binary or continuous variables (see Table 5). The control index *(Ei$_i$)*, adopted from McNamee (2005) (p_{504}), was included on the right-hand side of the model as a predictor.

Table 4
Summary of Principle Component Analysis (PCA).

Variables	PCA1	PCA2	PCA3	PCA4	PCA5	PCA6
Std. deviation	2.387	0.3282	0.3000	0.2447	0.1912	0.0802
Proportion of variance	*0.950	0.0179	0.0150	0.0099	0.0060	0.0010
Cumulative proportion	0.949	0.9678	0.9829	0.9928	0.9989	1.0000

Note: *Significant at 95% confidence level.

$$Y = ß_0 + ß_1 CFBE + ß_2 IGA + ß_3 FPC + ß_4 SDT + ß_5 AE + ß_6 EF + ß_7 HF + ß_8 RI + ß_9 MF + ß_{10} SP + ß_{11} DRR + ß_{12} WS + ß_{13} GP + ß_{14} AFMP + \mu i(Ei_i) + e_i... \quad (2)$$

Where Y is the dependent variable, representing well-being categories (0, 1 and 2); $ß_0$ is a constant and ßs are independent variables 1 to 14 (see Table 5). The latent effects, such as economic status, are not observable but are corrected by other variables in the equations. To reduce the biased effects of economic status, we produced *Ei* and incorporated it into Eq. (2).

We hypothesized that the economic status of households did not differ between the two CFUGs studied. For this, we considered the major economic variables, education, income, livestock value, and landholding, to test homogeneity. We logged (ln) income and, as suggested by ranked education, livestock value, and landholding, ran Levene's Test for equality of variances. PCA analysis showed that the *p value* was more than 0.5 in all five socio-economic variables: 0.57 (education), 0.26 (income), 0.74 (livestock value), and 0.36 (landholding). This reflects that the economic conditions of households were not significantly different and, thus, can be considered homogeneous. Therefore, we analysed the total population of the sample (377 households).

3. Results

3.1. Characteristics of the sample communities

Out of the total number of respondents, 100 (27%) were from low-income households, 198 (53%) from middle-income households, and 79 (21%) from affluent households (see Table 6). Family size was the largest among the low-income households (5.66) and smallest in the affluent households (4.68). In terms of literacy, 85% of the affluent households were literate, followed by 69% of the middle-income households, and 59% of the low-income households. Similarly, average landholding size was the highest for the affluent households (0.65 ha), which is nearly twice that of middle-income households. Average annual household income was NPR 978,608 (USD 9320) for affluent households, NPR 726,869 (USD 6923) for middle-income households, and NPR 633,000 (USD 6029) for low-income households. Regardless of well-being category, almost all respondents possessed permanent houses; nevertheless, the quality of houses varied between well-being categories. Generally, low-income households had single-story buildings, whereas middle-income and affluent households possessed two or more storeyed houses. Irrespective of economic conditions, almost all households received some benefits from CF, either directly or indirectly, for example from the green promotion.

3.2. CFUGs' resource investment in taxonomies of goods

Table 7 presents the investments in different taxonomies of goods. The CFUG's reports for the last five years indicate that nearly half of the investments made by the CFUGs were directed toward private goods (42% of total income), followed by common goods (31%), and public goods (27%). Of the different types of private goods, the highest investment was made in forest product collection, followed by forest-based employment creation, alternative energy, and skill development training. Regarding public goods, investment in roads and other infrastructure was about 10%. Common goods investment was the highest for special provision for women and low-income households (14%), followed by disaster risk reduction (DRR) (11%). Priority was given to common goods over other goods, primarily due to the high demand for community development activities among the members. An executive committee member of Kankali CFUG stated, *"we could hardly prioritize*

Table 5
Taxonomies of community forest goods and variable types.

Goods	Variable name/type	Variable description	References
Private	CFBE*	Creating forest-based employment	Adhikari et al., 2004; Pokharel, 2009; Waleligm, 2016
	IGA**	Income-generating activities	Pokharel, 2009; Walelign, 2016
	FPC**	Forest product collection	Walelign and Jiao, 2017; Walelign, 2016; Gauli and Hauser, 2011
	SDT*	Access to skill development training	Chhetri et al., 2012; Walelign, 2016
	AE*	Alternative energy	Felix and Gheewala, 2011; Chhetri et al., 2012
Public	EF*	Educational facilities	Walelign, 2016
	HF*	Health facilities	Pokharel, 2009; Chhetri et al., 2012
	RI*	Roads and other infrastructure	Nagendra, 2011, p.26; Lund et al., 2013
	MF*	Market facilities improvement and construction	Nagendra, 2011
	AFMP*	Awareness of forest management plan	Toft et al., 2015
Common	SP*	Special provision to women and low-income households (capacity building)	Pokharel, 2009
	DRR*	Disaster risk reduction	Thwaites et al., 2014;
	WS*	Water source conservation	Pokharel and Suvedi, 2007; Russell et al., 2013; Melnykovych and Soloviy, 2014
	GP*	Green promotion	Pokharel and Suvedi, 2007

Notes: *Binary variable; **Continuous variable.

our funds for private forest goods, as the decision on investment in common and public goods is high, whose output is visible in society, nevertheless, we tried our best to allocate fund for private goods."

3.3. Households benefiting from different taxonomies of goods

Fig. 3 shows that the benefits from private goods were mostly enjoyed by affluent households. More than 70% of the affluent households had benefited from the CFUGs' investments in private goods, with the exception of investment in FPC. Conversely, less than 50% of the low-income households had benefited from investments, with the exception of SDT. Similarly, more than 60% of the households of all income levels had benefited from investments in public goods, such as RI, MF, and AFMP, with the exception of investment in MF and AFMP, from which the low-income households did not benefit. In the case of common goods, more than 50% of the households across all income categories benefited from SP and DRR, whereas less than 40% benefited from WS and GP.

3.4. CFUGs' contribution to the household well-being

The results of the multinomial regression analysis show that forest-based employment creation, income-generating activities and alternative energy were significant at the 1% level, with a $p = .0000$, 0.0011, and 0.0000, respectively, while skill development training and FPC were significant at 5% and 10% levels ($p = .0145$ and 0.0760, respectively). All positive coefficients indicate that affluent households benefited more from private goods. Among the public goods, with the exception of education facilities and awareness of operational plans, other remaining categories were found to be non-significant, indicating that investment in public goods does not necessarily support well-being. However, awareness of operational plans and education facilities were positively correlated with well-being at 5% and 10% levels ($p = .0103$ and 0.0863, respectively). This further suggests that direct benefits from these two categories of goods were realized more by affluent households, whereas benefits from investments in health facilities, roads, market facilities, and other infrastructure were realized by all income categories. In the case of common goods, community investments in DRR and water source conservation were significant at 1% and 5% levels ($p = .0062$ and 0.0270 respectively). The negative coefficient of DRR implies that the low-income households realized more benefits compared to the affluent households. On the other hand, the positive coefficient of water source conservation indicates the reverse. This

Table 7
CFUGs investment into different taxonomies of goods* (in NPR**).

Taxonomies of goods	Total***	Percentage share
Private		
Creating forest-based employment (CFBE)	6,864,965	14
Income-generating activities (IGA)	6,040,628	12
Forest product collection (FPC)	7,679,304	15
Access to skills development training (SDT)	200,000	0.4
Alternative energy (AE)	175,000	0.3
Sub total	**20,959,897**	**42**
Public		
Educational facilities (EF)	2,132,826	4
Health facilities (HF)	3,145,200	6
Roads and other infrastructure (RI)	5,302,460	10
Market facilities improvement and construction (MF)	3,175,369	6
Awareness on forest management plan (AFMP)	189,786	0.4
Sub total	**13,945,641**	**28**
Common		
Special provision to women and low-income households (capacity building) (SP)	7,381,420	14
Disaster risk reduction (DRR)	5,559,257	11
Water source conservation (WS)	183,652	0.4
Greenery promotion (GP)	2,040,586	4
Sub total	**15,146,915**	**30**
Total	**50,070,453**	**100**

Source: *Field survey 2016–2017; **1 USD was approximately equal to 103.34 Nepalese Rupees (NRs) in 2018; ***Computed from the official reports of the CFUG.

Table 6
Average socio-economic status of community members*.

Well-being	Family size	Literacy (%)	Income (NPR**)	Landholding (ha)	Households with the permanent house (%)	Livestock value (NPR)
Low (100)	5.7	59	633,000	0.2	96	34,568
Middle (198)	4.9	69	726,869	0.4	99	58,878
Affluent (79)	4.7	85	978,608	0.7	100	73,977
	5.1	**0.7**	**754,722**	**0.4**	**98**	**55,594**

Source: *Field survey 2016–2017. Figures in parenthesis under 'Well-being' refer to households in Table 3; **USD 1 = NPR 103.35 (dated 6 February 2018).

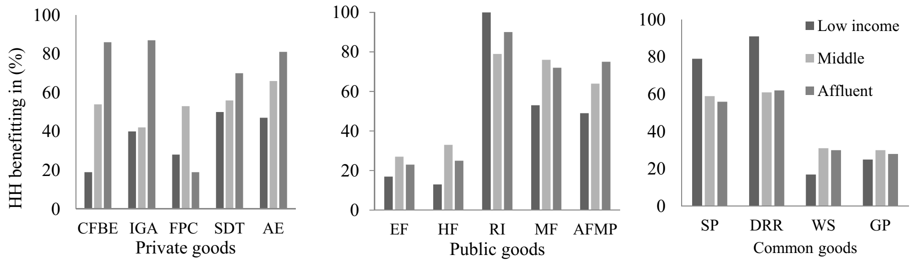

Fig. 3. Proportion of households benefiting from different taxonomies of goods (in %).
Note: Abbreviations for all goods are in Table 5.
Source: Field survey 2016–2017.

Table 8
Contribution of different taxonomies to household well-being.

Variables	Coefficients	Std. error	t-Statistic
Private goods			
Creating forest-based employment	2.0444***	0.2604	7.8500
Income-generating activities	0.7135***	0.2327	3.0650
Forest product collection	0.1403*	0.0978	1.1435
Access to skill development training	0.4962**	0.2266	2.1890
Alternative energy	1.0211***	0.2417	4.2238
Public goods			
Educational facilities	0.3526*	0.2581	1.3661
Health facilities	−0.0839	0.1404	−0.5981
Roads and other infrastructure	−0.1436	0.3290	0.4367
Market facilities improvement and construction	0.2699	0.2483	1.0870
Awareness on forest management plan	0.5409**	0.2326	2.3247
Common goods			
Special provision to women and low-income households (capacity building)	−0.1510	0.2355	−0.6410
Disaster risk reduction	−0.6146***	0.2448	−2.5103
Water source conservation	0.4782**	0.2474	1.9326
Greenery promotion	−0.3089	0.2481	−1.2448
Economic index (Ei)	−2.6095***	0.4536	−5.7521
Constant/intercepts			
Well-being (lower/middle)	7.8851**	1.3470	5.8539
Well-being (middle/ affluent)	11.6226 ***	1.4489	8.0216

Note: Significance at* 10%, ** 5%, ***1%, N = 377, Ei as a control factor.

further demonstrates that low-income households are also likely to benefit from common goods, as they live on the fringes of rivers and are more vulnerable.

Two variables, i.e. special provision and greenery promotion were not significant. The significant and positive relation of *Ei* with well-being (see Table 8) shows that the affluent households realized benefits from investments, while that of other groups was limited.

4. Discussion

4.1. Linkages of resources flow with different taxonomies of goods

Our findings show that the CFUGs had allocated their resources to different taxonomies of goods; the majority of investments are targeted at private goods, followed by common goods and public goods. This contradicts the findings of other studies conducted in the mid-hills of Nepal. For example, Pokharel (2009: p.70) reported that 55% of community forest investments are in public goods, followed by 28.5% in private goods, and 24% in common goods. Similarly, Chhetri et al., (Chhetri et al., 2012: p.118) reported that 45.2% of total investments are made in public services, whereas Lund et al., (Lund et al., 2013: p.3) reported that 50% of total investments were made in the public sector and 30% in common goods. However, the differences could be due to the classification of goods. The above-mentioned authors did not classify investments based on the nature of the goods; rather, they focused on the areas of investment. For example, income-generating activities were often classified as common goods/public goods, despite the fact that individual members benefit from such activities.

We found that the affluent households were mostly benefiting from private goods (Tables 7 and 8). However, it can also be clearly seen that the CFUGs' investments in private goods trigger an improvement in the economic status of all households, increasing from low income to affluent status. A user involved in investment decision-making said that "*we generally focus our investment in common and public goods rather than in private goods; however, investment in private goods has brought positive changes as the economic status of households has shifted upwards, i.e. from lower to higher income brackets*". This finding is similar to those of Bocci et al. (2018) and Chhetri et al. (2012), which finds that low-income households moved toward higher income brackets with increasing investment from the CFUGs. Likewise, Pokharel (2009) observed that the second highest share of CFUG funds goes to pro-poor groups, which also contributes to improved economic status. We further found that the level of investment was higher in private goods targeting low-income households, such as the creation of forest-based employment opportunities, income-generating activities, and FPC. Our finding agrees with that of Pokharel (2009) that low- and middle-income households largely experience an increase in income levels through employment opportunities in forest management activities. The affluent households gained more income and enhanced their living conditions, as of low-income households who strongly depend on forest resources, as observed in the previous findings, whether in Nepal (Charlery and Walelign, 2015; Chhetri et al., 2012; Adhikari et al., 2004) or elsewhere (Walelign and Jiao, 2017 p.6). However, our findings demonstrate that low-income groups did, in fact, become affluent, which resonates with the findings Walelign (2016) and Gauli and Hauser (2011: p.42), in which it was seen that poorer households generated more income from forests.

4.2. Investment in private goods may improve well-being

Our results show that a CFUG that is investing in private goods can improve the conditions of low-income groups; this agrees with the findings of Harbi et al. (2018) and Ludvig et al. (2018). It was observed that investments in one of the five different types of public goods were almost non-existent, which further implies that priority was not given to such investments. For instance, benefits from investments in roads and other infrastructure, such as market facilities cannot be exclusively realized by the poor households, as CFUGs cannot exclude outsiders from enjoying benefits. As a community member stated, *"the CFUG should invest in community welfare rather than in public sector development; if not, what is the role of the state?"* Although Lund et al. (2013: p.3–4) studied 45 CFUGs in Nepal indicate that affluent households benefit more from investments in the construction of infrastructure, such as schools, markets, and health facilities, and from capacity development training. This does not hold true in our case, primarily due to the non-exclusionary nature of these goods. Nonetheless, significant and positive coefficient values of educational facilities suggest that affluent households had realized benefits from investment in educational facilities, as the majority (85%) of these households were educated. This finding agrees with many recent studies (Pokharel, 2009; Adhikari et al., 2004), which demonstrate that low-income households cannot enjoy the benefits of educational facilities, as their children seldom get the opportunity to go to school. In an FGD with low-income household members, a user explained, "*we don't have enough land to grow crops. Earning from manual labor is our only option for survival. The earnings of one person in the family are not sufficient to feed all. So, all of us must work to solve our hand-to-mouth problem.*" Our findings are consistent with those of Nagendra (2011: p.26), whose study in Nepal and Tanzania demonstrates that forest user groups invest more in building schools. However, such investments do not necessarily benefit lower income households whose children cannot afford to go to school (Schreckenberg and Luttrell, 2009: p.227).

When examining the parameter "awareness of FMP", the coefficient was positive and significant at a 95% confidence level, indicating that the affluent households were involved in awareness programs so that this group has greater knowledge of the FMP. Toft et al. (2015) conclude that CFUG members, especially low-income groups, do not have detailed knowledge of the content and provisions of the FMPs. According to a key informant, "*FMPs are used for controlling users in forest product harvesting and extraction.*" This shows that ignorance of the content and provisions of FMPs poses a risk that not all the CFUG members will benefit from investment in private goods (ibid). Moreover, Meilby et al. (2014: p.9) contend that the benefits may vary across different physiographic regions of Nepal; however, private goods, such as forest wages and involvement in forest management activities seem to always have a high relevance irrespective of the region.

4.3. Provision of investment in different taxonomies of goods

Community Forest Guidelines (2008) and its revised version (2014) point out that it is important to ensure support for poorer groups within communities, but these guidelines largely remain rhetoric. Nonetheless, one interesting observation was the significant negative regression coefficient for the parameter "DRR", indicating that low-income households benefited from investments in this area. It could be argued that low-income households live on marginal lands, such as river banks and landslide-prone areas, and are, therefore, beneficiaries. This is also concluded by Thwaites et al. (2014: p.823–826) in a study in the Lamjung district in Nepal, which found that most of the very poor and poor households live close to landslide and flood-prone areas with potential impacts on both residential areas and farmlands. The low-income households from Tebrikot and Kankali stated that their houses are close to landslide-prone and flood-submerged areas; so, the rainy season always scares them because of fear of landslides moving or engulfing their houses. Investment in DRR activities, such as constructing embankments, planting in landslide-prone areas, and protection of riverbanks, therefore, directly benefits low-income households. Conversely, the significant positive regression coefficient value of the parameter, "water source conservation", indicates that affluent households enjoy benefits from water conservation. The reason might be that those households can use water for other income-generating activities, for instance, vegetable cultivation and cattle rearing, which are out of reach for low-income households. In this context, the incomes have contributed to an enhancement of their economic status. Similar to the findings of our study, a study undertaken in India (Foster and Rosenzweig, 2001) suggests that benefits from water source conservation are realized by low income to affluent households. The non-significant negative coefficient value of the parameter, "special provisions for women and low-income households", indicates that there is a higher likelihood of low-income households benefiting from such investments, which is in line with the provisions of the *Community Forest Development Guidelines* (2014). Eventually, there is potential for such households to elevate their status, meaning that such a targeted approach may ultimately contribute to improving well-being.

More generally, our results indicate that, although almost a fifth of the CFUGs' total investment went toward public goods (such as health, roads, market facilities, and other infrastructure), such investments did not benefit any household category in particular. McDermott and Schreckenberg (2009) found similar results in their study carried out in Nepal, the USA, Kenya, and Tanzania. Low-income households are more likely to be disadvantaged, and therefore not benefit from public goods investments. Vyamana (2009) contradicts this assertion; arguing the case of Tanzania, where participatory forest management failed to improve social capital for low-income households and excluded such households from participating in income-generating activities. Conversely, investment in private forest goods, and access to skill development training and alternative energy made up less than 1% of the total investments in the Tanzanian case study; yet, such investments resulted in the high realization of benefits. Our study echoes this and we emphasize that investment in private goods is more likely to result in improved well-being than investment in public or common goods.

5. Conclusion

In answer to the question of what goods CFUGs should prioritize for investment, we argue that investments in common and public goods do not necessarily benefit all households fairly. In particular, low-income households do not benefit from public investment as much as their affluent counterparts. Therefore, a targeted intervention in favor of low-income households is necessary to promote sustainability through CF. This is also justified from the perspective of welfare economics, which argues that investments targeted at low-income households lift their economic status.

Investments in private goods, such as income-generating activities, direct forest income, and employment opportunities in forest activities, as well as training in capacity building and local resource management, stimulate economic growth and support household well-being in the long run. Despite this, CFUGs are currently concentrating more of their investments in public and common goods. As a result, low-income households are being excluded from the benefits of such investments. Investments in public goods, such as schools, health, and road construction generate indirect benefits and contribute to overall economic growth. However, because of the non-excludability and non-rivalrous nature of such investments, they do not improve the economic status of low-income households significantly. The current priorities of CFUGs, which focus on public goods, limit the options for investment in private goods. In fact, investment in public goods are the responsibilitiy of the state, rather than CFUGs.

We conclude that an allocation of resources should specifically target low-income households, allowing them to benefit more directly. Curtailing investments in private sectors probably slide low-income households into deeper poverty. Investments in "community" activities are often manipulated in favor of affluent households. Therefore, it is necessary to keep exclusive provisions of private investments in the policy framework. As forest management plans are key to forest operations and investments, the CF guidelines should be revised accordingly. This will emphasize investments in the areas of employment generation and income-generating activities which will not only fulfill the immediate livelihood needs of the low-income households but also stimulate the development of a green economy in the future.

Acknowledgments

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Paper IV

Factors affecting fuelwood consumption and CO_2 emissions: an example from a community-managed forest of Nepal

Submitted to ***Journal Energy Research & Social Science***

Factors affecting fuelwood consumption and CO_2 emissions: an example from a community-managed forest of Nepal

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Abstract: Fuelwood is the primary source of energy in Nepal, where 87.1% of the energy is derived from woody sources and therefore becomes a major source for carbon emissions. This study explores the factors affecting the fuelwood consumption, the amount of carbon emissions including the potential for carbon sequestration in community forests, taking a case study of Kankali CFUG of Chitwan district of Nepal. Interviews with 217 households revealed that 60 percent of the households still depend on fuelwood for cooking, which apparently emits approximately 13.68 tons of carbon dioxide annually. The emission varies with the economic status of the households, as poor households emit more carbon. Similarly, the carbon emission was directly proportional to the family size and livestock holding, and inversely proportional to landholding and per capita income. A more conservation-oriented forest management along with activities to support livelihood had contributed to lower carbon emissions. Interestingly, poverty-energy trap seemed to have a distinct gender dimension. We argue that CFUGs need to invest in income-generating activities for local users, and especially for women of low-income households, in order to reduce current carbon emission.

Keywords: fuelwood; community-managed forest; energy; alternative energy; low carbon emission

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1. Introduction

Global warming has been a topic of discussion for the last three decades, where household energy consumption is one of the major triggering factors [1]. About 2.9 billion people in developing countries are still dependent on fuelwood for cooking and heating [2,3,4] and this has become one of the primary drivers of climate change. The sustainable development goals (SDGs) put the reduction of biomass fuelwood by sustainable energy by 2030 as one of its central goals [4]. Therefore, it is important to assess factors which encourage households to reduce the use of biomass, and shift towards more efficient fuels [4]. Forests provide the main sources of energy for the people living in rural parts of developing countries, and Nepal is not an exception. This has led to deforestation (e.g., annual deforestation rate in Terai region is 0.44%; [5] and forest degradation. About 80 percent of Nepalese continue to use solid fuels such as firewood and animal dung as their major source of cooking (World Bank, 2015). The energy mix pattern of Nepal shows that approximately 87 percent of the total household energy comes from fuelwood [6]. However, evidences on emission of CO_2 from fuelwood consumption are limited.

Understanding of household energy consumption is very important in the formulation of policies [3]. On one hand, "energy ladder is reported as a common model to describe the household fuel choices in developing countries [introduced by 7]", where primitive fuels, such as fuelwood and agricultural waste are replaced by transition fuels, such as kerosene and then advanced fuels, such as liquefied petroleum gas (LPG) and electricity in the processes of urbanization/development [7]. On the other hand, studies show that energy transition does not occur as a series of simple, discrete steps as the "energy ladder" implies. Instead, "energy stack" is more common, where with increasing income, households adopt new fuels and technologies that serve as partial rather than perfect substitutes for the more traditional ones [7]. Knowledge of how changes in economic disparity affect the pattern of energy use can help to understand the carbon emission pattern and identify the group where intervention is required.

The long-term community-managed forest (CMF) seems capable to contribute various aspects of society including poverty [8,9,10]. In such forests, economy of low-income households enhance, behaviors of energy consumption are changing among different economic classes. This has proliferated well in the terai and also in few hilly areas that lie close to market and road-head, which has led to the promotion of alternative energy sources, such as LPG.

Feminization of poverty has been an established fact [11], however, the links of gender-poverty and energy use (carbon emission) have not been adequately established [12]. Therefore, in addition to the specified objectives of energy consumption at all socio-economic class is further disaggregated in the lines of gender to highlight a preliminary link between gender, economic class, and CO_2 emission.

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In 1998, fuelwood derived from forests constituted the largest proportion of the total fuelwood consumption (78 %), whereas this dependency reduced to 64 percent in 2013 in Nepal [13]. In rural areas, one-third of the forests are being managed by communities as CMFs in which 60.9 percent of all households still depend on the fuelwood [14]. The main goal of this study is to assess the energy consumption patterns and factors affecting carbon emission by exploring the situation in a CMF from the Terai region of Nepal. The objectives to meet this goal are to;

- Assess extent of fuelwood consumption and carbon emission from community managed forest
- Identify factors affecting carbon emission, such as income, household size, literacy and gender composition in the community managed forest
- Examine the carbon balance situation in the community managed forest

2. Methodology

2.1 Study Site

The Kankali community managed forest that is situated in Terai region of Nepal was selected for this study. The total area of forest is 749 hectares and the total number of households in its community forest user group (CFUG) is 2065. A long history of community-based forest management (since 1995) and income generation by selling forest products were two main criteria for the selection of the CMF. This site has also been closely observed for a decade because of an establishment of permanent research site by the Institute of Forestry, Nepal. This CFUG generates fund by selling forest products either to the users or to outsiders. The fund is ploughed back in the name of direct and indirect investment in forest conservation, community development, community awareness programme, subsidies on alternative energy and other livelihoods improvement activities.

Data Collection

The selected CMF and CFUG is taken as a case to understand energy consumptions by the households within one year. Primary data were collected from the CFUG and complemented by the secondary data from the CFUG records and inventory of 2013 from Institute of Forestry permanent plots. The unit of analysis for the social data is an individual household and for the biophysical data is a sample plot. The households were surveyed to know the details about family occupation and their dependency on forest resources or other alternative sources for the energy. Following [15] and [16], participatory well-being ranking was carried out as listed in the following steps:

- Using the snowball sampling, key informants such as municipality secretary, teachers, local leaders, and CFUG executive members were selected for well-being ranking.
- Using the DFID framework and considering five different assets - physical, social, financial, natural and human [17] a well-being categorization was done for each settlement.

- The key informants classified each household in the CFUG into three categories; low, medium and affluent. The low-income households (n=590), medium income households (n=1150), and affluent income households (n=325).

A stratified random sampling was carried out based on the well-being ranking of the households. Referring to [18], we estimated a sample size of 217 households where we interviewed 80 male and 137 women. We assumed a prevalence rate of 50 percent to allow maximum variability, with an allowable error of 10 percent at a 95 percent confidence interval. We divided the sample size (low income 60, middle 122 and affluent 35) based on population probability of the size of each well-being category. Women respondents accounted for more than half of the total respondents.

Respondents were interviewed with the help of a structured pre-tested questionnaire. The questionnaire was prepared by considering socio-economic variables such as the number of family members, education, asset ownership, household income, livestock number, and quantity of fuelwood used. The questionnaire was translated into the local language (Nepali) and tested before the interview. The first author (SB), along with trained field enumerators (two male and one female), carried out data collection between August 2016 and September 2017. The interview was carried out either in the morning or in the evening as per the convenience of the respondents so that the maximum amount of time could be invested in data collection and a maximum number of household members could be involved. The reason for ensuring maximum number of household members was to extract in-depth information and allow self-triangulation. We were able to capture detailed demographic and socio-economic information through a household survey.

In addition to structured interviews, three focus group discussions (FGDs) were also conducted with a participation of total of 47 CFUG members representing different economic groups. FGDs were conducted separately to understand the role of community forests and how community forestry is promoting the use of alternative energy. Likewise, 14 key informants (female:6, male:8), including political leaders, school-teachers, business persons, and executive committee members, were also interviewed. After completion of the household survey, information was cross-checked and verified with randomly selected households in each settlement to avoid discrepancies and inconsistencies in data. The open-ended questions were coded before the information was entered into the computer. Data analysis was performed in *SPSS* (version 24).

The forest inventory data of 2013 were taken from the recorded data of Institute of Forestry. By following the basic plot design of [19], the data for 2016 was collected by First Author (SB) and Coauthors (KG) and (BB) and the enumerators, which includes data of three nested sub-plots. Trees with a diameter at breast height (DBH) of above 10 cm were measured. The parameters included species identification, positioning, DBH, and height of trees from 57 plots.

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2.2 Data Analysis

2.3.1 Socio economic model specification

Before analyzing the household consumptions of different sources of energy, we needed to unpack various parameters which depend on household consumption, such as financial and social status of the households [20].

We hypothesized that socio-economic factors and carbon emissions have a strong relationship. Nevertheless, the pervasive role of economic factors in the consumption of fuelwood cannot be undermined. Referring to previous work we wanted to identify the most influencial parameters for the consumption, like land ownership [21], literacy (number of educated family members), income [22], livestock number [23], family size, awareness, alternative energy use and livestock unit. We hypothesized carbon emissions (Cei) on the left-hand side of Equation 1 is measured, by taking the socio-economic variables (Table 1) presented on the right-hand side;

$$Ce_{i=}a_1\ well\text{-}being+a_2 familysize_i+a_3 literacy_i+a_4 Percapita+a_5 landhol+a_6 LSU+a_7 incomefbemp+ a8awareness+e_{i)} \quad \text{……………………………………} (eq1)$$

We used a linear regression model to examine the relationship between fuelwood used from the community-managed forest in relation to low carbon emissions. We considered the quantity of the fuelwood use as a dependent variable and all the associated socio-economic variables as independent variables (see *Table 1* for details).

Table 1. Explanatory variables, expected direction of relationship with response descriptions

Independent variables	Explanation	Expected Sign	References
Well-being	Categories of household according to economic class (poor=0, medium=1 & affluent=2)	-	Rezitis and Ahammad, 2016 [24], Rao,1990 [25]
Family size	Number of household members	+	Rao,1990 [25]
Literacy	% of educated household members above 5 years	-	Van der Kroon *et al.*, 2013 [3], Chhetri *et al.*, 2012 [26]
Per capita income	Total/gross household income (salaries or cash-in-hand/ad-hoc) of all family members	+	Charlery and Walelign, 2015 [22] Rao,1990 [25]
Landholding	The total area of land owned by the household, including renting out and barren land (hectares)	-	Filmer and Pritchett, 2001[21] Rao,1990 [25] Van der Kroon *et al.*, 2013 [3]

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Livestock Unit	The number of livestock units owned by the household[6].	+	Schellenberg *et al.*, 2003 [23]
Forest-based income	The total income (i.e. permanent or temporary job) from forest	-	Walelign and Jiao, 2017 [27]; Walelign, 2016 [9]; Gauli and Hauser, 2011 [28]
Awareness	Awareness regarding alternative energy (Yes or No)	-	Toft *et al.*, 2015 [29]

Note: + for the positive relation and – for the negative/ inverse relation between fuelwood use and variables

2.3.2 Estimation of the potential of carbon emissions and sequestration

Carbon sequestration is calculated by exploring the differences of the growing stock within a year. To estimate the potential carbon sequestration forests were classified into *shorea robusta* dominated forests and other terai hard wood forests. The differences in the growing stock of 2016 and 2013 was analyzed using the volume functions derived by [30] assuming that the calculated average increment can serve as a proxy for the above ground carbon.

Carbon consumption of a household is estimated from the annual household fuelwood consumption. To compute carbon dioxide (CO_2) emissions, we used the conversion factors for fuelwood into CO_2 equivalents based on the Intergovernmental Panel on Climate Change (IPCC), 1996 revised report on Guideline for National Greenhouse Gas Inventory. One *bhari* (back load) of fuelwood is equivalent to 40 kilograms. The biomass of fuelwood is converted into carbon by;

Carbon dioxide emission (CO_2 e) = biomass of fuelwood 0.47 (carbon) * 3.67 (CO_2 equivalent)*

Likewise, Carbon sequestration (CO_2 s) = growing stock increment of forest per year 0.47 (carbon) * 3.67 (CO_2 sequestration equivalent)*

3. Empirical Results

3.1 Socio-economic characteristics of the sample CFUG

In the studied community, the family size ranged between 1 to 12, with an average family size of 5.05. (Standard Error (SE) 0.13124). Likewise, the per capita income of households ranged from NRs 5,000 to NRs 233,333.3 with an average income of NRs 52758.5 (SE 2770.2). Annual household fuelwood consumption varied from 0 kg to 5760 kg per household, with an average of 1,720.9 kg (SE 85.7). The high standard errors of both per capita income and fuelwood consumption indicate that there is high variation. The maximum livestock[7] holding is eight whereas minimum livestock holding is 0, with an average of 1.2 (SE 0.089). Likewise, landholding ranged from 0 ha to 1.91 ha, with an average of 0.41 ha (SE0 .024).

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[6] 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 cited in [31]

[7] Livestock refers for the cow and buffaloes

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Table 2: Socio-economic parameters of the sampled community

	Minimum	Maximum	Mean	Std. Error
Well being	0	2	0.88	0.04
Family Size	1.00	12.00	5.0553	0.13
Per capita income	5000	233333.3	52758.5	2770.20
Fuelwood	.00	5760.00	1720.9217	85.77
Literature	.00	1.00	.7024	.012
Landholding	.00	1.91	.4129	.024
Livestock unit	.00	8.00	1.2568	0.08
Awareness	.00	1.00	.4516	0.03
Forest-based income	.00	12400.00	1796.1290	112.05

Source: Household survey 2016-2018

3.2 Status of energy consumptions by households

Figure 1 shows that more than one-third of all households depend solely on LPG as an energy source, followed by a combination of LPG and fuelwood. There are no households who exclusively used biogas, and the use is always associated with fuelwood or LPG, or both. A very few number of households (i.e., 14.7%) depended solely on fuelwood for energy. Nevertheless, fuelwood has remained a primary source of energy.

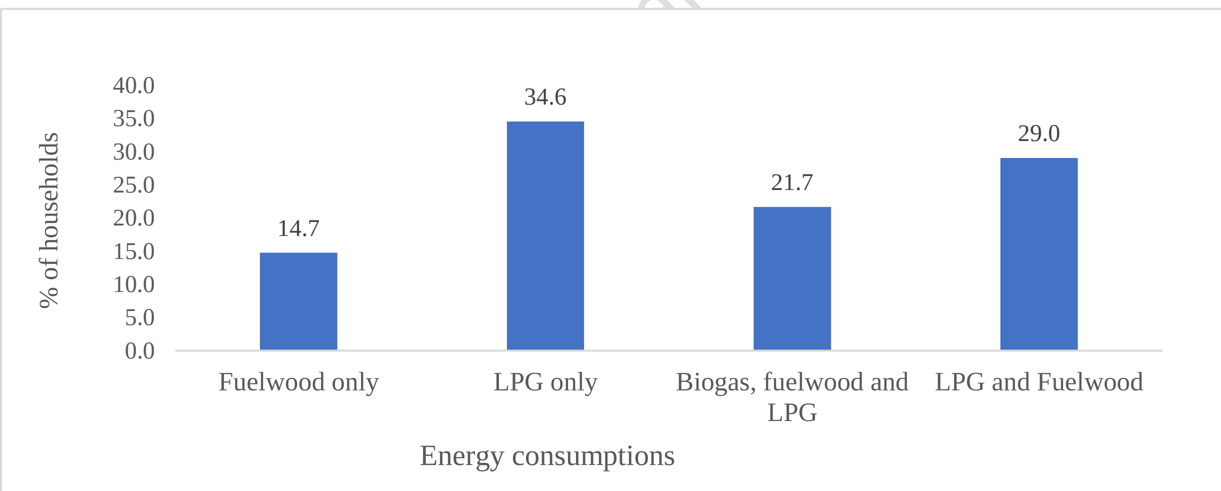

Figure 1: Distribution of energy consumptions

The results of Pearson correlation test between fuelwood consumption and other socio-economic variables, is shown in Table 3. Well-being has significant negative correlation with fuelwood consumption indicating that the affluent households consume lesser amount of fuelwood than poor household. Family size has significant positive correlation with fuelwood consumption, indicating that households with bigger family size consume more fuelwood. Likewise, literacy shows an inverse relationship with fuelwood use suggesting the higher number of educated family members the lesser the amount of the fuelwood consumed. Per capita income is highly significant inverse related indicating that the higher the income the less the dependency on forest resources. Results also show that households possessing a greater number of livestock consume more fuelwood.

Table 3. Correlation between low carbon emission and other socio-economic variables

Variables	Pearson correlation	P-value
Well-being	-.198	.003
Family size	.247	.000
Literacy	-.155	.023
Ln_per capita income	-.275	000
Ln_forest-based income	.116	0.087
Landholding	-.066	0.334
Livestock unit	.134	0.043
Awareness	.098	0.149

3.3 Factors affecting carbon dioxide emission

The results from the multiple linear regression analysis (Table 4) shows that the family size, per capita income and livestock income and family literacy were found to be significant determinants of fuelwood consumption (p = 0.000; 0.009; 0.002; 0.082, respectively). The positive coefficient value indicates that the larger the number of family members, the higher will be the fuelwood consumption. This could be driven by the needs and the availability of time to engage in the collection of fuelwoods. Likewise, households possessing a higher number of livestock consume more fuelwood, which is related to the fact that more fuelwood is needed to cook food based on the available livestock. The negative coefficient value of per capita income shows that increase in family income decreases the consumption fuelwood. People tend to switch to other alternative energy sources particularly LPG, when the income starts to rise. Similar is true for the relationship between literacy and fuelwood consumption. Educated households use less fuelwood. This could be related to the observation that better-educated households know about the health impact of indoor pollution of fuelwood burning and seek for alternative energy such as LPG.

Table 4. Factors affecting carbon dioxide emission

Variables	Coefficients [a]	Standard Error
Constant	10.635***	2.611
Well-being	-0.064	0.344
Family size	0.348***	0.096
Literacy	-1.584*	0.905
Per capita income	-0.565***	0.213
Income from forest	0.197	0.123
Land holding	-0.269	0.464
Livestock unit	0.348**	0.188
Awareness	0.188	0.366

*Significance: *10%; **5%; ***1%*

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3.4 Fuelwood consumption and carbon emissions

The per capita carbon emission from the poor medium and affluent households are 4.12, 2.63 and 2.15 tons, respectively. This calculation shows that low income households emits nearly two-fold CO_2 compared to affluent economic classes.

Table 5: Economic classwise household fuelwood consumptions and CO_2 emissions

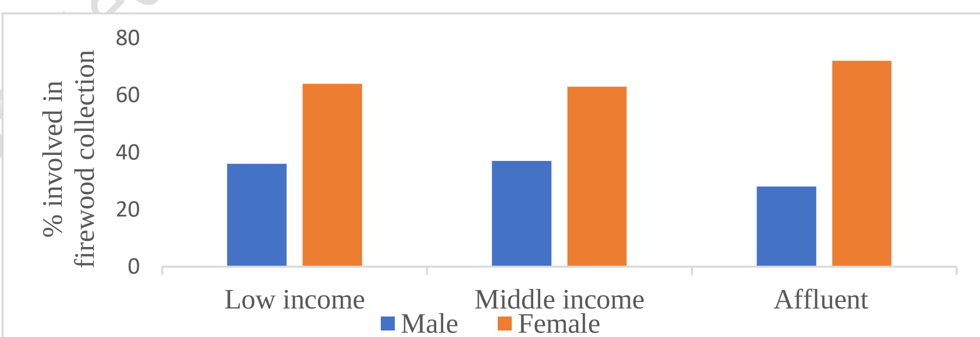
Economic Class	Fuelwood use (kg per year)	CO_2 (tons per year)
Low income	2392.0	4.12
Medium	1526.5	2.63
Affluent	1248.0	2.15

Source: Household survey 2016-2018

The inventory data reveals that carbon sequestration is 17.56 ton/households while that of emission is 13.68 ton/households, indicating that current emission is lower than sequestration. This is mainly because of fuelwood control of harvesting from the community forests and a shift to other alternative sources of energy.

3.5 Intra-household gender analysis of energy provisioning

Women from low-income households are responsible for provisioning fuelwood for everyday use, which situates them at the bottom of the energy ladder. Our data highlights the highly gendered nature of poverty-energy trap which distinctly affects women from low-income group the highest. While 64 percent of women from the low-income group collect fuelwood for daily provision, only 36 percent of men from the same income group are involved. Despite their higher dependency on fuelwood, representation of the low-income group in the CF is the lowest among economic classes. Furthermore, women who are primarily responsible for daily household energy provision from the CF, have negligible presence in decision making bodies such as CFUG executive positions. With 31 men from low-income class represented, only one woman from the same class was found to be in the executive committee. The representation of women, however, increases moving up the economic ladder.



Source: Household survey 2016-2018

Figure 2: Gender-disaggregated representation of fuelwood collection across different class

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3. Discussions

Among the various energy sources utilized by human society to fulfill their energy needs biomass still constitutes to be the primary energy source in rural areas of developing countries like Nepal [32]. About one billion people in Asia depend on biomass as their main source of energy [33]. Our findings also show that although the households from studied CFUG used energy from different sources, the majority of them still depends on biomass (i.e., fuelwood in this case). Nepal is one of the highest traditional fuel consuming countries in Asia because of its high dependency on traditional biomass fuels, mostly fuelwood, the limited extent of charcoal and crop and animal residues [34]. This further resonates with the findings of several researchers [32, 33, 35].

The results showed that 60 percent of the households were dependent on multiple types of fuel for cooking and heating, followed by LPG, biogas and electricity, which also resonates with the finding of [36, 37] that globally 40% of the population is fully dependent on biomass for cooking. [38] argue that in most of the developing countries people are trying to explore the low emission biomass energy for cooking. With respect to economic classes, the household dwelling size per capita has a significant negative effect on fuelwood consumption which is line with the finding of [39] that wealthier households tend to consume less wood.

The regression analysis shows that there are various underlying factors such as per capita income, literacy, family size, livestock and landholding which determine the use of fuelwood as an energy source, and similar findings were also found by previous studies elsewhere [eg., 24,25,40]. For example, the relationship between household income and fuelwood consumption indicates that the higher the income, the lesser the fuelwood consumption [41]. As income increases, the use of alternative energy sources, such as kerosene and LPG, is gaining ground in Nepal and is reducing the need for fuelwood [42]. Similarly, family size is one of the underlying factors, as the fuelwood use increases with an increase in family size. In our case, the low economic households have greater family size, which also use more fuelwood. [43] show that family size, income, amount cooked, and burning hours significantly affect the amount of fuelwood used per family per year studied in a mountain area of Bangladesh. Taking into account different family sizes, our study found that 2,392 kg fuelwood per family per year is consumed by low-income households which is almost two time higher compared to the affluent households.

Landholding size is one of the factors, which accelerate fuelwood consumption. In general households having higher landholding and higher income are found to extract lesser quantities of fuelwood from CMF [44]. In our case, the more the landholding, the less the fuelwood need as household's fuelwood since land holding also represents the economic status in the village. Generally, the households with higher landholding size are affluent households, hence their fuelwood consumption is less. Furthermore, middle and affluent classes have diversified energy use and hence they do not extract as much as fuel wood from CMF in comparison to low-income groups. In addition, an increase in the number of livestock units also increases fuelwood consumption because many people use fuelwood for preparing food for their livestock; this is most common practice in low economic families.

This study also found that the relationship between the economic group and fuelwood energy consumption has very distinct gender characteristics. In an intra-household analysis, it was observed that the male-female share of fuelwood collection tilted more towards women. While 70 percent of women from low-income households are involved in fuelwood collection for daily use while only 30 percent of men from the same economic class are involved for the same task. Our finding is consistent with those of the previous studies, which show women (and children) as primary collectors of fuelwood from forests on daily basis [45, 46]. Due to the gender division of labour within households, women across different economic classes, have the responsibility of not only meeting energy requirements of the household by collecting fuelwood from the forest but also wisely using them in the kitchen and deciding on energy use [47]. There also exists gender-based differences in collecting the types of fuelwood. Women collect branches and twigs for everyday use, whereas men carry logs, which require tree felling, which happens occasionally in all CMF. The data shows that the number of *bhari* of wood carried by men across all economic classes is larger than that of women. Furthermore, women's role in energy provisioning is tedious compared to men, which implicates time poverty due to lack of women and a loss of opportunity to engage in other productive activities that generate income and hence pull them out of poverty trap. Moving up the energy ladder is necessary for moving higher in the economic status [48]; however, our case study suggests a possible vicious energy-poverty cycle where women of low economic classes, lack agency to make a change in their energy use. The situation of women from this economic class is further exacerbated by their low representation in CFUG executive positions.

The CMF plays a vital role in promoting energy alternatives by offering subsidy on installing biogas in individual households. Besides that, the CMF conducts awareness-raising programme which supports the changes in the energy consumption behavior of users. Amid growing researches around the world have also found similar findings [eg., 10, 35]. Because it is women who bear the disproportionate share of fuelwood energy use [12], such interventions from CFs have to be targeted at women for the desired result of reducing CO_2 emission. In our study site, the representation of women in the CFUG executive committee is very low compared to men which is further decreases while moving down the economic classes. Hence, women, who are highly dependent on the CF to meet their everyday energy provision, have very limited chances of influencing resource distribution and allocation through CF-related activities. Livelihood activities of CFUGs that contribute towards decreasing of fuelwood among women of low-income group not only contribute towards decreasing the global CO_2 emission but, as a more direct benefit, improve the air quality of the immediate environment preventing any associated negative effects on the health and overall family wellbeing, providing better chances of moving up the economic ladder [49]. A recent study in Nepal, however, also found a reverse energy transition trend (i.e., moving down the energy ladder) whereby people abandoned modern fuels and returned to biomass based traditional cooking practices [50]. Our study reveals that the CO_2 emissions are low compared to the potential for carbon sequestration. This retrospectively suggests that CMF is contributing towards green economy development [51].

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4. Conclusions

The energy consumption of the studied CFUG is similar to other developing parts of the world. A majority of households depend on biomass (fuelwood) for energy. However, the dependency on energy sources vary over time and with the socio-economic conditions, high-income households rely on alternate source of energy such as the LPG, while the poor still use fuelwood. The dependency on CMF for the fuelwood collection is still high, mainly because of the large number of low economic class households, low landholding households, and large size families. The small opportunities for women to get involved in other productive work as they bear the drudgery of collecting fuelwood from CMF for daily use are causing additional pressures and gender imbalances. The current assessment reveals that the community had a positive carbon balance, which reveals that community forestry can contribute to a shift towards a green economy perspective. The use of forest resources, such as fuelwood can be reduced by increasing the level of income per capita. Focusing on such activities, especially on women of the low-income class can help to break the vicious poverty-energy cycle. In addition, promotion of alternative energy-efficient provisions can support low carbon emissions which can address various challenges related to carbon emission and sustainable management of energy in developing counties like Nepal. It is the responsibility of federal government to develop a favorable/good policy in order to promote low carbon investment and attain economic growth at national, provincial and local levels.

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Paper V

Using MCA tools for evaluating community-managed forests from a green economy perspective: lessons from Nepal

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Using MCA Tools for Evaluating Community Managed Forests from a Green Economy Perspective: Lessons from Nepal

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Abstract

Nepal is currently reformulating its forestry policies at provincial level and proposing forest management practices to stimulate the green economy. Various community-managed forests models have been designed by the Nepal government to decentralize the country's forests for their sustainable management. This study aims to facilitate the process of identifying appropriate forest management options in two provinces, namely Provinces Three and Gandaki. Four forest management options, namely – passive, active, scientific and multiple, were identified following the existing management practices. For the evaluation of the overall performance of the options, a framework with three criteria, 10 indicators and 28 verifiers were designed. The framework followed the green economy perspective, considering the improvement of forest conditions, economic and social well-being, and low carbon emission. The Analytical Hierarchy Process was used to prioritize the best management option and analyse trade-offs to guide future decision-making and reduce the risk of unwanted consequences. Our results show that the elicitation of preferences for the evaluation criteria varied by stakeholder groups. Their preference was largely guided by improving the forest resource condition and economic well-being. Foresters prefer scientific and active forest management, policy-makers prefer multiple forest management and scientific management, whereas community forest user groups prefer active forest management. We argue that the scientific management approach may contribute better to the economic aspects, but it may often compromise the other aspects. Multiple forest management seems to be the best management option for the green economy, considering its ecological, economic and social consequences.

Keywords: forest management practices, green economy, analytical hierarchy process, stakeholders, community-managed forests, preferences

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1. Introduction

Nepal currently reformulating its forest policy at provincial level and proposing forest management options appropriate for the country. Both federal and provincial governments emphasize the need for simultaneously considering the dimensions of sustainable decisions to fulfill the long-term sustainable forest management (SFM) visions. Selecting appropriate forest management practice is a crucial step in the immediate and long-term way forward for forest management, in which the green economy guides the choice between the contrasting forest management options by taking prosperity and SFM at hand. Green economy aims to enhance resource sustainability; and well-being and social equity, while significantly reducing environmental risks, and low-carbon emission (UNEP 2011; UNDESA 2012). Bina (2013) gives priority to the green economy agenda, which is symptomatic of the growing economization of the sustainable development discourse, where environmental crisis is framed as a potential opportunity for further capital accumulation. There is no unanimous view among policy-makers and development experts on what represents and drives the green economy in developing countries (Karki 2013). Particularly in developing countries like Nepal, where forests are handed over to local communities for their management, and where forests play a dominant role in fulfilling the basic need for natural resources, of the local communities, community-managed forest (CMF) is highlighted as a promising approach to enhance the green economy (Bhandari et al. 2019; Aryal et al. 2019). It aims at conserving forests to enhance the well-being of the communities living close to forests (Harbi et al. 2018).

CMF has a potential to contribute to all three pillars of green economy, namely economy, environment and society, by investing in community development, forest management, livelihood improvement, and green infrastructures, such as plantation, tree stand improvement, and alternative energy (Baral et al. 2019). However, sustainability of CMF in general and its contribution to the realization of the green economy in particular depend on the selection of management option and its contribution to improving the well-being of the local community (NPC 2016; Baral et al. 2018; Baral et al. 2019).

In Nepal, four forms of CMF, namely passive, active, scientific and multiple uses, are being promoted as a silvicultural system in which the management approaches rely on community forest (CF), collaborative forest (ColF), buffer zone management forest (BZMF), and leasehold forest (LF). Although each forest management option has distinct management objectives, the primary goal of all remains the same, i.e. improving human well-being and promoting forest resource conservation with active involvement of local communities. Each forest management option plays a pivotal role in realizing the development of the green economy. The recent studies on forest management modalities largely focused on livelihoods and forest management (Pokharel et al. 2015; Baral et al. 2018). The research shows that the contribution of CF is low in local livelihoods but high in forest conservation, whereas the biophysical and socio-economic outcomes of ColF and LF are less researched (Pathak & Bohara 2017). Likewise, BZCF mainly focuses on conservation and less on research. From the perspective of the green economy, each CMF has the potential to contribute, but which one is the best option in terms of resource sustainability, well-being, social equity, and low carbon emission is not explored. In addition, these forest management approaches are being promoted haphazardly, without considering their potentiality in maximizing

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their contributions to the green economy development. Furthermore, no assessment has been done about the silvicultural practices to determine which approach best suits the country's economic development. The country is in a policy reform process and needs recommendations for accommodating the management options to the changing institutional structure (Banjade et al. 2017).

Making sustainable decisions by looking at the future consequences of forest management in the green economy context is now a major concern for various levels of government in Nepal. Consequently, federal government agencies are exploring the best practices to deal with the complex problems of natural resource management. Therefore, this study aims at identifying the appropriate forest management practices to maximize their contributions to green economy development in the new federal structure. In the past, the priority was largely timber-centric management, where different stakeholders' views and needs were often ignored. Many studies are motivated by foresters' or communities' opinions, which lack decision-making by policy-makers and local government representatives. The findings of the research would, therefore, be useful for the overall forestry sector, which is trying to switch from subsistence to commercial management in a new institutional structure. Multi-criteria analysis (MCA) techniques are believed to help decision-makers in solving forest management problems (Keeney & Raiffa 1976) in allowing a strong representation of various stakeholder groups and incorporating their perceptions into the selection of management options (Mendoza & Prabhu 2005; Khadka et al. 2008; Biswas et al. 2010; Jalilova et al. 2012). When stakeholders are not fully involved in framing, analysing, selecting, and implementing management options, it might not fulfill their interest and they might seek other ways of articulating their needs, hampering the decision process (Birkhof 2003). By agreeing the view this research tried to answer the question; which forest management approaches seem appropriate towards the realisation of the green economy? More specifically, this paper focuses on:

i. identifying a set of criteria and indicators to assess the green economy
ii. evaluating the performance of different CMF from green economic perspectives
iii. performing scenario analysis to identify an overall compromise solution, and
iv. drawing policy implications for promoting the best forest management option in Nepal.

2. Research design

2.1 Selection of criteria, indicators, and verifiers

The main criteria and indicators used for investigating the contributions of CMF into green economy development according to UNEP (2011) are: i) resource sustainability (e.g. forest condition, diversity, forest growth, and harvest), ii) human well-being and social equity (e.g. employment, capacity building, and inclusion of poor and marginalized communities), and iii) low carbon emission (e.g. use of fuelwood, use of timber for other purposes, alternative energy). The three principles of the green economy are considered as the main criteria, for which a number of indicators and verifiers were defined to decompose them. Through three mini-workshops at different level from national to local, participation of with five to eight experts from various fields -forestry experts, scientists, CFUG members, policy-makers, civil societies representatives and international/ national government organizations representatives and review of available literature on the green economy, the authors of this paper developed a set of indicators and verifiers. Referring to ITTO (2005), Jalilova et al. (2012), and Baral et al. (2018) the three main criteria

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were further decomposed: C1 refers to resource sustainability (e.g. forest condition, forest structure, forest regeneration, and stand density), C2 refers to human well-being and social equity (e.g. employment and income generating activities) and C3 refers to low carbon emissions (e.g. alternative energy and energy saving). All criteria, along with the related indicators, were clearly defined to inform the respondents about the purpose of the research, which also helped to shape the understanding at one pace. The primary author, along with the first coauthor, translated the vision and goals into meaningful and measurable criteria and indicators. Altogether three criteria, 10 indicators and 28 verifiers were listed (Table 1).

Table 1: Criteria, indicators & verifiers for evaluating the performance of CMF practices

Criteria, Indicator and Verifier **Criteria 1: Resource sustainability**	Basis of scoring	References
I1. Forest Condition		
I1.1. Stand structure	Poor = one age class trees (matured/young/pole) Fair = two age classes (either matured & young) Good = Three age classes (matured, young, & pole; pole, established sapling & sapling)	DFRS, 2015
I1.2. Regeneration condition	Poor = 2000 seedlings/ha Fair = 2000–5000 seedlings/ha Good = More than 5000 seedlings/ha	
I1.3. Growing stock volume	Poor = declining trend Fair = moderate trend Good = increasing trend	
I1.4. Stand density	Poor=10-39% crown closure Fair=40-69% crown closure Good=70% or more crown closure	
I1.5. Species composition	Poor = one valuable tree species in the CMF Fair = 2–3 valuable tree species in the CMF Good = 3 or <3 valuable tree species in the CMF	DFRS, 2015 & ComFoRM manual, 2011
I2. Maintenance of tree species diversity		
I2.1. Species richness	Poor = Very few different types of species Fairly= Fairly distributed different types of species Good = Number of different types of species	Community Forestry guidelines, 2003, 2008 and 2014
I2.2. Species evenness	Poor= Unequal distribution of species Fairly= Fairly distribution of species Good= Equal distribution of species	
I3. Forest growth and harvest		
I3.1. Amount of timber harvested per year	Poor = up to 1% of AAH amount in a year Fair = 2% of AAH harvestable amount in a year Good = 3% of AAH harvestable amount in a year	Community Forestry guidelines, 2003, 2008 and 2014 Community Forest Timber/ Firewood Collection and Selling Guideline 2014
I3.2 Amount of fuelwood harvested per year	Poor = Harvested fulfills ≤ 50% of the user needs Fair = Harvested fulfills 50-75% of user needs Good = Harvested fulfills ≥ 75% of user needs	
I4. Biotic influences		
I4.1. Grazing system	Low = (>10% of the area is grazed) open grazing Fair= (about 10-30%) Manage grazing Good=Control grazing	
I4.2. Forest fire	High intensity=High effect surface & crown fire	

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	Fair= low effect with surface & crown fire Low effect with surface fire	Forest Fire Management Strategy-2015 (we took on the basis of fire intensity), Community Forestry Inventory guidelines, 2004
I5. Employment through forestry		
I5.1. Creating forest-based employment	Poor = no employment created Fair = Up to 10% of HHs get job Good = <10% of HHs engaged in forest-based employment	Community Forestry Inventory guidelines, 2004
I5.2. Income generation activities	Poor = Up to 5% of the HHs engaged in IGAs Fair = 5–15% of the HHs engaged in IGAs Good = 15% of the HHs engaged in IGAs	
I6. Capacity building programmes		
I6.1. Access to skill development training (specific training which creates job market)	Poor = up to 10% of the users' HHs Fair = 11–20% of the users' HHs Good = 20% of the users' HH	
I6.2. Capacity building training (forest management practice)	Poor = up to 10% users' HHs (both male & female) participate in trainings Fair = 11–20% of the users' HHs (male & female) Good = 20% users' HHs (both male & female)	
I6.3. Participate in the workshop and study tour	Poor = up to 10% HHs (both male & female) Fair = 11–20% HHs (both male & female) Good = <20% HHs (both male & female)	
I7. Inclusion of poor and marginalized communities		
I7.1. Budget spent on pro-poor activities	Poor = 25% of poor HHs get a contribution Fair = 26–50% of poor HHs get a contribution Good = 50% of poor HHs get a contribution	
I7.2. Agendas/decisions targeting poor	Poor = up to 20% poor & marginalized agendas Fair = 26–50% poor & marginalized agendas Good = 50% poor & marginalized agendas	
I7.3. Proportion of poor and marginalized in the executive committee	Poor = up to 25% of poor & marginalized HHs Fair = 26–50% of poor & marginalized HHs Good = 50% of poor & marginalized HHs	
Criteria 3: Low carbon emission **I8. Alternative energy**		
I8.1. Use of Liquefied petroleum gas (LPGs)	Poor = up to 10% of the HHs use Fair = 11–20% of the HHs Good = 20% of the HHs	CBS data, Alternative Renewable Energy Subsidy Policy 2016
I8.2. Installment of biogas in house	Poor = up to 10% of the HHs Fair = 11–20% of the HHs Good = 20% of the HHs	
I8.3. Plantation of tree inside forests	Poor = very few - less than 5% Fair = 25% of HHs Good = More than25% of HHs	
I8.4. Plantation of tree in farm and agriculture land	Poor = very few - less than 5% Fair = 25% of HHs Good = More than 25% of HHs	
I9. Use of timber for other purpose (value addition)		
I9.1. Use of timber for furniture	Poor = up to 25% of the timber	

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	Fair = 26–50% of the timber Good = 50% of the timber	
I9.2. Engineering products	Poor = up to 25% of the timber Fair = 26–50% of the timber Good = 50% of the timber	
I10. Energy saving devices		
10.1. Use of improved cooking stove	Poor = ≤ 25% HHs have cooking Fair = 26–50% HHs Good = 50% HHs	
I10.2. Installation of solar	Poor = ≤ 25% HHs installed solar panels Fair = 26–49% HHs installed have solar panels Good = ≥ 50% HHs installed solar panels	Renewable Energy Subsidy Policy 2016

2.2 Methodological approach of the study

The data collection stages consisted of description of study environment by collecting background information about the different CMFs and their management practices, selection of different experts to be consulted, and elicitation of the preferences for the set of criteria and indicators referring to the three green economy frameworks. The participants shared their perspectives of the current CMF practices and evaluated the importance of the indicators with regard to green economy development.

(i) Selection of eight CMFs and description of study environment

In the first stage, background information was collected on the study areas, i.e. provinces 3 and Gandaki in the central Terai of Nepal, and the study areas were described. The region has covered a total area of about 41,804 km². The study sites were selected because, firstly, all forest management approaches were practised there and the District Forest Officer was committed to sustainable and scientific forest management practices. Secondly, forest officials and other decision-makers had sound knowledge of all management approaches due to their long involvement in forest management. Thirdly, to create consistency, judgments of different stakeholders- indicators and verifiers were discussed, and a common understanding was developed.

Field investigations were carried out in Chitwan and Nawalparasi districts, where four forest management practices (passive, active, scientific, and multiple management) were available. Eight CMFs were selected two from each management practices, which cover about 2483.28 ha of forest area, of which 782.36 ha was covered by multiple management, 788 ha covered by scientific forest management, 906.75 ha by active forest, and 6.17 ha covered by passive forest management. A series of discussions were held on study site selection with officials of the Department of Forests and District Forest Offices (DFOs) of the respective districts. A total of eight sites from the two provinces and two districts (namely Chitwan and Nawalparasi) were selected for this study (Table 2).

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Table 2: Characteristics of the study sites

Attributes	Management scenarios	Selected CMF	Area (Ha)	HHs
Multiple use forest management	Zonation of forests according to management objectives, limited inventory, common understanding for planning and implementation process, focus on multiple benefits from forests	Kankali, Khairani municipality, Chitwan district	549.49	2065
		Shree Janajagaran Community Forest, Madyabindu, Nawalparasi	232.87	400
Scientific forest management	Intensive inventory, focus silviculture practice in harvesting, high forest management intervention, especially on thining and harvesting, timber centric	Agingire Community Forest	290	605
		Dudhkoshi Community Forest	498	881
Active forest management	Inventory, incremental based felling, limited forest management interventions, especially cleaning of harvested plots, timber centric	Madyabindu Collaborative forest	588	3840
		Akaladevi	199	102
Passive forest management	Limited management intervention, only removal of fallen, dead disease and decayed trees	Pipaltar Leasehold, Echyakamana VDC	2.84	6
		Mirgakunga Bufferzone Forest	3.33	3563
Total			**2363.53**	**11462**

The selected CMF options are different in case of the area and the number of households, however, they were categorized into four management options based on the management interventions they applied.

(ii) Selection of experts

A total of 69 experts — CFUGs members (15), foresters (14), scientists (12), policymakers (16), and local government representatives (12) — were selected for MCA at the national, province and local levels. In total, we conducted four mini-workshops at the national level, four workshops at the provincial level, and eight consultation meetings, one each in eight CMF, with the CMF members. MCA is used for assessing resource sustainability and well-being, as indicated by Mendoza & Prabhu (2000, 2003), Wolfslehner et al., (2005), Khadka &Vacik (2012) and Jalilova et. al., (2012). In this study, two different methods for the elicitation of preferences for the green economy assessment were used: (i) scoring and (ii) pairwise comparisons. In each level of assessment, both methods were employed (Prabhu et al., 1999, Schmoldt et al., 2001; Ramanathan, 2001; Vacik et al., 2001).

(iii) Elicitation of Preferences

The scoring technique was applied for the criteria and indicator (C&I) assessment during field-level discussions, followed by repeated assessments at the province and national level. We followed Mendoza et al. (1999) and assigned a score to each criterion that reflected a perceived

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degree of importance. The participants were instructed to give a weights to each criterion on a 9-point scale (1=weakly important, 3=less important, 5=moderately important, 7=more important, and 9= extremely important, and 2, 4, 6, and 8 were used as intermediate levels). The indicators were scored on a scale from 1=least important to 100 = most important. The indicators were then ordered according to their mean ratings and the relative importance was expressed as a rank for each indicator (Mendoza et al. 1999; Mendoza & Prabhu 2000 a, b). Scoring was also used for exploring and judging the current condition of each indicator relative to the desired condition under each criterion considering the performance of the selected forest management options. The assessment was done for each management option on a scale of 1-4 with regard to its potential for future improvements in relation to the current situation.

(iv) Pairwise comparison of preferences

The pair-wise comparison technique is based on the Analytic Hierarchy Process (AHP), developed by Saaty (1995). Pairwise comparisons were done based on the ordinal input (from the scores provided by the stakeholder groups) according to every single indicator, and priorities were calculated using the Eigenvalue method (Saaty 1977). In total, 36 pairwise comparisons were made, 12 at each level. Each participant had the chance to argue different opinions in her or his group and in the plenary as well, and a consensus had to be reached based on the preferences of the members of the group. As a consequence, the individual judgments of each member within a group were used to formulate one single representative judgment for the entire group in the negotiation process. However, in order to allow synthesis of the individuals, group priorities within the AHP the judgments had to be combined, so that the reciprocal of the synthesized judgments was equal to the synthesis of the reciprocals of these judgments (Saaty 2008). The preferences obtained by stakeholder groups often do not indicate large differences. If groups or individuals have different priorities of importance, it is suggested that their synthesized judgments (final outcomes) should be raised to the power of their priorities, leading to the calculation of the geometric mean. Therefore, the inputs from all stakeholders at each workshop were provided individually for the whole C&I set and the data were then averaged using the geometric mean to further process the preferences into the expert choice software. The consistency ratio (CR) was considered to be between 0 and 0.10 for all comparisons. Table 4 presents the synthesis of stakeholders preferences values for the criteria using the scoring while tables 5 and 6 present the geometric mean of the priorities of the pairwise comparison technique.

(v) Development of forest management options

In Nepal different CMF approaches are practised; community forest, leasehold forest, buffer zone management forest, and collaborative forest. In terms of intensity of management, there are mainly four options: (i) close to naturalness also known by passive management has been practised in buffer zone management forest, (ii) active forest management (incremental felling), (iii) scientific forest management and (iv) multiple forest management, mainly practised in community forest and collaborative forest. By using the three criteria and 10 indicators, the experts consulted at national and province levels were asked to define forest management options which are capable of supporting development towards the green economy. Twelve experts from six different institutions (namely Ministry of Forest and Environment, Department of Forests, non-governmental organizations, civil society, scientists, and municipalities), who were directly or indirectly involved in decision-making, policy reformulation and implementation of forest management,

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participated in the workshop at national level. At province level, 12 experts from ministry, municipality, politicians, district forest offices, Federation of Community Forestry Users Nepal, and CMF users were involved in the assessment of the management options.

Finally, the basic elements of the four forest management options were defined (Table 3). The first option is characterized by the existing management practices, which can also be called business as usual or passive forest management (MO I). The second option (MO II), is a more active forest management option, which is based on the concept of incremental felling. The third option (MO III), is a scientific forest management practice, which focuses on the economic potential of the forest. Finally, option (MO IV) is a multiple forest management option, where many aspects are addressed. All management options were designed in terms of their practical applicability, incorporating several concepts of SFM and opportunities for forest development.

Table 3: Characterisation of the forest management options

Management elements	MO I Passive forest management	MO II Active forest management	MO III Scientific forest management	MO IV Multiple forest management
Forest sustainability sustainable management & use of forest resources	No significant actions	Dead, dying, diseases & deformed (4Ds) trees are removed, enrichment planting, removal of debris from the harvested area	Harvesting of green trees, fire management, and grazing, cleaning of harvested plots	Selective harvesting of trees, leaving of trees based on conservation significances
Human well-being and social equity Reinvestment in income generation and employment opportunities	No employment	Limited income and employment on forestry, only by harvesting and logging operations	Labour intensive and high employment creation	High, employment creation from timber and other recreational services
Low carbon emission Carbon friendly development & Alternative energy	No removal of carbon, and no investment for carbon stock enhancement	Limited carbon stock (timber) removal, with investment on carbon-efficient technology such as biogas, cooking stove	High carbon stock (timber) removal, low investment in carbon-efficient technology	Limited carbon stock removal, with investment in combining efficient-energy technologies

3. Application of the evaluation framework

3.1 Relative importance and preference of criteria

We performed pairwise comparisons for the three criteria with various stakeholders at national (n=31), provincial (n=17) and local (n=21) level stakeholders were asked to rate each criterion according to their perceived importance with respect to the green economy (presented in Table 4). The result shows that resource sustainability (C1) was seen as the most important criterion at province and local level, and human well-being and social equity was the first priority at national level, considering management from the green economy perspective. Human well-being and social equity (C2) is the second most preferred criterion for both province and local level stakeholders. The low carbon emission (C3) was the least important criterion with respect to green economy development for all stakeholder groups.

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Table 4: Preferences of criteria at different management level based at on pairwise comparisons technique

	Criteria		
Stakeholders	C1. Resource Sustainability	C2. Human well-being & Social Equity	C3. Low carbon Emission
National (31) *	0.383	0.403	0.141
Province (17) **	0.301	0.244	0.171
Local (21) ***	0.321	0.297	0.158

Note: ** National level stakeholders represent policy-makers, forester, scientists*

***Province level stakeholders represent policy-makers, forester, scientists and local government representatives*

****Local level stakeholders represent forester, CFUGs members and local government representatives (mayor, secretaries, and ward chairperson)*

3.2 Relative importance of indicators

The relative importance of each criterion was derived from the scores assigned directly for each criterion during the stakeholders' workshop. In total, 10 indicators were assessed by using pairwise comparisons, where the number of indicators varied from three to four under each criterion (Table 5). The result shows that biotic influences (I4), employment through forestry (I5) and alternative energy (I8) are the most important indicators, which are either favourable or unfavorable for green economy development. Almost all stakeholders gave the highest priority to the management of forests with regard to biotic influences.

Table 5: Relative weight of criteria and indicators based on geometric mean of the synthesized stakeholder group judgments

Criteria & Indicators	**Synthesized priorities of stakeholders**					
	Foresters	Scientists	Policy-makers	CFUGs members	Local government representatives	Overall
C1. Resource Sustainability	**0.308**	**0.298**	**0.300**	**0.298**	**0.300**	**0.301**
I1. Forest condition	0.241	0.187	0.195	0.240	0.191	0.210
I2. Maintenance of tree species diversity	0.324	0.301	0.309	0.404	0.305	0.327
13. Forest growth and harvest	0.353	0.324	0.358	0.406	0.344	0.356
14. Biotic influences	0.517	0.462	0.466	0.529	0.462	0.486
C2. Human well-being and social equity	**0.244**	**0.241**	**0.245**	**0.245**	**0.250**	**0.244**
I5. Employment through Forestry	0.298	0.302	0.298	0.298	0.304	0.299
FI6. Capacity building programmes	0.226	0.236	0.230	0.228	0.244	0.230

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I7. Inclusion of poor & marginalized communities	0.162	0.173	0.162	0.164	0.182	0.165
C3. Low carbon emission	**0.190**	**0.170**	**0.157**	**0.167**	**0.174**	**0.171**
I8. Alternatives energy	0.297	0.306	0.328	0.339	0.332	0.317
I9. Use of timber in other purpose	0.238	0.233	0.239	0.265	0.279	0.243
I10. Energy saving device	0.340	0.265	0.287	0.286	0.291	0.293

3.3 Comparing Management Alternatives

A qualitative assessment of the four management options was done by the local facilitators and researchers based on the results of the content analysis of the existing action plans and the collection of baseline information. Table 6 shows the performance of management options with respect to the 10 indicators. Assessment was done for each alternative in four categories with regard to its potential for future improvements in relation to the current situation: +++ (forest management situation is highly favourable for green economy development); ++ (forest management situation is moderately favourable for green economy development); + (forest management situation is slightly favourable for green economy development); and − (forest management option allows no change). The qualitative analysis shows that all indicators are fulfilled by multiple forest management, followed by scientific forest management and active forest management in that order. Table 6 reveals that multiple forest management is the most preferred, followed by active management and scientific management.

Table 6: Qualitative assessment of management options with respect to each indicator

Criteria and Indicators	Passive forest management	Active forest management	Scientific forest management	Multiple forest management
C1. Resource Sustainability	**6**	**8**	**9**	**10**
I1. Forest condition	+	++	+++	+++
I2. Maintenance of tree species diversity	+++	++	+	+++
13. Forest growth and harvest	+	++	+++	++
14. Biotic influences	+	++	++	++
C2. Human well-being and social equity	**2**	**7**	**6**	**8**
I5. Employment through Forest	+	++	+++	+++
I6. Capacity building programmes	**-**	+	++	+++
I7. Inclusion of poor and marginalized communities	+	+++	+	++

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C3. Low carbon emission	**0**	**6**	**4**	**7**
I8. Alternatives energy		++	+	++
I9. Use of timber in other purpose	-	++	++	++
I10. Energy saving device		++	+	+++
Total number of (+)	**8**	**21**	**19**	**25**

Note: + has a positive impact, - has a negative impact, 0 has no impact

Furthermore, the AHP technique was employed to select the overall best management options in comparing the performance of each alternative regarding all 10 indicators. Pairwise comparisons were made based on the qualitative assessment of the potential impacts of each option with regard to each indicator and in using the preferences of the various stakeholder groups for the C&I set. According to the overall results of the AHP, the multiple use forest management option is preferred by a majority of stakeholders as the best performing management option, scientific forest management is the second-best alternative, and passive forest management is the least preferred option (Table 7). Moreover, the results based on the preferences of the stakeholder groups were somehow comparable to the overall results. All preferred multiple use forest management option, followed by scientific forest management, whereas academics preferred active forest management as the second-best option.

Table 7: Overall priorities of management options with respect to all stakeholder groups based on the geometric mean of their synthesized priorities

Management Options	**Foresters**		**Scientists**		**Policy makers**		**CFUGs members**		**Local government representatives**		**Overall**	
	Rank	Priority	Rank	Priority	Rank	Priority	Rank	Priority	Rank	Priority	Rank	Priority
Passive forest management	4	0.232	4	0.252	4	0.266	4	0.224	4	0.233	4	0.241
Active forest management	3	0.394	2	0.443	3	0.504	3	0.383	3	0.407	3	0.424
Scientific forest management	2	0.472	3	0.437	1	0.635	2	0.483	2	0.502	2	0.501
Multiple forest management	1	0.568	1	0.551	2	0.627	1	0.553	1	0.584	1	0.576

Also, when the geometric mean of the overall priorities for all management options with respect to all criteria is calculated, the multiple use forest management is the most preferred option, followed by scientific forest management (Figure 1). Passive forest management is the least preferred forest management option.

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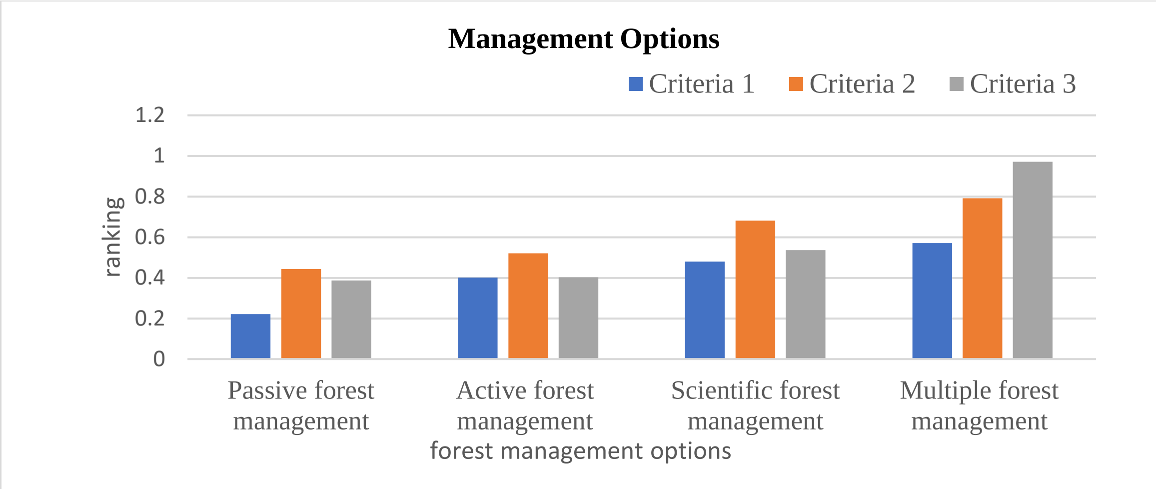

Figure 1: Overall priorities of management options

Further examination of the four alternative management options with three green economy demonstrated why multiple use forest management is the most preferred option. The functions of multiple services of forest can enhance well-being as well as support resource enhancement.

4. Discussion

4.1 Forest management in a green economy

The current management practices applied in CMF still focus on conservation and subsistence need. The management practices pay little attention to resource sustainability, human well-being and low carbon emission (Karki 2013). It is because only foresters or bureaucrats are being involved in deciding and developing policies and other actors or interests have limited involvement (Baral & Vacik 2018). In this respect, the criteria and indicators used in this study for evaluating forest management options with respect to the green economy allow a wider perspective in choosing an appropriate management option. Of the 10 indicators, the biotic influences (I4), employment through forestry (I5) and alternative energy (I8) are highly important indicators, a finding which echos with Chhetri et al. (2012). Therefore, management options should consider these aspects of implementation. The forestry sector plays a major role in translating green economic opportunities into concrete livelihood and environmental gains, ecotourism, forest-based livelihoods, and renewable energy solutions—biogas, bio-briquettes and micro-hydro energy to fuel the green growth practices for sustainable development (Karki 2013). For instance, Subedi et al. (2014) estimate that the forestry sector has the potential to generate 1.4 million full-time equivalent jobs in Nepal compared to the current employment of 145,00 full-time jobs. Human well-being is highly preferred criterion for national level stakeholders whereas resource sustainability is the highest preferred criterion for provincial level stakeholder. As the forest area in Nepal has reached to 44.5% (DFRS 2015), the national level stakeholders may have showed their priority from conservation to people's well-being as the national policy documents have also given high priority for prosperous Nepal and happy Nepali (MoFE 2018). Whereas, the reason for the high preference for resource sustainability given by provincial stakeholders could be that stakeholders still give high priority to biophysical condition improvements while well-being is seen as a benefit obtained from forest management. In the context of federalization, when the forests, except National Parks, have brought under the jurisdiction of provincial government, conservative approach seems to lead the forest management in years to come. The low preference for low carbon emission is related to no tangible benefits for stakeholders. The global community, including Nepal, has accepted that the green economy can be an important strategy to achieve the goal of sustainable development through CMF. Joshi et al. (2018) echoes stated that multiple forest management strategies can achieve the goal of sustainable development through the green economy path. However, a policy and a plan are missing for taking action (Karki 2013).

4.2 Best forest management options

Our analysis provides important insights into the relevant aspects of selecting an appropriate forest management option in the two provinces. The intensity of forest management is often described using either economic or ecological considerations, which result in passive and active management practices. This has provoked discussions on whether the approach is acceptable for long-term forest management planning or not (Möhring 1969). The approach brought the key stakeholders together and encouraged them to identify the appropriate forest management options which contribute to green economy development.

Four categories of forest management approaches have been defined along a gradient of management intensity. This allows grading and comparison of various types of forest management with different objectives. The geometric mean of synthesized priorities shows that multiple use of forest management was the most preferred management option for all stakeholders except policy makers (Figure 1). Scientific forest management is the most preferred one, being the second most preferred for all other stakeholders except scientists, while active management is the third best option. On the contrary, passive management was the least preferred, which is also supported by a number of researchers (Yadav et al. 2009; Joshi et al. 2018). The reason for preferring multiple use forest management as the most appropriate approach could be its capacity for fulfilling the diverse needs of the users. For users, mostly with a rural background and from an agrarian economy, fuel wood and fodder are as important as timber, or sometimes more. In addition, forests are also a source of water and contributes to mitigating disaster-related risks (Baral et al. 2019). However, its role in supplying timber to households cannot be ignored. In addition, the sale of non-timber forest products is one of the major sources of cash income for rural households. Likewise, it also provides recreational services to users and outsiders. The scientific management options, despite its potential of generating significant revenue for the community and government, comes in as the second priority. It can be assumed that the majority of users are not able to enjoy benefits; rather, it turned to be an elite capture (Yadav et al. 2009; Lund et al. 2013, Walelign & Jiao 2017; Baral et al. 2019). All stakeholders prefer multiple management because forests are being managed not only for timber and firewood, but also for tourism, soil conservation, and watershed protection. However, this view contradicts with that of the policy-makers, who gave priority to scientific management. This is primarily for two reasons: firstly, to generate more revenue from forests, secondly, to create local-level employment generation and reduce import of timber in the country, which corroborates with the finding of Basnyat et al. (2018).Nevertheless, multiple management emerge as the second preferred option among policy-makers as well.

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4.3 Policy implications for promoting appropriate forest management options

The MCA could potentially improve the quality of decisions by balancing interests and thereby allow solutions which result in a higher level of overall stakeholder satisfaction (Nordström et al. 2010; Khadka & Vacik 2012). Aside from the opportunity for all stakeholders to express their own objectives and visions, it is also possible to accurately structure the needs of different groups and improve the quality of the decision-making process (from societal perspective), which can help in the implementation (c.f. Nordström et al. 2010) of forest management options. Although stakeholders often have similar perceptions, the importance of criteria and indicators was seen to vary. For instance, the foresters' and scientists' groups have given relatively similar ratings, but the group of policy-makers and local government representatives had perceptions different from those of the forest user groups. Many case studies have shown that it is very important to explore how different stakeholders understand or conceptualize appropriate forest management (Purnomo et al. 2004). Our findings resemble those of Purnomo et al. (2004); Khadka et al. (2008); and Jalilova et al. (2012) who in their studies in Indonesia, Nepal and Kyrgyzstan respectively, also exhibit differences in stakeholders' preferences with regard to forest management.

Perceptions of stakeholders were analysed by various researchers; Stainback et al. (2011), which studies an agroforestry programme in Rwanda and KC et al. (2014), which investigates the community forest users' perceptions of the community forestry programme in Nepal, involve a one-to-one comparison between and within criteria to indicators and have come up with detailed judgment of perception. Preferences are guided by interests, largely for maximizing the contributions of the forestry sector to the economic aspects, especially on revenue generation (Chhetri et al. 2012 and Lund et al. 2013). The different forest management options which are being practised in Nepal need to change the current timber-centric management practices, especially those of scientific management and active management. Forest is not only a source of timber but also part of rural livelihoods, where active role of the local community cannot be undermined (Baral et al. 2018). Considering the high contribution to all three pillars of green economy development, there is a need for revising and realigning the policies and programmes from these aspects.

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5 Conclusion and Policy Implications

This paper has demonstrated different CMF approaches and stakeholders' perceptions by using the multiple criteria decision-making analysis. The performance of the different management options in contributing towards the green economy differs, guided by resource sustainability, human well-being, and social equity, and low carbon emission. Both passive and active forest management practices dominate CMF in Nepal. This is mainly due to the fact that forest stakeholders are not thinking out of the box, and consider management only as 'conservation', which in fact it is not. Furthermore, the policy processes in forest management are dominated by forestry professionals, and other stakeholders have limited involvement. The timber-centric management practices dominate overall planning, while the needs of other stakeholders are often ignored. This study recommends sustainable forest utilization, while fulfilling the needs of users and enhancing human well-being. In the context of federalization, the provincial and local governments can formulate policies based on users' preferences, which is multiple use forest management, followed by scientific forest management. National level stakeholder consultations provided sufficient information for the understanding of the existing forest management system and local socio-economic and environmental conditions. There is a need for identifying appropriate forest management practices, where the diverse interests of stakeholders can be addressed without compromising on green economy development. However, conflict of interest among decision-makers cannot be ignored. Moreover, forests being the source of livelihoods of people, the current timber-centric management might contribute to harnessing the economic potential. But this would compromise the ecosystem services of forests and requirements of the locals. We argue that there is an urgent need for revising forest management planning approach to consider multiple use forestry practices against the current timber-centric management. Furthermore, research on the green economy context should include a scenario analysis to provide other wanted and unwanted consequences that could have short- and long-term impacts on sustainability.

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Annex II: List of Instruments Used for data collection

Annex IIa: Forest Inventory Checklist

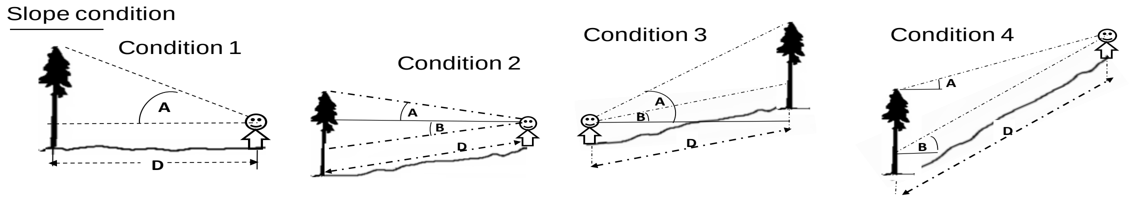
Basic Information	
Enumerators:	
Recorder:	
Date:	
Time:	
CFUGs Name:	
Forest Name:	

A. Plot Description

Plot number:	Forest type: Natural - Plantation	Strata: (Dense, Sparse...)
Slope (^{o}):	Elevation:	Aspect, S, E, W, NE, NW, SE, SW, Flat
X- coordinate:	Y-coordinate:	Dominant Species:
Canopy density (%)	Shrub Cover: (%)	Grass Cover:(%)
Soil Type: clay, loam, sandy, boulder	Soil colour:	Moisture content %: (High, medium, low)

1. Tree (All tree species with above DBHcm 30 cm or above with plot size 20 *25m)

1. Tree - DBH and height measurements | Strata:



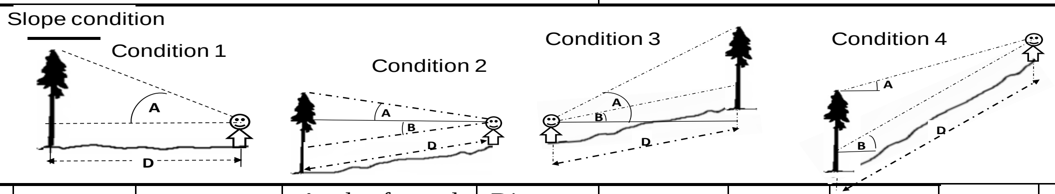
SN	Species	DBH (cm) measured at breast height (1.3m)	Angles formed by top and base of the tree: top (A)	Angles formed by top and base of the tree: base (B)	Distance to the tree (m) (D)	Slope condition (see figure above)	Ocular Tree height (m)	Tree Quality	Health State	Remark
1		.	0	0	.		.			
2		.	0	0	.		.			
3		.	0	0	.		.			
4		.	0	0	.		.			
5		.	0	0	.		.			

* Appropriate slope correction has been applied and measurements will be made
* The species of unidentified trees will be recorded as Sp 1...Sp 2 likewise and distinguishable characteristics will be noted as remarks

*** High-quality sound tree.** A live tree with a good form. Other sound tree. A sound live tree not qualified in class 1. The tree must have now or prospectively at least one 3 m section of sawlog quality or two 1.8 m or longer saw log sections. A log is considered as a saw log (merchantable) if the yield of lumber is 50% or more of the yield of a perfectly straight and sound sawlog. 3. Cull tree. A live tree that, because of poor form, roughness, injury or decay, does not now or in the future yield logs of merchantable quality.”
***Tree health State: Healthy:** A live tree that shows no sign of reduced vigour,
Declining: A live tree that shows signs of reduced vigour.
Dying: A live tree that shows clear signs of dying

2. Pole (All pole species with above DBH cm10 cm to 29.9 cm with plot size 20*25m)

2. Pole- DBH and height measurements	Strata:	Plot No.:



SN	Species	DBH (cm) measured at breast height (1.3m)	Angles formed by top and base of the tree top(**A**)	base (**B**)	Distance to the Pole (m) (**D**)	Slope condition (see figure above)	Ocular Pole height (m)	Pole Quality	Health State	Remarks
1		.	0	0	.		.			
2		.	0	0	.		.			
3		.	0	0	.		.			
4		.	0	0	.		.			
5		.	0	0	.		.			
6		.	0	0	.		.			

* Appropriate slope correction has been applied and measurements will be made
* The species of the unidentified pole will be recorded as Sp 1...Sp 2 likewise and distinguishable characteristics will be noted as remarks
*Pole Quality: A live tree with a good form and prospectively produced merchantable quality saw log, other: A sound pole class 1 but 50% of pole quality is used for logs. Cull: deformed one
*Tree health State: Healthy: A live tree that shows no sign of reduced vigour, declining: A live tree that shows signs of reduced vigour. Dying: A live tree that shows clear signs of dying

3. Advance regeneration (species with above DBH CM 4.0cm to 9.9 cm, plot size 10*15m)

SN	Species Name:	Girth (cm)	Height (m)	SN	Species Name:	Girth (cm)	Height (m)
1				6			
2				7			
3				8			
5				10			

4. Sapling: 2 to 3.9 cm DBH with *Plot size = 5*5m*

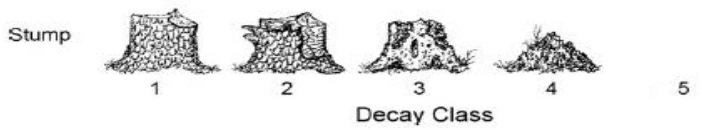
S N	Species	No	S N	Species	No

5. Tree Seedling: below 2cm DBH with *Plot size:1*1m*

S N	Species	No	S N	Species	No

6. Stump measurement (Plot size 500 m square)

S.N	Species	Basal Diameter (cm)	Height (m)	Approximate Age (Year)	Stump Decay class (I to VI)
1					
2					
3					

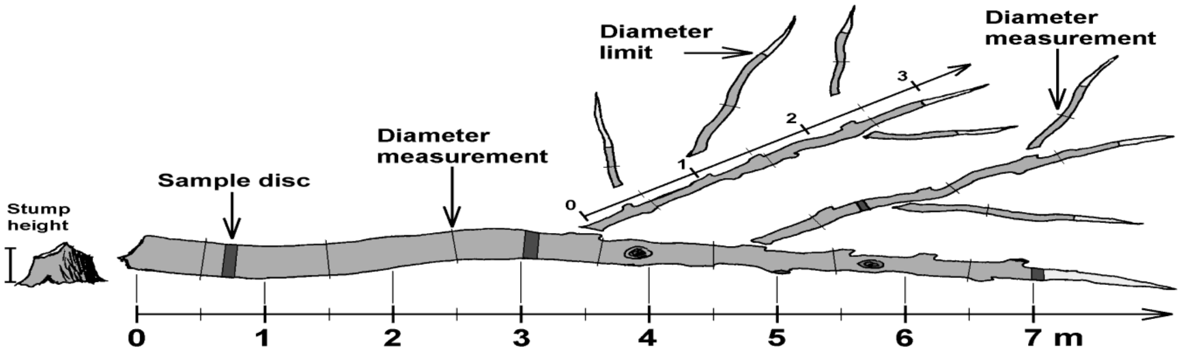


Stump Class **Definition**

Decay Class	
I	Bark Intact, Twigs, needles and branches present, **Covered by bark**, **outline intact**, **cylindrical stump**
II	Bark Missing especially when sun-exposed, Twigs and needles absent, Hard or partly soft, **knife**, Smooth, outline intact, a **cylindrical stump with bark often lost**
III	Bark Missing or partly intact, Branches absent, and branch stubs pull, **Begins to soften, thumbnail**, **cylindrical stump but with crevices**, Easy to turn over
IV	**Bark Missing**, soft, **thumbnails and knife penetrate**, Large crevices, small pieces missing, **Conical, very soft**
V	Bark Missing, Large pieces missing, **outline deformed hardly visible stump**
VI	Outline hard to define, Not **visible stump**

7. Log, Down and Deadwood measurement									
	Standing dead wood			Down and dead wood					
Species	Height (cm)	DBH (cm)	Decay class (1, 2, 3, or 4)**	Length (cm)	Decay class (1, 2, 3, or 4)**	Maximum dia. (cm)	Medium Dia. (cm)	Minimum dia. (cm)	Remark

**Decay classes for standing dead wood, down and dead wood	
CLASS 1:	With branches and twigs but without leaves
CLASS 2:	With no twigs, but with small and large branches
CLASS 3:	With large branches only
CLASS 4:	Bole (trunk) only, no branches



B. Forest Disturbances

SN	Disturbances	The extent of impact on the selected plot (%)
1	Forest fire	
2	Soil erosion/landslide	
3	Tree Lopping	
4	Tree logging/Tree harvesting	
5	Grazing	
6	Leaf Litter collection	
7	Insects and pathogen problem	
8	Invasive/exotic species	
9	Shrubs/weeds	
10	Fallen trees/wind throws	
11	Encroachment (Human)	

C. Tree Ring count (30 cm DBH and above)

SN	Tree no	Tree species	DBH over back (cm)	DBH Class	Sample number

Note: Class I - 30-40 cm dbh; class II- 40 to50 cm dbh class III – 50-60 cm dbh; class IV – 60 -70 cm dbh; class V 70=60 cm dbh; class VI – 80 -90 cm dbh; class VII – 100 and above

Annex IIb: Household survey questionnaire

SN	Questions	Answer
1	Name of CFUG Member	
2	Sex of the CFUG members	
3	Serial No of Name in OP/Constitution	
4	Name of CFUGs	
5	Name of interviewer	
6	Date of interview	
7	Data entered by	
8	Date of Entry	

A. Information about Respondent/Household head

	Questions	Answer	Remark
1	Name of Respondent		(if different from CFUG members)
2	Caste	Brahmin/Chettri ....1 Janajati ....2 Dalit...3 Other Terai caste 4	
3	Age of the respondent		
4	Sex of the respondent	Male ....1 Female...2	
5	Well-being situation of HHs	Rich ....1 Medium ....2 Poor ....1 Very poor 2	
6	Household characteristic based on livelihood strategy	Agriculture ....1 Business ....2 Service...3 Wage labour ....4 Cottage industry/enterprise ....5 Occupational work ....6 Others (specify)..............................7	(Only one response)
7	Are you native to this place?	Yes ....1 No..2	If yes go to B
7.1	If no, when did you or your family member migrate?	Year:	
7.2	If migrated place of migration? **Enumerator, specify place:**	Adjoins/within district ....1 Hill district ....2 Terai district ....3 Mountain district ....4 Other countries 5	

B. Demographic information

Name (First name only)	Age	Sex		Education (year of schooling)	Occupation	
		Specify	**Code**	Actual	Specify	**Code**

Sex: 1. Male 2. Female
Education: Put 0 if not attended formal school
Occupation: **1.** Student 2. Agriculture 3. Wage-earning 4. Service 5. Business 6. Occupational work 7.Cottage/ green industry 8. Forest products business 9. Dependent

C. Economic Situation

	QUESTIONS	ANSWERS	SKIP
C1	Do you have own house?	Yes.. 1 No 2	**If no go to C3**

1.1. If yes, what is the type of house you are staying?

Parameter	Type 1	✓	Type 2	✓	Type 3	✓	Type 4	✓	Type 5	✓
Wall	Mud		Cemented		Twigs					
Roof	Thatch		Tin		Tile		Slate		Cemented	
Storey	One		Two		More					

Put a tick mark on the selection

C2. Landholding situation of HHS (Unit either in Ropani or Katha

	Unit	House yard	Cultivated low land	Cultivated Upland	Private forest/ pasture	Fishery pond	Land without ownership entitlement
Family own							

C3. Livestock holding

SN	Type	Total Nos	Total Value in Rs
1	Cow		
2	Ox		
3	Buffalo		
4	Goat		
5	Sheep		
6	Pigs		
7	Chicken		
8	Ducks		
9	Others specify		

D. Dependency on Forest Resources

D1. What do you get from the forests? **(Most 3)**

1.	**2.**	**3.**

Code:

Employment.................................... 1
Wild edible food 2
Roofing material (Thatch)................ 3
Grazing land..................................... 4
Firewood 5
Timber... 6
Forage/fodder.................................. 7
Other forest products (Honey/Silk)........ 8
Fish 9
Medicinal plants.................................. 10
Aquatic plant....................................... 11
Sand/stone... 12
Water 13
Drift wood... 14
Canes (Khadai) 14
Others (specify) 15

D2. What is your household's requirement of?

	Forest products	**Unit**	**Amount Required**	**Rs/Unit (local market)**	**Remark**
1	Timber	Cft			Per annum
2	Pole	Number			Per annum
3	Fuelwood	Bhari			Per month
4	Fodder	Bhari			Per month
5	Forage/Litter	Bhari			Per month
6	Grasses	Bhari			Per month

D3. How much forest products had you collected last year from the following sources?

			CF forest	**Govt forest**	**Private source**	**Purchas e**	**Other**
1	Timber	Cft					
2	Pole	Number					
3	Fuelwood	Bhari					
4	Fodder	Bhari					
5	Forage/Litter	Bhari					
6	Grasses	Bhari					
7	Other specify						

D4.	**Adoption of clean and energy saving technology**	**Yes/No**
1	Biogas	
2	ICS	
3	Rice husk stove	

D5.	**What fuel do you use for cooking purpose?**	**Now**
1	Fuelwood	
2	Kerosene	
3	Electricity	
4	LPG gas	
5	Bio-gas	
6	Cow dung cake	
7	Crop residue	
8	Brushwood	
9	Solar	
10	Coal	
	Total	**100 percent**

E. Are you or family members representing in any of the following local organizations?

SN	Organizations	Response Yes/No	General member (No)		Executive (No)	
			Male	Female	Male	Female
1	Saving and credit group					
2	Community Forest User Group					
3	Agriculture-related					
4	Agriculture group					
5	Infrastructure related group (drinking water, road, irrigation etc)					
6	Youth club/NGOs					
7	Cooperative					

F. Have you or your family member ever received in any kind of training from forest-related institution (CF, DFO, FECOFUN..)

Organizations	Response Yes/No	Number of family member trained	
		Male	Female
Skill development /Job oriented training			
Agriculture based income generating training			
Forest-based income generating training			
Office management/administrative			
Forest management			
Leadership/ institutional management training			
Business mgt/entrepreneurship			
Gender equity & social inclusion			
Orientation course			
Other/ specify			

G. Food security

SN	QUESTIONS	ANSWERS	SKIP
1	What is your overall food sufficiency situation in your family this year from your own farm production?		
2	If not sufficient, how have you managed?	Another permanent source of income... 1 Sale/mortgage of assets.................. 2 Sale of livestock............................ 3 Loan .... 4 Other non-farm activities .... 5 Other farm activities .... 6 Wage-earning................................ 7 Remittances.................................. 8 Loan .... 9 Others.. 10	

H. Employment on forestry activities

SN	Activities	Response Yes/No	No of days worked		Daily wage received (NRs)	
			Male	Female	Male	Female
1	Forest protection/watchers					
2	Silviculture operation (thinning, pruning, cleaning etc)					
3	Forest product harvesting and distribution (Felling, logging, loading, carrying etc)					
4	Plantation					
5	Community development such as road, building and other infrastructure development work					
6	Forest-based enterprise/income generating activities					

I. Social benefits from forestry activities

SN	Activities	Investment from community forest Yes/No	Benefited from investment support Yes/No
1	Education facilities (school construction, teacher salary, furniture etc.)		
2	Health facilities (health post-construction support, salary, medical equipment support etc)		
3	Road construction, repair and improvement		
4	Other community development related work (drinking water, irrigation, etc		
5	Market facilities construction and improvement such as collection centre, market equipment		
6	Capacity development (leadership skills,)		

J. Equitable benefits sharing

SN	Activities	Provision (Yes/No)	Implementation (Yes/No)	Benefited (Yes/No)
1	Reservation/special priority to women and poor in decision making			
2	Equitable sharing of forest products/Priority to poor and marginalized			
3	Different price according to economic conditions			

K. Resource base creation

SN	Trees type	Plantation on farm land (Yes/no)	Unit	Total
1	Timber		Number	
2	Fuelwood		Number	
3	Medicinal plants		Area	

L. Natural resource conservation activities in your village implemented by CF?

	Was the program implemented? (Y/N)	Was this beneficial to you? (Y/N)
Community plantation		
Road/canal plantation		
Private forestry/ Agroforestry		
Nursery establishment		
Spur/embankment construction		
Water source conservation		
Fencing		
Others specify		

M. Income different sources

SN	Source	Approx. Amount in Rs
A.	**Agricultural Income (Gross income)**	
1	Cereals	Rs.
2	Fruits and vegetables	Rs.
3	Pulses and Oilseeds	Rs.
4	Cash crops	Rs.
B.	**Livestock income (Gross)**	
5	Livestock sale	Rs.
6	Milk and milk products	Rs.
7	Dung cake	Rs.
8	Eggs	Rs.
9	Wools	Rs.
C.	**Non-agricultural Income**	
10	Business	Rs.
11	Salary/Pension	Rs.
12	Wages	Rs.
D.	**Income from forestry activities (Gross)**	Rs.
13	Fuelwood	Rs.
14	Fodder	Rs.
15	Thatch grasses	Rs.
16	NTFPS	Rs.
17	MAPs	Rs.
18	Others	
E.	**Tourism-related works**	Rs.
19	Hotel Owners, Guides, Souvenir shop operators Service Providers	
F. 20	**Pension**	Rs.
G	**Remittances**	
H.	**Wetland-related income**	
21	Fishing	Rs.
22	Ducks	Rs.
23	Aquatic Plant	Rs.
24	Boating	Rs.
25	Rented out properties/land	Rs.
I.	**Enterprises** Forestry related Non-forestry related	
J.	Others	Rs.

N. In your view, how community forestry has contributed to well-being situation in your village?

O. What should be done to improve well-being situation of your households?

Annex IIc: CF Record Collection and Analysis, including consultations with CFUGs office bearers/leaders

The research will collate CF records to understand the current level of harvest, especially for commercial purpose, amount of forest product harvested from different silviculture operations and forest harvesting records to estimate the amount of growing stock volume harvested over the period of time, especially timber and firewood withdrawal from CF. In addition, it will also collect the following information;

1. Name of CF:
2. Year of hand over:
3. Preparation and revision:

OP	Year	Area (ha)	Members (No)	Key changes observed
Preparation				
First amendment				
Second amendment				
Third amendment				
Fourth amendment				

4. CF current management objectives

Objectives	Changes in objective if any over time	Reasons if any

5. Silviculture operations

Silviculture operation prescribed in the plan	Actual implemented in the ground	Reasons if any

6. Harvesting records (last five years)

Year	Harvesting amount (GS volume)	Actual harvested quantity (GS Volume)	Forest products	
			Timber	Firewood
Unit				
1				
2				
3				

7. Distribution of forest products

Year	Harvested/Collected		Distribution within the group		Sold outside group	
	Timber	Firewood	Timber	Firewood	Timber	Firewood
Unit						
1						
2						
3						

8. Price of timber and firewood

Year	Auction price		Harvesting cost		Transportation cost	
	Timber	Firewood	Timber	Firewood	Timber	Firewood
Unit						
1						
2						
3						

9. Sources of income of CFUGs (NRs) in last five years

SN	Sources	Year I	Year II	Year III	Year IV	Year V
1						
2						
3						

10. Sources of expenses of CFUGs (NRs) in the last five years

SN	Sources	Year I	Year II	Year III	Year IV	Year V
1						
2						
3						

11. Key activities of the CFUGs on forest management

SN	Activities	Year I	Year II	Year III	Year IV	Year V
1						
2						
3						

12. Key activities of the CFUGs on well-being improvement/livelihoods/community development

SN	Activities	Year I	Year II	Year III	Year IV	Year V
1						
2						
3						

13. Support received from projects/development organizations

SN	Organizations	Year I	Year II	Year III	Year IV	Year V
1						
2						
3						

Annex IId: Checklist for with CFUGs leaders/focus group discussion

Name of the CFUGs:

A. CFUGs management

1. Could you please give a brief history of the CF management? When the CF was handed over and what are the management activities your group has been conducting (chronological order).

2. What are the benefits to the groups received from the management of community forests? Please specify

3. How the forests are being managed? What are the activities do you undertake annually for the management of forests?

4. Who supports on managing community forests? Have your group received any support from the management of community forests?

5. What are the problems do you face on the management of the forests?

B. Ecological sustainability

1. How forest inventory on community forests are being carried out? What is the use of the forest inventory? Why forest inventory on community forest is needed?

2. How forest products, especially timber and firewood harvesting decisions are being made? How forest inventory results are being used on harvesting decisions?

3. Do users have competency on forest inventory including yield predictions from forests? Who supports on harvesting and yield regulations?

4. What are the major disturbances and threats to the community forests? What activities are being carried out to address these disturbances?

5. How forest conditions have changed (increased, decreased, similar) in comparison to the last five years? What are the factors responsible for the change?

6. Do the community forests have been able to meet the demand of the forest products, especially timber and firewood of the users? How users are meeting their need of the forest products?

7. Do you think that present management practices of the forests are sufficient to ensure long term sustainability of the forests? Give reasons?

8. How do you achieve your goals of forest management (e.g. thinning using contractors, thinning as a joint community activity, thinning from above, thinning from below, lopping the branches, removal of low-quality trees, etc?)

9. What are the actions you take to make your CF sustainably managed (ecological perspective-species diversity)?

10. What should be done to ensure forest sustainability?

C. Well-being contribution

1. How funds or income from the community forests are being utilized? What are the areas of investment of the fund?

2. How priority for fund utilization are being planned? Who make decisions and how?

3. Who has benefited from the above investment of community forests and how?

4. How community forest group is working on inclusion and equitable sharing of the benefits?

- Inclusions
- Sharing of timber
- Sharing of firewood
- Investment on pro-poor activities

5. How community forests have contributed to improving livelihoods in general and well-being situation of the local community, especially of the poor and marginalized community?

6. How community forests have contributed to improving the income of the members? Which group of the community have benefited and how?

7. How community forests have contributed to the creation of employment opportunities of the local community? Which group of the community have benefited and how?

8. How community forests have contributed to social and community development in your locality? What are the major interventions carried out and how these interventions are being planned? Which group of the community have benefited and how?

8. How community forests have contributed to the improvement of the environmental situation in your locality? What are the major interventions carried out and how these interventions are being planned? Which group of the community have benefited and how?

D. Well-being classification?

What are the criteria we need to consider in defining well-being situation of the local community? What makes people well-off?

How the well-being situation should be measured?

Annex IIe: Checklist for interaction with forest officials and other stakeholders

Name of the respondent
Position
Office
Contact Number

A. CFUGs management

1. What are the benefits to the local community from the management of community forests? Please specify
2. How community forests are being managed? What are the activities do users carried annually?
3. How your organization is supporting on the management of community forests?
4. What are the problems on the management of the community forests?

B. Ecological sustainability

1. How forest inventory results are being used for ensuring sustainable management of community forests? How forest inventory results are being used on harvesting decisions?
2. Do users have competency on forest inventory including yield predictions from forests? Who supports on harvesting and yield regulations?
3. What are the major disturbances and threats to the community forests? How DFO is supporting to address these threats?
4. How forest conditions of community forests have changed (increased, decreased, similar)? What are the factors responsible for the change?
5. Do you think that present management practices of the forests are sufficient to ensure long term sustainability of the forests? Give reasons?
6. What should be done to ensure forest sustainability?

C. Well-being contribution

1. How funds or income from the community forests are being utilized? Who has benefited from the above investment of community forests and how?
2. How community forest group is working on inclusion and equitable sharing of the benefits?
3. How community forests have contributed to improving livelihoods in general and well-being situation of the local community, especially of the poor and marginalized community?
5. How community forests have contributed to improving the income and employment of the members? Which group of the community have benefited and how?
6. How community forests have contributed to social and community development? Which group of the community have benefited and how?
7. How community forests have contributed to the improvement of environmental situation? Which group of the community have benefited and how?

D. Well-being classification?

1. What are the criteria we need to consider in defining well-being situation of the local community?
2. What makes people well-off? How the well-being situation of the community should be measured?

Annex IIf: Checklist for observation

The research will observe forest management practices and also interact with key informants, CFUGs leaders and another knowledgeable person to understand existing forest management practices, dependency on forest resources and harvesting practices**.** Following are a point to consider in the observation;

- Forest harvesting plan and practices
- Growing stock volume harvested per year
- Silvicultural operation practices
- Silvicultural prescriptions mentioned in the operational plan are appropriate or not?
- Forest Income and reinvestment in different areas
- Different income generation provision to the special group of CF
- Fund collection and utilization in
- Forest management trends
- Committee and General Meeting
- Participation of women and other groups in the meeting and their stake
- Record of decision

Annex IIg: Participatory Well-being ranking methods

During the Participatory well-being ranking, a group of households will be asked to rank themselves according to economic and social status. Following sequential steps will be followed/.

Step I: CFUG level workshop for identification of the criteria and verifiers for the well-being ranking
The research will organize CFUGs level workshop to identify criteria for well-being assessment. The participants of the workshop would be community forest leaders, users, poor and marginalized groups and another knowledgeable person such as school teacher, community/social mobilizers and development organization representative working in the village.

- Brainstorming with the participants will be carried out identify all the criteria which users consider important for assessing well-being situation in their community and village.
- Participants will be asked to prioritize the criteria following pairwise ranking techniques.
- Three to five main criteria for well-being ranking will be identified in the consensus of the participants.

After identification of the criteria, the participants will be asked to classify the households into four groups considering the criteria discussed earlier. They will be asked to identify the verifiers for measure of each criterion. Below criteria presents tentative indicators for well-being assessment

Well-being group	Verifiers
Rich	
Medium	
Poor	
Very Poor	

Step II: Social map preparation and updating the list of of the member households of the community forest user groups. After reaching on consensus of the criteria, the participants will be asked to prepare a social map of the community showing major settlements, road and households. They will be asked to identify all households in the map along with updating the member list of the households. After listing off the households, the number, name of the households and settlement will be written in two meta cards.

Step III: Well -being ranking: The participants will be divided into two groups and would be requested to rank the members into four well-being groups as per the agreed criteria. Two groups will be asked to rank households independently and participants will be asked to group meta cards into four groups. After completion of the group work, the plenary session with the participants will be organized.

Step III: Finalisation of the Well-being ranking: During the plenary session, the facilitator read the name and a serial number of each household and ask the group leaders present their rank. The facilitator writes the results and participants would be asked for reseason if any differences are observed between two groups. The consensus would be reached among the participants on the well-being ranking of each member. The table below presents a template which will be used for finalization of well-being ranking.

SN	Name	Settlement	Group A rank	Group B rank	Final agreed rank

Criteria for the Well-being Ranking

Well-being Ranking	Characteristics / Criteria
Rich	• Sufficient food for 12 months or more with a surplus for sale; • Large house with slates or tin roof and separate animal shed; • 15 Ropani (about 0.8 hectares) and more land • kharbari (thatch land); • Good quality livestock • At least 2 family member engaged in a permanent job, business or other secure off-farm jobs with a good cash income; • Children attend schools and colleges in towns, • Most family members are literate; • Most depend on their private forest.
Medium	• Sufficient food for 9-12 months • Medium size house, with or without slates or tin roof and a separate animal shed; • 15 Ropani (0.5 - 0.8 hectares) of land (Sometimes may have more land than that), • Family labour exchange for agricultural work; • Keep 3-4 livestock; • At least 1 engaged in a permanent job, business or other secure off-farm jobs with a good cash income • Depend on both private land and sometimes community and government (non-FUG) forests for forest products;
Poor	• Sufficient food for 6- 9 months; • Work on daily wages for twelve months to survive • Mostly household members are illiterate few children are literate; • Less than 5 Ropani (0.25 hectares) of land • Keep some livestock almost all belonging to rich/ medium class people raising on tenancy • Most depended on community and government (non-FUG) forests for forest products.
Very Poor	• Sufficient food for 3-6 months • Work on daily wages for twelve months to survive • Mostly household members are illiterate few children are literate; • Less than 2 Ropani of land • Keep some livestock almost all belonging to rich/ medium class people raising on tenancy • Number of people in the household is less and also mostly represent the old and the disable people • Most depended on community and government (non-FUG) forests for forest products.

Annex IIh: Sequential steps for Appropriateness analysis of the community forests using the Multiple Criteria Decision-making Analysis

The appropriateness analysis of the community forests in the different physiographic region of Nepal will be carried out following eight sequential steps.

Step I: Indicative criteria and indicators development
Prior to the initiation of analysis, the research will collect background information related to the study especially focusing on policy, social, economic and biophysical aspects. A set of indicative criteria, indicators and verifiers will be developed. The indicative C&I will be shared with the relevant experts at the national level for refinement before field testing.

Step II: Site level stakeholders mapping and selection
The research has identified four categories of stakeholder who have a direct or indirect stake on community forest management. This includes (a) policy-makers (b) government officials (c) civil society actor/conservation partners, (d) users and executive committee members of community forests and (e) researchers. Each category of the stakeholders will be mapped in consultation with studied community forests user groups and district forest officials.

Step III: Finalization of the criteria, indicators and verifiers
The field level stakeholder workshops will be organized for finalization of the C&I from an ecological economic sustainability perspective. Around 40 participants, at least 10 from each category will be invited for the workshop. The criteria and indicators will be finalized based on stakeholder's comments and suggestions.

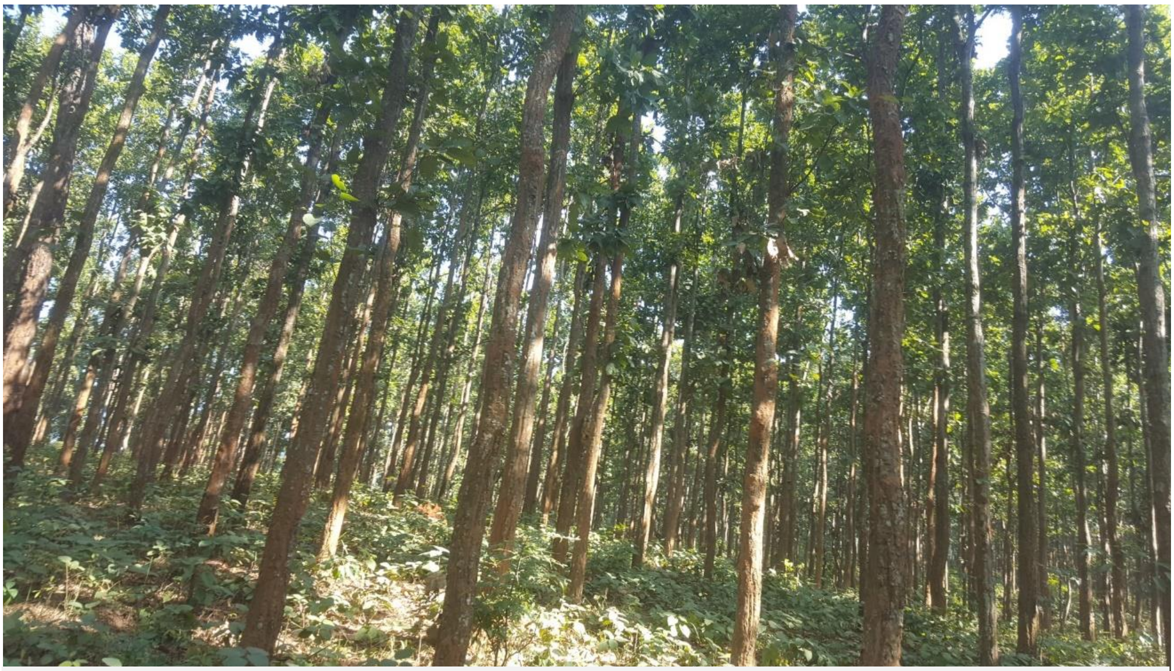
Step IV: Ranking of criteria and indicators
The research will carry out one by one survey of stakeholders representing at least 10 respondents from each category for ranking of criteria and indicators. The respondents will be asked to rank criteria and indicators on the basis of individual perceptions and preference using a ten point ranking scale [from 0 to 9], where 0= not important preferred at all and 9 = highly preferred. After completion of the survey of at-least 40 respondents, the preferences of the stakeholders against different criteria and indicators will be ranked.

Step V: Validation workshops on the ranking of criteria and indicators- one in each district
A site level stakeholder workshop will be organized in each district to validate stakeholder ranking. Around 40 participants representing different groups will be invited for the validation workshop, of which half would be respondents for the survey.

Step VI: Identification of management options
After validation of the ranking, participants will identify different management strategies inconsistent with the C&I validated earlier. Furthermore, they will also be requested to define their management strategies considering local context, their need and priority.

Step VII: Appropriate analysis based on stakeholders' preference and actual practice
After the identification of preferred management strategies, the research will conduct field level review/focus group discussions in selected community forests to assess similarities and differences between stakeholder priority and practice. The analysis will focus on whether there is coherence between the preferred management strategy and filed practice. Finally, final management strategies and their trade-off will be assessed using the AHP.

Annex III: Field pictures



Picture I: One of the studied forest- Kankali

Picture II: Inventory and Household survey team

Picture III: Inventory Plot design

Picture IV: Forest inventory

Picture V: Focus group discussion with local communities

Picture VI: Household survey

Picture VII: On-site discussion with DFO officials and local communities

Picture VIII: On-site discussion with local communities

Picture IX: Consultation with local government representatives

Picture X: Multicriteria analysis at municipality