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RESEARCH PAPER

Rapid Silviculture Appraisal to Characterise Stand and Determine Silviculture Priorities of Community Forests in Nepal

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Abstract Community forestry in Nepal is an example of a successful participatory forest management program. Developments in community forestry in four decades have focused on the social and governance aspects with little focus on the technical management of forests. This paper presents a silviculture description of community forests and provides silviculture recommendations using a rapid silviculture appraisal (RSA) approach. The RSA, which is a participatory technique involving local communities in assessing forests and silviculture options, is a simple and cost-effective process to gather information and engage forest users in the preparation of operational plans that are relevant to their needs. The RSA conducted on selected community forests in Nepal's Mid-hills region shows that forests are largely comprised of dominant crowns of one or two species. The majority of studied community forests have tree densities below 500 stems per hectare as a consequence of traditional forest management practices but the quality and quantity of the trees for producing forest products are low. Silviculture options preferred by forest users generally are those which are legally acceptable, doable with existing capacities of forest users and generate multiple forest products. For sustainable production of multiple forest products, the traditional forest management practices have to be integrated with silviculture-based forest management system.

Keywords Forest structure · Multiple-use forest · Selective harvesting · Participatory forest management

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Introduction

Nepal's community forests represents more than four decades of participatory and decentralised forest management (Springate-Baginski et al. 2003; Pokharel et al. 2007; Dahal and Chapagain 2008). During this period, community forestry was focused solely on the protection of forests by local communities (Yadav et al. 2009; Ojha et al. 2014) creating 18,960 Community Forest User Groups (CFUGs) managing 1.8 million hectares of forestlands (Department of Forests 2015). There is good evidence that community forestry has achieved its goal in forest rehabilitation and environmental protection (Yadav et al. 2003; Gautam et al. 2004; Iversen et al. 2006), but there are concerns about its impact on rural livelihood and social equity (Adhikari 2005; Nightingale 2005; Dahal and Chapagain 2008; Chhetri et al. 2012). Community forestry largely failed to improve livelihoods and food security because of status and gender-based inequality, insecure property rights, poor intra-CFUG governance, lack of government support and poor flow of material benefits to community members (Baynes et al. 2015). Silviculture operations on community forests are required to improve forest productivity and the flow of material benefits to community members, but it has to be conducted in a manner that also address other constraining factors. Silviculture operations can increase the sustained yield and quality of products that will be vital in improving livelihoods of communities now and in the future.

Selective felling, singling (removal of less promising poles in multi-stem trees), thinning, pruning, and weeding are silvicultural treatments prescribed in operational plans by many CFUGs (Acharya 2004; Department of Forests 2015). These prescriptions are made for conservation-centric forest management, which largely overlook the sustainable harvesting aspects of the forests. A common practice is to over-harvest poles and understorey saplings creating an even-aged stand dominated by commercially viable timber species (Yadav et al. 2003, 2009). The current silviculture poses threats to species diversity and the multiple-use objectives of community forest management. CFUGs require multiple use forestry based on principle of sustainable management of forests, i.e., silviculture systems which promote production of multiple forest products at shorter cutting cycles to meet livelihood requirements of local communities.

Critics maintain that forestry operations in community forests are not adequately applied as per forestry science. For example, thinning which is generally applied as an intermediate treatment to enhance forest growth is practiced in Nepal as a major harvesting operation although the harvest levels and systems of tree removal are similar to thinning (Ojha 2001). Additionally, silviculture operations on community forests are not straightforward because people want to meet their multiple, sometimes conflicting needs from a relatively small area of forestland (i.e., <1 ha of forest per household). More importantly, forest regulatory agencies, i.e., District Forest Offices, make decisions related to tree harvesting to maintain a good 'public image' of forest protection by prescribing annual cutting far lower than the potential.

Silviculture practices of CFUGs are guided by their operational plans[1] which are part of the contract for transferring forest rights to communities. Currently these plans are prepared using standard inventory procedures to assess forest conditions and estimate timber growing stock and annual allowable cut (AAC) with the assistance of District Forest Offices field staff (Ministry of Forest and Soil Conservation 2000). The inventory guidelines require stratified systematic sampling using rectangular plots of 20 × 25 m at sampling intensities of 0.5–1 %. The aim of the forest inventories is to assess the condition of forests and calculate the AAC. The AAC is one of the goals of the operational plans, these set the amount of timber and other forest products that CFUGs can harvest each year without compromising the forest condition. The AAC is a way to implement sustained yield harvesting but most operation plans lack clear guidance on which silviculture systems to apply to achieve such (sustained) yields. Timber inventories therefore have become just an activity to generate data relating to forest characteristics rather than providing appropriate silviculture systems for yield regulation.

Paudel and Ojha (2008) have identified several problems with the inventory guidelines for community forestry in Nepal. These problems include: (1) complexity and rigidity of the forest inventory approach requiring at least 12 days to complete inventories of a 50 ha forest; (2) high costs of forest inventories to CFUGs and district forest offices (DFO) (estimated to be NRs 10,800 to NRs 13,800[2]); and (3) lack of personnel both in DFOs and CFUGs competent enough to carry out forest inventories. Because of these problems, forest inventories are often done haphazardly and their interpretations result in poor quality operational plans (Toft 2013; Toft et al. 2015). The operational planning process becomes a burden to communities, as CFUGs have to pay for the services required in preparing operational plans (Rutt et al. 2015). Even when CFUGs get their operational plans, management prescriptions which include thinning, selection felling, replanting, and pruning are often not implemented, thereby putting the relevance of the operational plans under question (Rutt et al. 2015; Toft et al. 2015).

Despite widely acclaimed success, community forestry has not made significant impacts on improving rural livelihoods (Dougill et al. 2001; Malla et al. 2003; Kanel and Kandel 2004). The low impact of community forestry on rural livelihoods is due, in part, to the lack of active forest management to enhance forest productivity (Yadav et al. 2009). The lack of active forest management is associated with several underlying factors including technical issues, protection oriented forest management, poorly designed silvicultural practices and limited practical knowledge on forest management (Yadav et al. 2011). Gilmour (2014) noted that despite the advances in the understanding of social and policy arrangements of community forestry in the last few decades, particularly in Asia, there has been an apparent lack of a coherent body of knowledge on appropriate technical systems for community

[1] Operational plans, also known as work plans, are periodic plans of actions developed by the CFUGs and officially approved by district forest offices (DFO). They specify the forest management objectives of the CFUGs and provides a detailed plan of actions to achieve those stated objectives including rules related to forest management, and utilization. The Forest Regulation (1995) and Community Forestry Guidelines (1995) provide specific content and process guidance for the operational plans.

[2] US $ 1 = NRs 100.

forestry. This paper is an attempt to describe the silvicultural characteristics of community forests under prevailing traditional silvicultural knowledge and practices, identify major factors that govern these practices and develop a short-list of new silvicultural options that suit the management objectives of forest users.

This study presents a method based on rapid appraisal techniques to assess the silvicultural status of selected community forests in the Nepal Mid-hills region and the community preferences related to scientific forest management. The results of the appraisal are used to recommend silvicultural options for managing community forestry to improve food security and livelihoods of forest users.

Methodology

General Profile of Selected Community Forests

Nepal's mid-hills region forms a belt running from the east of the country through to the west characterised by rugged to steep terrain with elevations ranging from 700 to 3000 m altitude. The region is a mixture of agricultural land, grassland, shrub land and forests (Adhikari et al. 2007). Most farmers in the region rely on forests to maintain a range of ecosystems services in addition to the flow of nutrients and energy from the forests to their farms (Gilmour 2008; Palikhi and Fujimoto 2010). The region has 13,606 community forests with a total area of 1.17 million ha representing approximately 30 % of the total forest area in the country (Department of Forests 2015). The EnLiFT Project[3] selected one CFUG in six Village Development Committees (VDCs) in Lamjung and Kavre Districts as representatives of the Mid-hills for intensive studies based on the size of the community forests, community diversity, accessibility, effectiveness of managing forests, and geographical distribution. The area of these community forests ranged from 53 to 298 ha and the number of households involve ranged from 83 to 302 (Table 1). Each CFUG households has a share on average of three quarters of a hectare which is comparable to the 0.78 ha average for the Hills regions reported by the Department of Forests (2015).

Rapid Silvicultural Appraisal

Rapid rural appraisal techniques were adopted to examine silviculture practices in community forests in Nepal. These involve quick forest inventories to obtain representative pictures of stand structure and composition and participatory workshops to help forest users identify silviculture systems suitable for their needs– herein referred to as 'rapid silvicultural appraisal (RSA)'. The RSA is an approach to silviculture assessments of community forests to obtain a snapshot of the forest resource in contrast to the detailed and time-consuming standard forest

[3] EnLiFT Project is the short name of the Australian Centre for International Agriculture Research funded project FST/2011/076 which is a research project aiming to enhance livelihood and food security through agroforestry and community forestry in Nepal.

Table 1 Area of community forest and number of households by CFUG

Village Development Committee	Name of CFUG	Land area (ha)	Number of household members
Mithinkot	SaPaRuPa	297.8	302
Dhunkarka	Kalopani	168.8	278
Chaubas	Phagar khola	53.2	84
Jita/tandrang taksar	Lampata	74.5	246
Dhamilikuwa	Aapchaur	122.5	244
Nalma	Langdi Hariyali	275.9	167

inventories. It also includes assessment of user preferences for silviculture systems. The RSA was conducted in March–July 2014 in the six selected community forests in Kavre and Lamjung Districts (Fig. 1). In Kavre District, the selected CFUGs were SaPaRuPa, Kalopani and Phagar Khola: Village Development Committees (VDC) of Mithinkot, Dhunkarka and Chaubas, respectively. In Lamjung District, the selected CFUGs were Lampata, Aapchaur and Langdi Hariyali in the VDCs of Taksar, Dhamilikuwa and Nalma, respectively.

The general steps of the RSA are as follows. Stand characterisation.

1. Obtain permission and cooperation from government forestry agencies (i.e., the District Forest Office) and the CFUGs.
2. Develop a 'schematic map' of the forest and delineate approximate boundaries of forest blocks defined by homogeneity of species and age (size) class.
3. Collect management history of the site from interviews with key CFUG leaders.
4. Establish two temporary circular plots (one on the edge and one on center of the forest) with radii of 5 m for blocks with tree density $\geq$1000 stems per ha (sph) or 10 m radii for blocks with tree densities <1000 sph following Herbohn et al. (2014). A third plot is established somewhere in between the edge and center plots for larger blocks with multiple aspects (face of the slope). These number of plots are determined to be adequate due to relative homogeneity of most blocks in the studied community forests similar to experience of the first author on smallholder forests in the Philippines.
5. On each plot, trees were identified by local names, and tree diameter, height (total height and merchantable height), and crown radii were measured and regeneration and non-timber forest plants were counted and identified to local names.
6. Stem and crown diagrams were developed for each plot, then timber stocking (density, basal area, timber volume) and plant diversity (Shannon's diversity index) were calculated. Standing timber volumes were estimated based on basal area and merchantable height and corrected using a form factor of 0.6 suggested by Takur (2006) as a reasonable form factor for a number of species in Nepal. Crown and stem profiles were hand-drawn for each sample plot using collected tree maps and tree inventory data. Crown canopy cover (percent) of sample plots was estimated using dot grids overlaid on crown sketches (Pretzsch 2009).

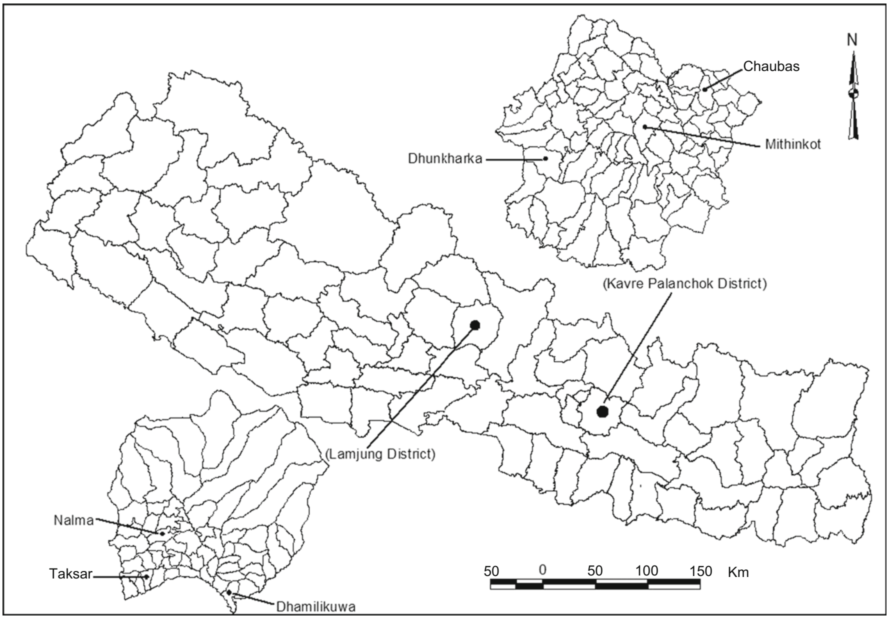

Fig. 1 Location map of the VDCs of selected community forests

Using a dot grid for estimating crown cover was preferred over field ocular methods because the latter is subjective and results could be highly variable depending on the experience of tree cruisers (Korhonen et al. 2006).

Trees were classified according to crown stratum—*dominant, co-dominant, and intermediate*. *Dominant trees* are trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the side. *Co-dominant trees* are trees with crowns forming the general level of the crown cover and receiving full light from above but comparatively little from the sides. *Intermediate trees* are trees shorter than those in the two preceding classes, but with crowns either below or extending into the crown cover of the co-dominant and dominant trees, receiving a little direct light from above, but none from the sides.

Participatory silviculture scoring and ranking.

7. CFUG executive committees were asked to nominate participants, and those nominated were invited to a workshop.
8. The stem and crown diagrams and timber stocking were presented to participants.
9. Silvicultural options suitable to community forests in the Nepal Mid-hills, derived from a review of the literature (published and grey) and foresters' consultations were presented and explained to participants.
10. Participants were asked to suggest other silviculture options relevant to their needs.

11. The participants identified criteria for evaluating the relevance of silviculture options.
12. The participants provided a collective score of 1–5 (least to best) for each silviculture option against each criterion.
13. Silviculture options were prioritized based on total scores.

Forest stand structure refers to the physical and temporal distribution of trees (Oliver and Larson 1990) and is often describe in terms of species distribution, vertical and horizontal spatial patterns, size of trees and age (Stone and Porter 1998). Understanding the forest stand structure provides the basis for any silvicultural intervention, particularly when there is expectation for multiple products and services from the forest. The structure of the six selected community forests are characterised based on tree species composition, distribution of basal areas, forest canopy classes and tree species, tree crown cover and occurrence of regeneration.

Results

General Silvicultural Characteristics

In Kavre District, the selected community forests are dominated by Khote Salla (*Pinus roxburghii),* Thingre *(Tsuga domusa),* Gobre Salla *(Pinus wallichiana)* and mixed native broadleaf trees (Table 2). The Gobre Salla were planted about 35 years ago while the Khote Salla and Thingre were naturally regenerated which was facilitated by strict protection from grazing. In Lamjung District, the selected community forests are dominated by naturally regenerated Sal (*Shorea robusta)*, mixed planted Sissoo (*Dalbergia sissoo*) and Chilaune (*Schima wallachii*), and mixed Sal-Chilaune naturally regenerated forests. The tree densities in the measured sample plots is below 500 sph with the exemption of sample plots in the Kalopani community forestry with tree density approximately 722 sph. The operational plans of these community forests did not include thinning activities. In practice, the forest is open to CFUG members for collection of firewood, tree biomass and grasses through traditional practices called *godmel*– collection of dead, dying, diseased and deformed trees and *jhadi katne*– removal of less preferred plant species (Ojha 2001; Acharya 2004). These operations are based on local knowledge of forest users without relating to the concept of stocking regulation, ecological implications or changes of forest structure.

Tree Sizes

Six out of eight stands had an average DBH of 25 cm or larger (Table 2), 25 cm DBH being the smallest DBH local saw millers prefer for timber milling for house construction and joinery. All community forests showed some degree of 'evenness' of tree sizes with Lamjung community forests exhibiting lesser DBH variation than the Kavre community forests. The community forests in Kavre District had more

Table 2 Silvicultural characteristics of selected community forests (CF) in Kavre and Lamjung Districts Nepal (2014)

Silviculture parameters	SaPaRuPa	Kalopani	Phagar Khola Stand 1	Phagar Khola Stand 2
Total area of plots (m^2)	942	471	628	628
Number of sample trees	41	34	29	30
Dominant tree species	Khote Salla	Thingre	Gobre Salla-Utis	Mixed broadleaves
Tree density (sph)	435	722	462	477
Mean DBH (cm)	17.4 (7.3)	26.4 (20.2)	26.6 (12.2)	19.2 (8.1)
Merchantable height (m)	5.2 (3.2)	8.5 (4.7)	10.8 (4.6)	4.5 (2.7)
Dominant tree height (m)	22	22	27	18
Stand basal area (m^2 ha^{-1})	12.1	62.1	30.8	16.3
Timber stock (m^3 ha^{-1})	46.2	402.2	249.2	54.3
Silviculture parameters	**Lampata**	**Langdi Hariyali**	**Aapchaur—Stand 1**	**Aapchaur—Stand 2**
Total area of plots (m^2)	628	628	628	628
Number of sample trees	21	24	21	12
Dominant tree species	Sal	Sal	Sal	Sisoo
Tree density (sph)	334	382	334	191
Mean DBH (cm)	29.3 (9.3)	25.5 (8.8)	24.9 (8.1)	32.1 (4.4)
Merchantable height (m)	8 (3.3)	8.3 (3.8)	6.6 (3.2)	10.3 (1.9)
Dominant tree height (m)	21	20	19	19
Stand basal area (m^2 ha^{-1})	24.7	22.7	18.0	15.7
Timber stock (m^3 ha^{-1})	132.8	119.1	82.0	98.9

Values on parenthesis represent standard deviation of sample trees; 1 m^3 is approximately 35.31 cubic feet

trees per hectare in the lower diameter classes (<25 cm) than those in Lamjung. There is an extreme case the Kalopani Forests where there is a relatively high density of trees >40 cm DBH (Table 3) due to the strict protection of mother trees. Comparatively, there is an extremely low number of trees in the 5–10 cm DBH classes with a more pronounced lack of saplings and poles in the Lamjung community forests. It should be noted that most of these studied forests, which are mostly even-aged, started from barren land and then regenerated naturally with strict protection against tree felling and grazing. The forest was opened to forest users where small poles, saplings, and grasses were removed from the forest on a regular basis through *godmel* and *jhadi katne* as part of their management operations. Currently, most of the studied community forests are already in an advance stage where the tree crowns are well developed, limiting light penetrating through the canopy.

Stand Structure and Composition

The distribution of trees across crown classes varies among community forests. In Lamjung district, we found that most of the trees are in dominant and co-dominant

Table 3 Timber volume (Vol) (m^3/ha) and tree density (Den) (stems per hectare, sph) of the six selected community forests in Kavre and Lamjung Districts, Nepal

DBH Class (cm)	SaPaRuPa		Kalopani		Phagar Khola 1		Phagar Khola 2		Langdi Hariyali		Lampata		Aap chaur 1		Aap chaur2	
	Vol	Den	Vol	Den	Vol	Den	Vol	Den	Vol	Den	Vol	Den	Vol	Den	Vol	Den
5–10	0.4	32	0.1	21	0.1	0	–	0	0.4	32	–	0	0.1	0	–	–
10–15	5.5	180	5.5	212	3.4	64	2.8	32	1.4	32	0.6	32	1.2	16	–	–
15–20	8.2	117	18.8	106	8.4	80	8.2	143	1.6	16	–	0	4.9	32	–	–
20–25	12.4	64	38.5	149	15.4	95	10.5	143	18.6	95	11.1	64	15.6	32	–	–
25–30	–	0	40.8	85	40	0	5.8	64	25.5	80	13.8	64	15.7	111	28.8	80
30–35	9.1	21	23.5	42	97.8	80	8.3	16	32.1	64	39	95	7.6	64	32.8	64
35–40	10.7	21	13.2	21	84.2	95	18.7	32	39.5	64	27.5	32	36.9	32	21.1	32
>40	–	0	261.8	85	–	48	–	48	–	0	40.9	48		48	16.2	16
Total	46.2	435	402.2	722	249.2	462	54.3	477	119.1	382	132.8	334	82	334	98.9	191

crowns classes (Fig. 2). In Kavre district, a more spread distribution of trees across the crown classes is apparent. Crown cover diagrams show some canopy gaps in the stands that forest users could use for timber and non-timber production. In addition to the timber species occupying the forest canopy, there are also non-tree vegetation undergrowth and tree regeneration on the forest floor.

The tree species listings, frequency for each species and Shannon's diversity index in the forest canopy, undergrowth of non-tree vegetation and tree regeneration are provided in Appendix Tables 6, 7 and 8. All community forests are dominated by one or two species of timber trees occupying the upper quartile of forest stand heights. In particular, community forests in Kavre shows higher tree diversity than those in Lamjung (Appendix Table 6). The list of naturally regenerating species shows differences in species in the upper canopy indicating the capacity of community forests to support recruitment of other species not represented in the forest canopy (Appendix Table 7). In most community forests, the number of regenerating dominant tree species is generally low. This is particularly expected for pioneer species like Khote Salla which it requires a bare site to regenerate. The non-tree vegetation growing below the forest canopy was also identified and counted (Appendix Table 8), of which seven species were identified including highly valued species such as *Allainchi* (*Amomum spp)* and *Lokta* (*Daphne bholua*) used for spice and bark peels used for hand-made paper, respectively. Allainchi is cultivated in the Phagar Khola community forests as an income generating activity for forest users, particularly involving its women members.

Timber Stock Profile

Timber stocking ranges from 46 to 402 m^3 ha^{-1} across the six community forests (Table 3). Only 2 of the 8 stands have timber stocking in the >40 cm DBH class and 6 out of 8 stands have 50 % of the stand volumes between 25 to 40 cm DBH. The RSA revealed that variation in tree DBH on studied community forests in the Nepal Mid-hills is low with standard errors of 8 to 10 cm and coefficients of variation of 30 % or less for most of the studied community forests. The estimated annual increment of pine forests in Kavre is below 4 m^3 ha^{-1} $year^{-1}$, well below the projected growth rate of 8 m^3 ha^{-1} $year^{-1}$ (Nepal Australia Community Resource Management and Livelihoods Project 2006).

Generally, the AAC for timber is well below the estimated range of AAC representing 40–75 % (pursuant to Guideline for Inventory of Community Forests, Ministry of Forest and Soil Conservation 2000) of the mean annual increment (MAI) of the forests (Table 4). Except for Lampata and Aapchaur community forests which AAC are within or near the AAC calculated from RSA, the approved AAC of the four other CFUGs are about 2–5 fold lower (for poor forest conditions) and 4–11 fold lower (for good forest conditions) than what is calculated in this RSA.

Silviculture Priorities of Forest Users

In the participatory scoring and ranking workshops, five criteria were identified by CFUG leaders as factors that are relevant to them when deciding on forest

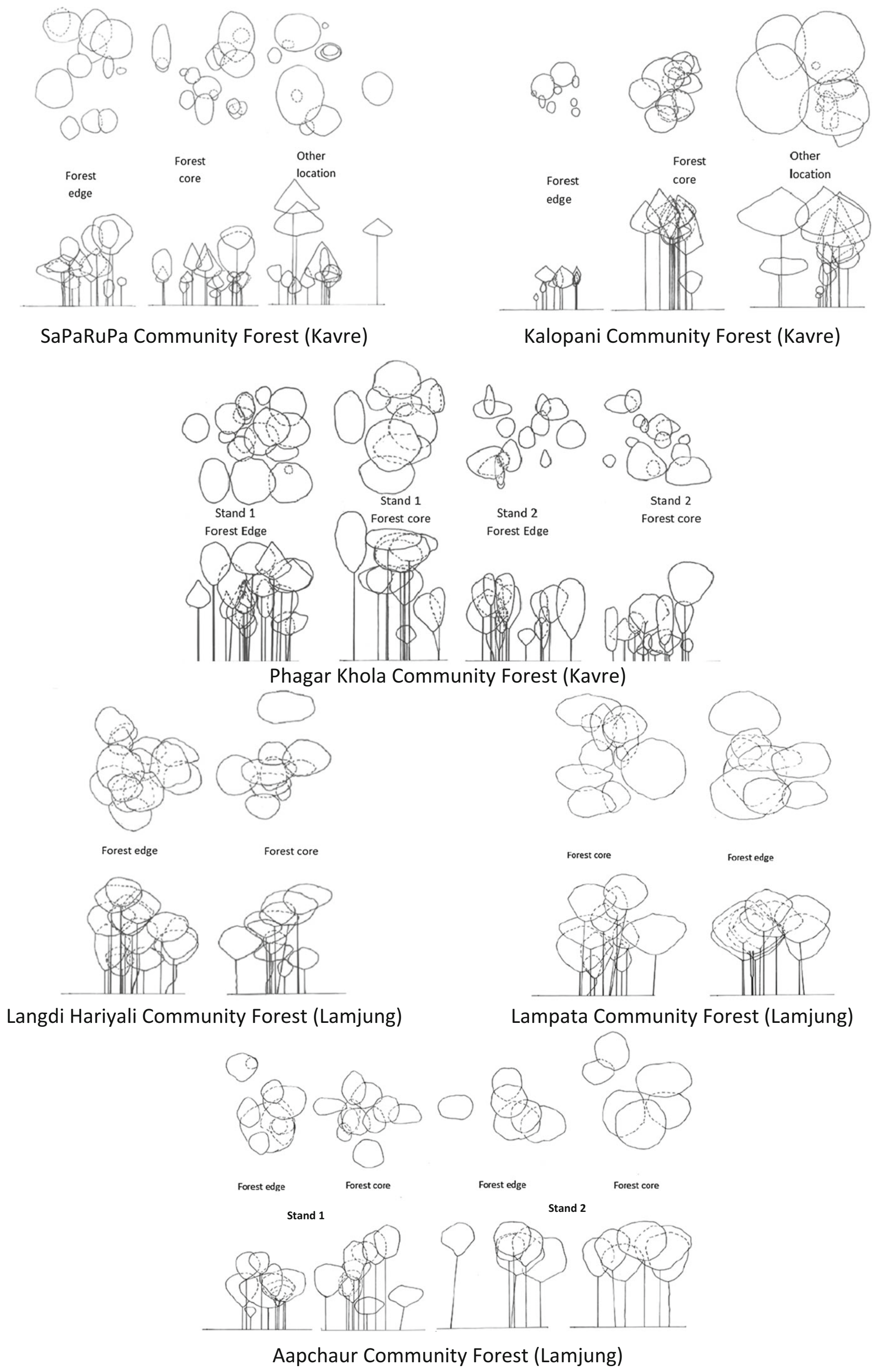

Fig. 2 Stand profile of selected community forests in Kavre and Lamjung Districts, Nepal

Table 4 Comparison of annual allowable cut (AAC) approved on Operation Plans and the calculated AAC derived from the rapid silviculture appraisal

CFUG Name	AAC (cft) indicated on existing OP	Timber stock (cft)	Est. stand age	Annual increment of the whole forest (cft)	Possible AAC (cft) range (40–75 % of MAI)
Kalopani	9281	2395,720	30	79,857	31,943–59,893
Saparupa	1750	485,499	30	16,183	6473–12,137
Fagarkhola	588	284,880	30	9496	3798–7122
Langdihariyali	3847	1159,538	50	23,191	9276–17,393
Aapchaur	4378	390,990	30	13,033	5213–9775
Lampata	4171	349,121	35	9975	3990–7481

Cf means cubic feet; 1 m^3 is approximately 35.31 cft

management: (1) forest users' interests and community preferences; (2) environmental and geographical conditions; (3) legal and policy suitability; (4) income; and (5) ease of implementation. The degree to which these factors are important for forest management decisions in each CFUGs varies. Negative thinning, which is forest management approach, involving removal of dead, decayed, deformed and diseased trees, has become popular among CFUGs because it satisfies community preferences. Moreover, shelterwood and selection harvesting are appealing to forest users because of the potentials of planting fodder trees and grasses, non-timber forest products, and medicinal and aromatic plants on the forests after treatments (Table 5). Shelterwood and selection harvesting options allow for continual extraction at low volumes of timber products to satisfy local timber demand. Preference for negative thinning is a reflection of forest users' demand for firewood and fodder, which are important for livelihood sustenance in rural Nepal. The lowest reported preference is for establishing new forest plantations using new timber species for commercial timber production. During discussions, it emerged that the resistance to planting new species was due to either lack of information for fast growing timber species or perceived negative ecological impacts of monoculture plantation as they have observed for pine plantations. Across all six CFUGs, the top five silviculture options identified from the participatory ranking workshop are (1) shelterwood, (2) negative thinning, (3) selection harvesting then conversion to timber-fodder forest garden, (4) selection harvesting then conversion to timber-NTFP-MAP forest garden, and (5) timber plantation maintenance (to include weeding, singling, sanitation cutting, and pruning).

Discussion

The study shows that the structure and composition of the community forests studied generally exhibit tree monocultures viz. with only one or two tree species in the dominant and co-dominant strata. This forest structure has been shaped by community forest management regimes including strict forest protection (to support

Table 5 Preference scores of possible silvicultural interventions provided by forest users of the selected community forests in Kavre and Lamjung Districts

Silvicultural option	Criteria***					Total
	1	2	3	4	5	
1. No timber management	6	15	16	6	7	50
2. Selection cutting from above	14	14	12	20*	19*	79
3. Negative thinning—removal of deformed, suppressed and unwanted trees and removal of grasses	20*	21*	20*	12	18*	91**
4. Regeneration felling—shelter wood: series of tree cuttings where good mother trees are retained	21*	20*	18	20*	18*	97**
5. Regeneration felling—seed trees: one time cutting of trees leaving a few mother trees	12	12	12	20*	16	72
6. Harvesting of trees within particular diameter classes—and replanting of the same species to develop an uneven-age stand	15	16	17	18	18*	84
7. Harvesting of trees within particular diameter classes—and replanting of new timber species desired by CFUG to develop an uneven-age mixed species stand	19	14	18	17	16	84
8. Harvesting of trees within particular diameter classes—and establishment of a timber- fodder forest garden	20*	17	19*	18	16	90**
9. Harvesting of trees for certain diameter classes—and establishment a timber–NTFP-MAP forest garden	20*	16	19*	19	14	88**
10. Establishment of new forest using a new timber species for commercial timber production	7	5	7	6	5	30
11. Stand establishment for new timber-fodder-fuelwood (multipurpose forest)	9	9	8	6	6	38
12. Timber plantation maintenance—weeding, singling, sanitation cutting, pruning etc.	16	21*	22*	12	17	88**
Total score	179	180	188	174	170	

* Scores in the 3rd quartile

** Top five silviculture options

*** Criteria for selection are: (1) forest users' interest and community preference; (2) environmental and geographical condition; (3) legal and policy suitability; (4) income; and (5) ease of implementation

growth of natural regeneration at the early stages of forest stand development) and traditional forest practices such as *godmel* and *jhadi katne,* which provide subsistence needs for fuelwood, fodder and timber. Silviculture practices on community forests are guided by local knowledge to produce timber products, particularly firewood, on a regular basis and timber on an *ad hoc* basis, resulting in tree densities that resembles forests where silviculture treatments are appropriately and timely applied. The current silviculture practices may sound good, but they do not meet the needs of forest users. It should be noted that although the stands are even-aged and nearly pure, pre-commercial and commercial thinning has not been happening on a scale described by the thinning guidelines for community forestry in Nepal. The forestry operations on community forests are governed by approved operation plans where timber harvests are dictated by AACs that are well below the potentially harvestable volume. Most community forestry harvesting operations deal only with small and defective trees having low market value and little or no value for commercial timber processing. These conservative harvesting approaches are common to many community forests in Nepal (Mallapaty 2013).

If community forests are to be managed to drive livelihood improvement for forest users, technical knowledge of silviculture for community forests should be made more widely available. Currently, the pace of developing silviculture technology for community forests lags behind the social and organisational development in the forest sector (Gilmour 2014). On the other hand, while silviculture is a basic course in a Forestry degree, silviculture training is based on industrial forestry which was then scaled down and repackaged for community forestry (Donovan 2001) where in Nepal the focus in the last four decades has been more on forest protection than timber production (Dougill et al. 2001). In a context where forest users are realising the value of multiple use forestry, to produce timber and non-timber products, it is essential to re-evaluate silviculture approaches to suit community forestry objectives. The call for re-evaluating silviculture technology to suit community forestry needs is not new. Evans (1992) argued that any forestry development that does not respond to the needs of local people is failing the purpose of forestry. Campbell et al. (1997), Ojha (2001), and Donovan (2001) later made the same call yet the forestry sector made no progress s in terms of identifying promising and applicable silviculture approaches for community forests.

The community forests selected for this study represents the dominant forest types in the districts. The current structure of existing community forests can provide large amounts of timber that can support timber-based enterprises. Forest users with the help of trained foresters should revisit their operational plans to include new silviculture systems that will increase timber and non-timber products outputs. Trained Nepali foresters may be assumed to have adequate silviculture knowledge, but anecdotal evidence suggests many lack practical silviculture skills. The silviculture systems for community forestry must not however undermine the environmental functions of community forests and forest users' needs and should recognise the institutional and policy context in Nepal. While this recommendation sounds typical for traditional forestry recommendations, the new silviculture for community forestry should embrace active silviculture practice requiring new enabling community forestry policies and regulations. As revealed from the forest users' workshops, it appears that prevailing policy and regulatory provisions have strongly shaped the silviculture practices, often undermining the forest users' needs and interests. This is largely due to the enduring power and control of government forestry agency on forest management (Ojha et al. 2014) despite the celebrated success of community-based forestry systems.

While CFUGs in Nepal are dependent on the legal function of operational plans, Toft et al. (2015), Rutt et al. (2015) and Paudel and Ojha (2008) state that operational plans are practically irrelevant because of the excessive forest inventory requirements. For the purpose of having a legal document that describes the condition and timber stock of community forests, simple forest characterisation and assessment techniques that generate information relevant to forest users, should be adopted. The RSA technique employed in this research using temporary circular plots of 5–10 m radius on the edge and centre of a forest stand is a simple inventory method to obtain silviculture characteristics of community forests. The experience with RSA showed that tree measurement and regeneration assessments can be completed in 4 days by a trained tree cruiser and two labourers for a 50-ha community forest. This is much simpler compared to the current inventory practice for community forests which requires 12–15 days for a 50-ha community forest for a team of a trained tree cruiser (ranger)and four assistants (Dhital et al. 2003; Paudel and Ojha 2008). The RSA is a far cheaper forest inventory method for community forests. The timber volume estimate, tree density and basal area obtained from the RSA are comparable to inventory obtained from similar forests following existing forest inventory guidelines. The inventory procedure adopted in this study is a more suitable inventory approach necessary for revising operational plans because of its ease of implementation at a cost of just a quarter of existing inventory practices for community forests in Nepal.

The participatory scoring and ranking phases of the RSA revealed that legal and policy suitability gets the highest score making it the most important criterion in deciding silvicultural management. Surprisingly though the 'income' criterion comes fourth in the rank putting environmental reason and social considerations over income. This shows that current forest management rationale is driven more by 'social', 'institutional' and 'environmental' dimensions than 'economic' objectives. Requirements for technical services came out as the least relevant criterion for prioritising silviculture indicating the persistence of conservative forest management ethos. Anecdotal evidences however showed a growing interest for forest users to be equipped with and be confident with technical forestry skills.

Results of the participatory scoring and ranking of silviculture options showed that shelterwood and selection silviculture systems are preferred for community forests in the Mid-hills of Nepal. The preference for shelterwood systems is a reflection of forest users' interests in forestry operations that will extract more timber. Due to multiple functions of community forests, forest users have identified selection silviculture systems as promising silviculture systems for community forests. Selection silviculture is a silviculture system where low-intensity timber harvest is made more frequently with the aim of creating a multi-age and multi-species forest. Additionally, selection silviculture meets ecological requirements for the growth of many forest species, including non-timber forest species. Selection silviculture however does not necessarily mean that future stands will depend on natural regeneration as many pine species are considered pioneer species requiring large crown openings for successful pine regeneration. Moreover, forest users preferred planting of fodder trees and other high valued timber on selectively harvested stands for obvious reasons. Shelterwood and selection silviculture systems are relatively new in Nepal advocated by the Government of Nepal through the Department of Forests' Guidelines for 'scientific forest management' issued in 2014 (Department of Forests 2014).

Conclusion and Policy Implications

The silvicultural characteristics of community forests and silvicultural priorities of community forest users in the Nepal Mid-hills has been described in this paper using a rapid silvicultural appraisal technique. This technique is suggested as suitable for preparation or revision of operational plans of community forests because of the ease of implementation and lower costs. Community forests were found to have stocking that approaches tree densities similar to a well-regulated stands. This has been achieved not because of the silvicultural prescriptions of the operational plans but due to traditional forest management practices applied on these forests. However, silviculture practices on community forests is inadequate in terms of level of foresty operation and forest product outputs due to policy, regulatory and institutional constraints. For community forests to better meet diverse objectives, silviculture practices should be improved putting traditional silviculture practice in a wider context of sustainable community forest management. A multi-age and mixed species forest will better meet the needs of community forest users. Such structure can be achieved through a series of frequent but low intensity selection harvests from across a range of size classes. Selection silviculture is widely practiced in the Americas and Europe (O'Hara and Gersonde 2004), but these technologies are not directly transferable to community forests because of the complexity of ownership and multiplicity of forest management objectives. It is therefore important to develop silvicultural skills of forest users, government foresters and other community forest stakeholders, i.e., Federation of Community Forest Users of Nepal (FECOFUN), through action research where local forest management practices are integrated in participatory silviculture technology development appropriate for Nepal. Forest users recognised the power and influence of Nepal's forestry agency in management and operation of community forests. Moreover, silviculture research has to take into account these power relations so that any new silvicultural innovations for community forests are smoothly institutionalised and backed-up by government forestry departments.

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Appendix

See Table 6, 7 and 8.

Table 6 Diversity of tree species on the six community forests

Species local name (scientific name)	SaPaRuPa	Kalopani	PhagarKhola Stand 1	PhagarKhola Stand 2	Lampata	LangdiHariyali	Aapchaur—Stand 1	Aapchaur—Stand 2
Ageri (*Melastoma melabatricum*)	2							
Bakle (*Myrsine capitellata*)	1							
Banjh (*Quercus leucotrichophora*)	1							
Chilaune (*Schima wallichii*)	6		4	5	6	1	7	5
Guras (*Rhododendron arboretum*)	3	1		3				
Jamun (*Syzygium cumini*)	1					1	1	
Kagiyo (*Tetrapogan tenellus*)	3							
Katus (*Castanopsis hystrix*)	1				5		1	
Mahuwa (*Madhuca latifolia*)	1							
Maluwa[a]	2							
Khote Salla (*Pinus roxburghii*)	20							
Uttis (*Alnus nepalensis*)	3		10	1				
Byapare[a]		1						
Kharane (*Symplocos theifolia*)		4						
Gobhre Salla (*Pinus wallichiana*)		7	8					
Rakchan (*Daphni phyllumhimalense*)		1						
Thingane[a]		1	1	2				
Thingre (*Tsuga dumosa*)		19						
Champ (*Michelia champaca*)			1					
Kafal (*Myrica esculenta*)			1					
Okhar (*Juglans regia*)			1					
Pahele (*Litsea spp*)			2	1				
Thale (*Arabidopsis thaliana*)			1	5				
Aangeri (*Goldfussia pentastemonoides*)				6				

Table 6 continued

Species local name (scientific name)	SaPaRuPa	Kalopani	PhagarKhola Stand 1	PhagarKhola Stand 2	Lampata	LangdiHariyali	Aapchaur—Stand 1	Aapchaur—Stand 2
Kamale (*Pilea symmeria*)				4				
Mail (*Pyrus pashia*)				1				
Maleto (*Macaranga pustulata*)				1				
PaateSalla (*Pinus patula*)				1				
Sal (*Shorea robusta*)					10	18	7	
Botdhagero (*Largerstromia parviflora*)						2	2	
Camuna (*Syzygium operculatium*)						1		
Harro (*Terminalia chebula*)						1		
Behunikath[a]							1	
Padke (*Albizia julibrissin*)							1	
Peepal (*Ficus religiosa*)							1	
Sissoo (*Dalbergia sissoo*)								7
Total of species	44	34	29	30	21	24	21	12
Shannon's diversity index (H)	1.89	1.32	1.76	2.17	1.05	0.95	1.68	0.68

[a] No scientific name found on available literature for this local name

Table 7 Diversity of tree regeneration by species on the six community forests

Species local name (scientific names)	SaPaRuPa	Kalopani	PhagarKhola Stand 1	PhagarKhola Stand 2	Lampata	LangdiHariyali	Aapchaur—Stand 1	Aapchaur—Stand 2
Ageri (*Melastoma melabatricum*)	95							
Chilaune (*Schima wallichii*)	8			13	146	19	17	23
Guras (*Rhododendron arboretum*)	9	4	12	32				
Kagiyo (*Tetrapogan tenellus*)	24							
Kalikath (*Myrsine semiserrata*)	2		14					
Katus (*Castanopsis indica*)	104				135		4	
Mauwa (*Engelhardia spicata*)	8							
Champ (*Michelia champaca*)	1							
Jamun (*Syzygium cumini*)	1					21		2
Kothe Salla (*Pinus roxburghii*)	2							
Uttis (*Alnus nepalensis*)	2	2		2				
Gobre Salla (*Pinus wallichiana*)		3						
Jhingane (*Eurya acuminata*)		2						
Kharane (*Symplocos theifolia*)		53						
Thingre (*Tsuga dumosa*)		2						
Kanike (*Lingustrum confusum*)		2						
Kaulo (*Persia bombycina*)		1						
Kharsu (*Quercus semecarpifolia*)		4						
Rakchan (*Daphniphyllum himalense*)		1						
Thingane (*Viburnum cordifolium*)		4		5				
Asare (*Lagerstroemia indica*)		2						
Lampate (*Duabanga grandiflora*)		1						
Pahele (*Synedrella nodiflora*)			15					
Paiyo (*Prunus cerasoides*)			3	3				

Table 7 continued

Species local name (scientific names)	SaPaRuPa	Kalopani	PhagarKhola Stand 1	PhagarKhola Stand 2	Lampata	LangdiHariyali	Aapchaur—Stand 1	Aapchaur—Stand 2
Kamale (*Pilea symmeria*)			19	3				
Asara (*Murraya koenigii*)				3				
Thale[a]				130				
Aangeri (*Lyonia ovalifolia*)				22			3	
Dudhilo (*Ficus neriifolia*)				2				
Kafal (*Myrica esculenta*)				4				
Lakuri (*Fraxinus floribunda*)				15				
Malayo[a]				10				
Badkuli[a]					4	5		2
Sal (*Shorea robusta*)					177	89	26	
Harro (*Terminalia chebula*)					9	2		
Botdhagero (*Lagerstroemia parviflora*)						2	25	
Camuna (*Syzygium operculatium*)						11		
Putalikath (*Tridax procumbens*)							1	
Aanchataruwa[a]							3	
Sisoo (*Dalbargia sissoo)*								17
Total	256	81	63	244	471	149	79	44
Shannon's diversity index (H)	1.45	1.46	1.50	1.67	1.21	1.27	1.52	0.99

[a] No scientific name found on available literature for this local name

Table 8 Diversity of non-tree vegetation by species on the six community forests

Species local name (scientific name)	SaPaRuPa	Kalopani	PhagarKhola Stand 1	PhagarKhola Stand 2	Lampata	LangdiHariyali	Aapchaur—Stand 1	Aapchaur—Stand 2
Mushkeri[a]	2							
Aaiselu (*Emblica officinale*)	6							
Chutro (*Berberis asiatica*)	1	5	5	8	3	4		
Nundhike[a]	1							
Kukurdina (*Smailex macrophylla*)		6				4		
Lokta (*Daphne bholua*)		46	5	5				
Nigalo (*Drepanostachyam sp*)		2						
Sugandhural (*Valeriana jatamansi*)		151						
Jamune mandra[a]		1						
Loth salla (*Taxus baccata)*		1						
Alaichi (*Amomum subulatum*)			12					
Allo (*Girardinia diversifolia*)			96					
Mail (*Pyrus pashia*)			2					
Malayo[a]			18	9				
Asare (*Lagerstroemia indica)*			2					
Basuki[a]			21					
Chulesi[a]				11				
Dhasingre (*Gaultheria fragrantissima*)				70				
Gharreghurre[a]				5				
Kalo aaselu[a]				4				
Kukurdaina (*Smilax ovalifolia*)				3				
Maghitho (*Bubica cordifolia*)				3				
Tite pati (*Artemisia vulgaris*)						5	102	25
Dhuhsul[a]							43	41

Table 8 continued

Species local name (scientific name)	SaPaRuPa	Kalopani	PhagarKhola Stand 1	PhagarKhola Stand 2	Lampata	LangdiHariyali	Aapchaur—Stand 1	Aapchaur—Stand 2
Banmara (*Eupatorium odoratum*)							71	187
Total	10	212	161	118	3	13	216	253
Shannon's diversity index	1.09	0.86	1.34	1.48	0.00	1.09	1.04	0.75

[a] No scientific name found on available literature for this local name

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