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Prospects of Application of Shelterwood System in Mature Pine Stands in the Hills of Kavre District

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Abstract

Nepal's forestry has given little or no attention to initiate productive management of forests. Forestry practices dominated by protection-centric dogma provided incentives to passive management of forests. Communities (also state) suffer from such state of inaction(s) in forestry. Despite many benefits, silviculture system based forestry remains neglected. Amid rare experience of application of shelterwood system (SWS) in Nepal, we have analyzed the prospects of application of SWS in the hills of Nepal.

This paper is based on the analysis of data from few demonstration plots in mature pine stands in Kavre district. The plots are established in mature pine plantations at rotation age. We applied SWS as a treatment in the demonstration plots and measured and compared the regeneration with the control plot. We demonstrate that SWS is applicable in mature pine plantations in the hills with some modification in felling pattern.

We also evaluate the social and biophysical response to crown opening under SWS. We analyze and enlist the challenges and prospects of the application of SWS in the sloppy hills. Our findings suggest additional set of precautions, such as the grazing and forest fire control, should be taken while applying SWS in the hilly terrain.

Keywords: Community forestry, forest management, plantation, shelterwood system, silviculture

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1. Introduction

Forest management in Nepal has been inarguably dominated by conservative narratives and therefore remained for decades without any active forest management initiatives. Forestry was limited to plantation, protection and to some extent thinning, pruning, fodder and grass cutting and removal of 4-D (dead, dying, diseased and deformed) trees which eventually led to overstocked stand (Hunt *et al.,* 2001). There is virtually no management in forest throughout the country (Yadav *et al*., 2011).

Trees and forests have played crucial role for survival in many societies and regions in the world. This role has been more immense in Nepal wherein a considerable fraction of the population heavily depends on forest and tree products for dwelling, food and food production, cooking, heating and medicine (Springate-Baginski *et al.,* 2003). Community forestry (CF) has been promoted in the last three decades in Nepal to provide forest users' greater control and access to forest resources and therefore improve local community's livelihood. However CF has not made significant impact on farming systems and rural livelihoods (Dougill *et al.,* 2001). Low impact of CF to rural livelihoods is brought about by the lack of active forest management to enhance productivity (Yadav *et al.*, 2009). The lack of active forest management of CF is associated with several underlying factors including technical issues, protection oriented forest management, poorly designed silvicultural practices and limited practical knowledge of forest management (Yadav *et al.,* 2011). Gilmour (2014) noted that despite the advances on understanding of social and policy arrangements of CF in the last few decades, particularly in Asia there has been an apparent lack of coherent body of knowledge on appropriate technical systems for CF.

During 1970s and 1980s, Nepal and Australian government through Nepal Australia CF Project jointly undertook pine plantation in the hills of Kavre and Sindhupalchowk districts. With financial and technical support of the Australian government and participation of local communities, Department of Forests (DoF) coordinated massive plantations in more than 22,000 ha in these district (Hunt *et al.,* 2001). Australian project also provided supports for the protection and tending of the seedlings. After the promulgation of Forest Act 1993 and Forest Regulation 1995, these forests have been gradually handed over to the communities and currently community forest user groups (CFUGs) are managing the forests.

Since the plantation, CFUGs with technical support of government forest technicians carried out one or two early thinning. After those thinning, forest management operations have not been implemented. Harvesting was limited to removal of fallen and dried trees. Apparently, there are no individuals or institutions who have gone against application of forest management operations for better forest productivity. There is a good knowledge base on forest management. Yet, little has been done for active forest management of mature pine stands- both in government managed forests and in community based forest management (CBFM). The reasons for such inaction, for example some of those social-institutional barriers, are partly detailed in article by Sapkota *et al*. (2017) in this proceeding. Recently, with the support of Australian through EnLiFT project, silviculture action research (SAR) is underway which has established silviculture demonstration plots in Kavre district (in CFUGs of Chaubas and Dhunkharka) trying to see the application of selection silviculture and regular shelterwood system (SWS) as alternative forest management options in stands with mature pine plantations.

In this article, we introduce SWS and see its prospects of application in mature pine plantation on the basis of the insights we receive from ongoing silviculture action research in Kavre district.

2. Silviculture, Silvicultural System

Silviculture has been defined as an art and science of controlling the establishment, growth, composition, health and quality of forests to meet the diverse needs and values of forest owners on a sustainable basis[5].

The objective of silviculture is to cover the available growing area of a stand with the desired species of plants, such as timber, fodder, non-timber forest products (NTFPs) etc. so as to fulfill the needs of the forest owners- private landholders, communities or governments. Unlike past initiatives which focuses mostly on optimisation of timber yield, recent silvicultural endeavour also considers the production of additional forest products and services such as fodder, NTFPs, fuelwood or water.

Silviculture system, however, is an organized program of treatments right from the regeneration preparation to the harvesting of the trees. British Columbia Ministry of Forests describes the silviculture system as:

> "*a planned program of treatments during the whole life of a stand designed to achieve specific stand structural objectives. This program of treatments integrates specific harvesting, regeneration, and stand tending methods to achieve a predictable yield of benefits from the stand over time".*

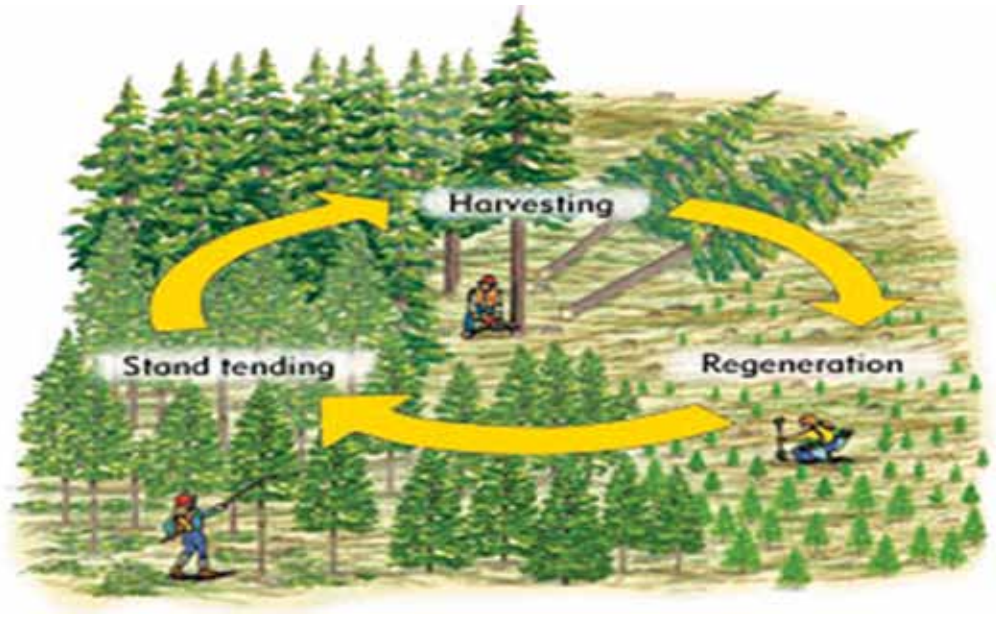

Figure 1. A typical sequence of a silviculture system (Source: BC Ministry of Forests).

5 (http://fwf.ag.utk.edu/Sites/Silviculture/Silviculture%20Definitions%202005.pdf).

As described in the Figure 1, any silvicultural system has planned sequence of activities relating to regeneration, (forest) tending and harvesting of the forests. Depending on the mode of regeneration and sequence of harvesting across the forests, there are three main silvicultural systems viz. clear cutting, shelterwood and selection. Depending on the system of arrangement of forest operations and pattern of felling, there are many modifications in these systems and many times they are categorised as separate silvicultural systems and described accordingly. However, basic principle of regeneration and silviculture operations and harvesting remains the same. Whatever be the silviculture system, following are their basic goals:

- Meet the forest management objectives of the forest owner,
- Provide timely availability of forest products,
- Produce a predictable harvest in long run,
- Balance the social, ecological and economic concerns,
- Ensure regeneration,
- Optimise growing space and site productivity, and
- Consider forest health issue.

3. SWS

SWS is one of several silviculture systems in which mature stands in a range of cutting series are removed so as to promote establishment of regeneration under the shelter trees. The system is applied in even-aged stand, and requires that the existing mature trees are removed to facilitate regeneration development. The system usually produces natural regeneration (BC Ministry of Forests) however, it may also involve plantation if the management objective is to increase species mix and stock.

Unlike clear felling system, SWS takes relatively longer time to completely harvest the upper storey. Seed trees or shelter trees are taken out in few successive felling whereas all trees are removed in a single operation in clear felling system. In the SWS the new crop or regeneration gradually develops under the shelter (protection) of the shelter trees. The shelter trees provide shade in the forest floor underneath which in turn protect the new seedlings from intense sunshine and also controls the development of weeds competing the desirable seedlings which may delay the establishment of a young forest (Herman, 1962). SWS allows practitioners to identify and retain

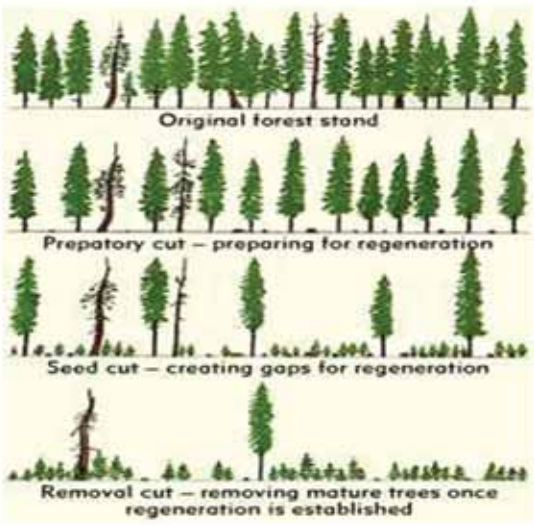

Figure 2. Shelterwood system, showing a series of cutting and regeneration development (Source: British Columbia, Ministry of Forests, Forest Practices Branch).

certain trees for shelter and seeds required for enhancing the future growth (potential) of young regeneration growing underneath.

As explained earlier, over storey trees are gradually removed in different set of cutting. Only few over storey trees, as the name suggests shelter trees, are kept throughout the forests to protect the regeneration below from the sunshine, frost etc. and facilitate the establishment of under storey regeneration. The residual shelterwood trees are not removed until the regeneration establishes and requires no protection from the shelter trees. Therefore, the period of retention of those shelter trees varies place to place and the nature of the under storey regeneration. Number of shelter trees required in a hectare also depends on the type of regeneration, planted or naturally grown, topography and soil type, aspect, soil moisture etc. For example, light demander regeneration might not need many shelter trees, whereas more shelterwoods are required for shade bearer regeneration.

The SWS typically involves series of cutting in an even aged or near even aged forest stand. BC Ministry of forests provides the detail account of such cutting as follows:

3.1 Preparatory Cuts

One or several preparatory cuts may improve the vigour of prospective seed-bearing trees such that they can produce a healthy cone crop and be wind firm. Most preparatory cutting is concentrated in the lower canopy classes; in effect, this harvest is similar to a low commercial thinning. If leave-trees can respond and improve growth and vigour, this often-overlooked treatment may contribute the most to a successful shelterwood system. As well, it can provide harvestable volume from stands previously considered too young for harvesting.

3.2 Establishment Cut, Seeding Cut, or Regeneration Cut

This cutting, which may be the first cutting in some stands, is intended to provide growing space for the regeneration to establish and to provide shelter for the young developing seedlings.

3.3 Removal Cut(s)

Once regeneration is established, stocking is acceptable, and shelter is no longer required, the sheltering over storey is usually removed. If left too long the sheltering over storey may hinder the developing regeneration, through excessive competition for light, moisture and/or nutrients. For shade-tolerant species it may be desirable to remove the over storey gradually with several removal cuttings over a period of time.

SWS tend to promote even-aged stands because the cutting and regeneration period is still concentrated near the end of one rotation and the beginning of the next.

3.4 Salvage Cut

This non-uniform commercial thinning removes wind throw, insect- or disease-killed timber, etc.

4. Silviculture Action Research in Kavre

In 2013, the Government of Nepal (GoN) and Australia initiated a research project called 'enhancing livelihoods and food security from agroforestry and CF in Nepal' which is shorthanded to EnLiFT. The objectives[6] of the projects are:

- To improve the capacity of household based agroforestry systems to enhance livelihoods and food security,
- To improve the functioning of CF systems to enhance equitable livelihoods and food security of CFUG members, and
- To improve the productivity of, and equitable access to, under-utilized and abandoned agricultural land.

As a part of EnLiFT project, SAR has been carried out in three CFUGs[7] in Kavre district since 2014. Demonstrations of best silviculture practices are being practiced in the selected CFUGs to examine application of silviculture systems and treatments of CF in a way that could promote food security and livelihood. Additionally, as an action research, the silviculture demonstration has tried to incorporate local silviculture knowledge and skills to best silviculture practices in Nepal. SAR has the following outcomes:

1. Analysis of silvicultural/biophysical characteristics of CF through participatory measurements in demonstration plots over a three-year period (within the duration of the EnLiFT Project) and then explaining silvicultural challenges with relevant set of factors,
2. Development of new silviculture for food security that can work for the poor and be applied in the context of CF – at least at the conceptual level providing broad principles and guidance illustrated through specific case studies, and
3. Development of tools for observation and measurement of resilient forest-human system given silvicultural interventions (A methodological contribution to how participatory silvicultural technology can be developed to address the concerns of poor, women and disadvantage groups focusing on food security).

The silviculture action research is trying to investigate on and answer the following research questions:

1. What are the institutional and regulatory arrangements required for silvicultural regime on CF that enhance food security?
2. What are the anthropological and ecological processes that are occurring for silvicultural regime that supports food security enhancement? and
3. What variable we need to measure and how do we measure to advance silvicultural knowledge and support policy making?

6 EnLiFT Project document, p. 7

7 Fagarkhola CFUG, Chapani CFUG in Chaubas VDC and Kalopani CFUG in Dhunkharka and Chalal-Ganeshsthan VDCs of Kavre

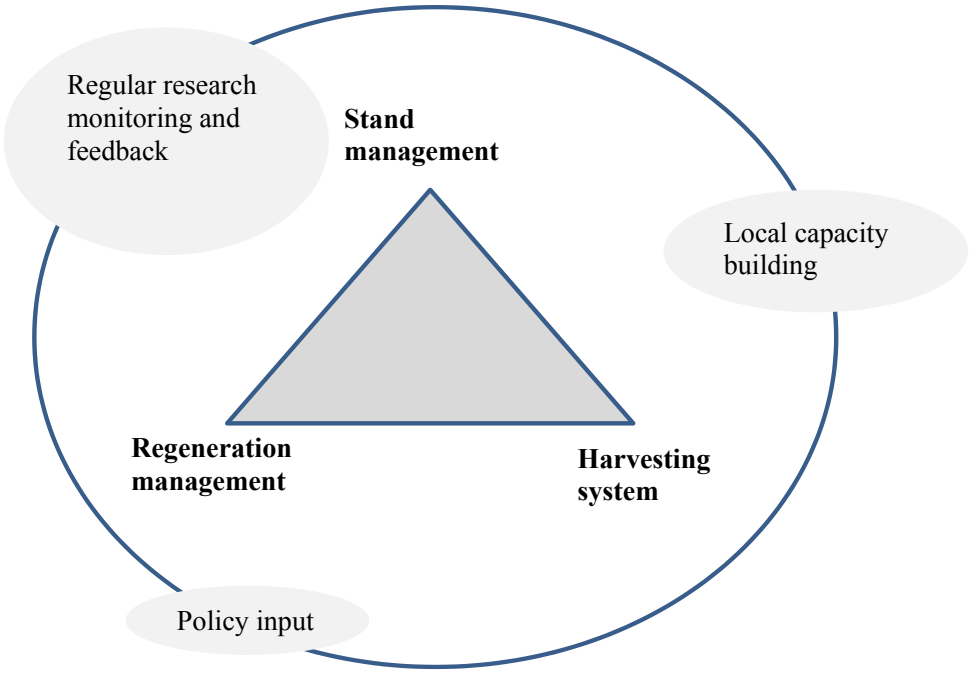

Figure 3. Guiding principle of EnLiFT SAR.

Silviculture demonstration is one of a number of activities of research activities of EnLiFT under the CF theme. The proposed silvicultural demonstration is closely linked with the broader policy and institutional innovations being initiated by other researchers of EnLiFT Project. A strong feedback mechanism between the silviculture demonstrations other EnLiFT action research activities has been ensured by strong collaboration and communication among the government and non-government forestry stakeholders such as District Forest Office (DFO), CFUGs, Federation of Community Forestry Users Nepal (FECOFUN), district government offices and local government.

Action Line 1: Demonstration of Silviculture System and Treatments

A total of eight demonstration plots have been established in three CFUGs of Kavre district viz Fagarkhola, Chapani and Kalopani. Selection of demonstration entailed a rigorous social/ institutional as well as silvicultural process. After a series of discussions among forest technician, local communities and relevant stakeholders, the SAR proceeded. The following flow summaries the steps taken well before the plot establishment up to the felling into the demonstration plots.

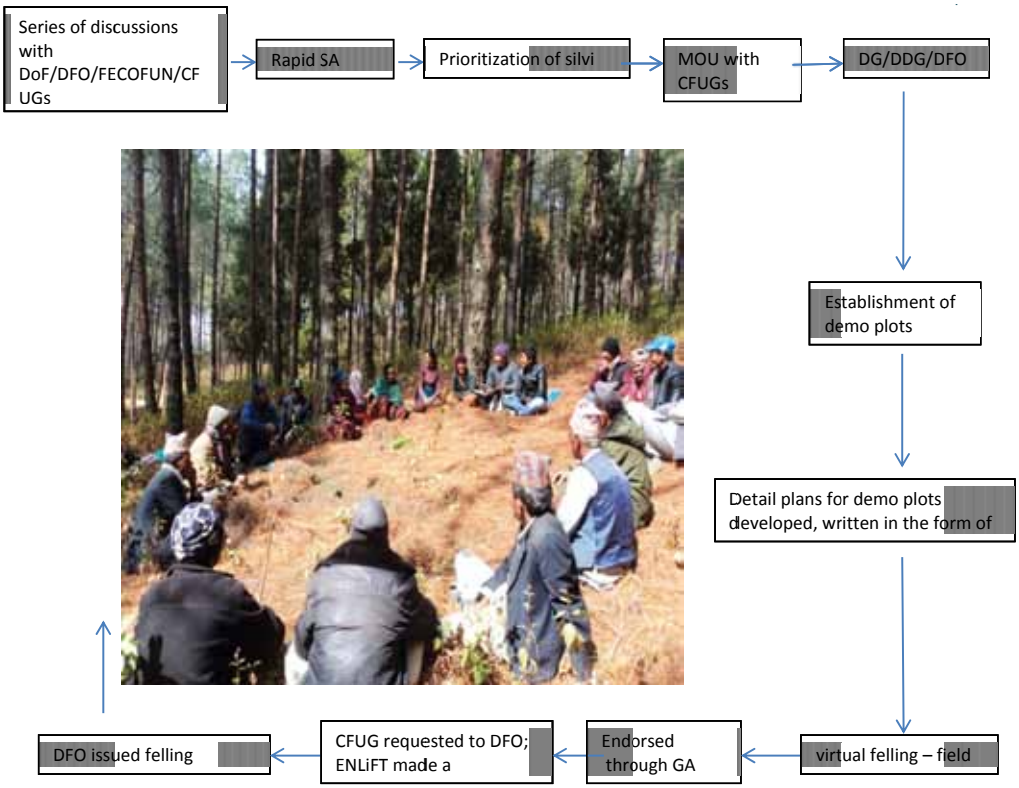

Figure 4. Process of silviculture demonstration and felling.

Detailed information of demonstration is given in Table 1 below.

Table 1. Characteristics of community forests where silviculture demonstration plots are established.

Demo-plot characteristics	Research Sites		
CFUG Name	Kalopani CF	Chapani CF	Fagarkhola CF
Household number	112	117	84
Type of forest	*Tsuga domusa*	*Pinus wallichiana*	*Mixed broadleaves*
Community forest area (ha)	*168.8*	*83.5*	*53.3*
Altitude (m)	*2400*	*1800-2000*	*1800-2000*
Plot number	3 plots	4 plots	1 plot
Plot size	60m x 70m	60m x 70x	40m x 70m
Total area of the plots (ha)	1.26	1.68	0.28

All of the demo-plots are rectangular and except demo-plot in Fagarkhola (which has one plot of 40m x 70m), all demo-plots are of 60m*70m with 10 metre wide buffer in each plot. (See Figure 3 for general plot layout). Each of the CFUG had prioritized a set of silviculture

treatment for demonstration. After rigorous process of obtaining felling permits from DFO (See next section), then the demo-plots have got the prescribed silviculture treatments.

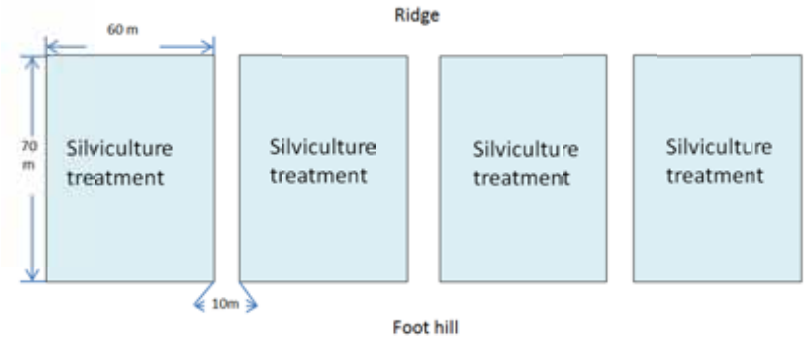

Figure 5. Demonstration plot layout (Cedamon *et al*., 2015).

The silviculture treatments which were selected from a workshop participated with CFUG members last July 2014 were randomly assigned for each plots. Following were the major silvicultural interventions in those plots:

1. Selection silviculture system (4 plots)

a. With the aim of creating uneven-aged mixed pine and broadleaves forest

b. With the aim of creating uneven-aged Thingre Salla Forest

c. With the aim of creating a Loth Salla and uneven Thingre Salla

d. With the aim of converting even age pine stand to uneven pine fodder forest garden

2. Negative thinning (1 plot)
3. Regular shelterwood System (2 plots)
4. Planting of Cardamom following thinning of mixed broad leaves (1 plot)

Out of total eight demonstration plots, two plots received (regular) shelterwood treatment. After demo-plot establishment, total enumeration of tree species was carried out with stem location through coordinates for trees above 10 cm DFB. Data of the total enumeration and tree coordinates were used to generate stock table and stem mapping indicating the residual trees and harvestable trees. The major harvest was carried out following the Scientific Forest Management (SFM) Guidelines 2014 of DoF. The number of residual shelter trees is about 50 stems per hectare (ha), which was twice the minimum number of shelter trees prescribed in the guideline.

Table 2. Stock table for shelterwood plot in Chapani CF, Kavre.

DBH class (cm)	Frequency of trees by species						
	Chap	Chilaune	Cryptomeria japonica	Gobre salla	Paiyun	Pathi salla	Total
10 - 15			2	12	1	6	21
15 - 20		1	2	24		30	57
20 - 25	1		3	5		32	41
25 - 30	2		1	2		32	37
30 - 35						38	38
35 - 40				1		20	21
40 - 45						9	9
45 - 50						1	1
Total	**3**	**1**	**8**	**44**	**1**	**168**	**225**

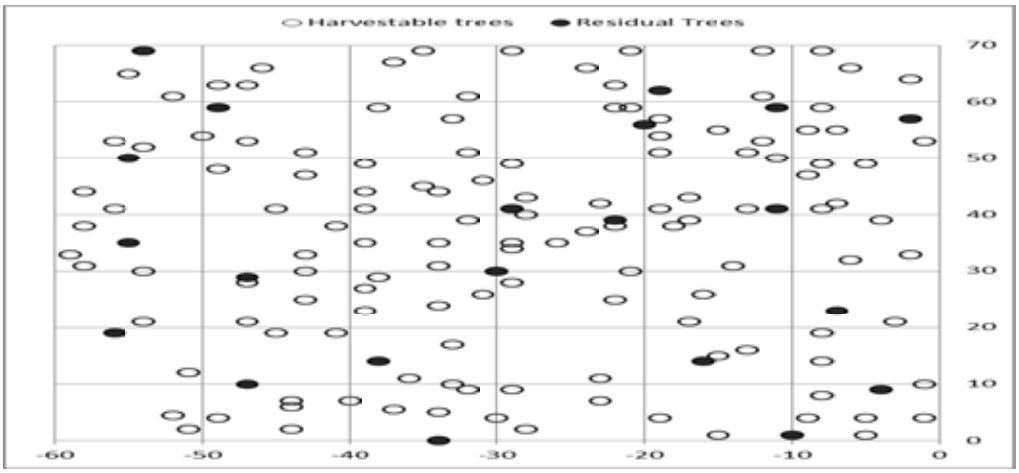

Figure 6. Stem mapping of shelterwood plot in Chapani CF, Kavre.

Similar procedure of enumeration and tree coordinates and stem mapping was carried out in shelterwood plot in Kalopani CF, Kavre. The data were then arranged and analysed to generate the stock table and stem mapping as follows:

Table 3. Stock table for shelterwood plot (plot 3) in Kalopani CF.

DBH Class (cm)	Actual stocking (sph)			Residual stocking (sph)		
	Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
0 - 5	5	2	18	1	1	
5 - 10	112	29	178	25	4	2
10 - 15	253	106	137	65	35	1
15 - 20	155	148	60	44	57	
20 - 25	148	120	32	48	46	

DBH Class (cm)	Actual stocking (sph)			Residual stocking (sph)		
	Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
25 - 30	59	89	24	27	52	1
30 - 35	19	38	20	14	29	3
35 - 40	11	11	18	9	9	2
40 - 45			14			5
45 - 50			4			4
50 - 55			6			2
55 - 60			1			
60 - 65			1			
Total	762	543	513	233	233	20

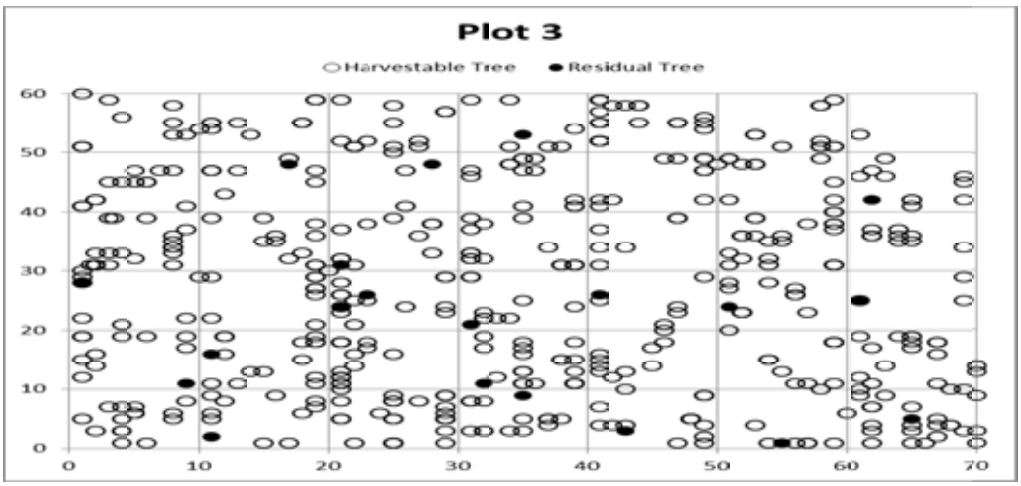

Figure 7. Stem mapping of shelterwood plot in Kalopani CF, Kavre.

Stock table of shelterwood plot of 60m*70m in Chapani CF shows a total of 225 trees above 10 cm DBH. Among 225 trees above 10 cm DBH, 21 trees were retained and 204 trees were removed. The total volume of the harvested trees was 102.7 m^3 (roughly equivalent to 3,594 cft). In Kalopani, leaving 21 trees as residual trees, 493 trees removed from the shelterwood plots which yielded total of 175 m^3 timber (roughly 6,125 cft) per ha.

Action Line 2: Scaling Out Demonstration Plot Experience to CFUG Level

The learning experience from application of silviculture treatments in demonstration plots has generated a good deal of confidence to work on a bigger scale in CFUGs. Year after the establishment of shelterwood demonstration plots, EnLiFT facilitated the operational plan (OP) revision process of Dharapani CFUG in Kavre. The 43 ha area of Dharapani CFUG is predominately covered with mature pine trees planted in late 1970s. The forest has been divided into 5 compartments as per the SFM Guideline 2014.

Table 4. Overview of forest compartments.

Block	Compartment	Area (ha)	Aspect	Slope (degree)	Regeneration	Crown density (%)	Forest management objectives
1	Chhapgaira	9.19	SE	20-30	Plantatioin	90	Timber/fuelwood production
2	Bhedikhor	7.34	S	25-35	Plantatioin	90	Timber/fuelwood production
3	Dharapani	9.85	SW	25-35	Plantatioin/ natural	80	Timber/fuelwood/ cardamom production
4	Kaloahal	8.76	S	15-30	Plantatioin	80	Timber/fuelwood production
5	Thumkidada	8.11	SE	20-30	Plantatioin/ natural	65	Timber/fuelwood/fodder production

While revising operation plan, SWS has been prescribed for the management of this CF with a major modification in the original SWS. The modification is that thinning[1] will be carried out in first five years successively each compartment. The thinning operation will reduce the current stocking of about 410 stems per ha to 150 stems per ha (approximately in 9m*9m spacing). The basis of selection of residual trees (the 150 stems) is bole quality, spacing and tree vigor (retaining the best ones). After five years of thinning in each compartment, a series of cutting will begin as per the SWS. Each year, 5-10 shelter trees will be identified as shelter trees to provide protection to the emerging regeneration underneath (Table 5).

Table 5. Forest management prescription for Dharapani CFUG, Kavre.

Block	Forest operation year and number of residual trees	Regeneration cut pre	Regeneration cut	2nd stage regeneration cut and forest operation	Final cut and forest operation
1	Harvesting year	2015/016	2020/021	2025/026	2030/031
	Number of remaining trees after harvest (stem/ha)	150	10-40	Residual trees 5-20/ ha plus mechanical thinning of new seedling	Final cut and 2nd stage thinning
2	Harvesting year	2016/017	2021/022	2026/027	2031/032
	Number of remaining trees after harvest (stem/ha)	150	10-40	Residual trees 5-20/ ha plus mechanical thinning of new seedling	Final cut and 2nd stage thinning
3	Harvesting year	2017/018	2022/023	2027/028	2032/033
	Number of remaining trees after harvest (stem/ha)	150	10-40	Residual trees 5-20/ ha plus mechanical thinning of new seedling	Final cut and 2nd stage thinning

1 Cutting out of trees at or near rotation age is not, technically, a thinning operation. Thinning here should be understood as simply removal of trees from existing stand

Block	Forest operation year and number of residual trees	Regeneration cut pre	Regeneration cut	2nd stage regeneration cut and forest operation	Final cut and forest operation
4	Harvesting year	2018/019	2023/024	2028/029	2033/034
	Number of remaining trees after harvest (stem/ha)	150	10-40	Residual trees 5-20/ ha plus mechanical thinning of new seedling	Final cut and 2nd stage thinning
5	Harvesting year	2019/020	2024/025	2029/030	2034/035
	Number of remaining trees after harvest (stem/ha)	150	10-40	Residual trees 5-20/ ha plus mechanical thinning of new seedling	Final cut and 2nd stage thinning

The proposed modification in the pattern of harvesting viz. thinning cum SWS is prescribed for the sloppy terrain of Mid-hills where removing all trees except shelter trees would accelerate the soil erosion and expose the regeneration unfavorably to adverse climatic condition. In addition, the entire 43 ha forest has been regenerated through pine plantation carried out in late 1970s to early 1980s. The forest is covered with mature fine trees at harvestable age throughout the forest, requiring thinning compartment after compartment each year instead of concentrating series of cutting in each compartment as per SWS. Not only the bio-physical reason, removing vast amount of timber from the forest in a single year needs huge amount of labour and social/ institutional preparedness which may pose governance challenges.

5. Discussion and Conclusion

The government has proactively taken actions for the management of forests throughout the country. Building on the demonstration experiences at project level, and realizing the profound possibility of realising economic benefits, government has been actively engaged into devising policies to provide legal basis of forest management. SFM guideline 2014 has already been promulgated. However, early initiatives of active forest management have been concentrated in Terai forests. Such initiatives are virtually non-existent in other physiographic zones such as Mid-hills. In this context, forest management initiatives in the Mid-hills, particularly in forest stands of mature pine plantation in the form of demonstration, learning and scaling out is important and necessary. Silviculture action research of EnLiFT project is one of such endeavour.

Based on the silviculture demonstration plot experience and following the scaling out at CFUG level, SWS is technically (and socially) appropriate for the management of mature pine stands of Kavre and other similar forests across the nation. However, application of SWS certainly does have challenges (Box 1).

However, the potential challenges are more related to governance than to the technical implementation of the SWS. For example, risk of fire, grazing, fund misuse, sub-optimal skill of CFUGs/DFO can be avoided or mitigated through proper management and capacity building. Some of the challenges such as difficult to diversify species mid and limited survival rate of planted seedling relate to technical challenges which may require further research.

Box 1: Major challenges of Shelterwood system in pine stands

- Risk of fire, wind throw and soil erosion,
- Difficult to diversity species mix, under storey plantation has limited survival rate (~40% in case of Kavre),
- Risk of damage of regeneration by grazing and fire,
- Potential damage to young trees while felling,
- Diminishing recreational value, habitat and biodiversity,
- Governance challenge (e.g. risk of fun misuse),
- Institutional challenge (misleading media reporting, CIAA etc),
- Lack of capacity (of CFUG, DFO etc).

However, shelterwood is still the most applicable system for the management of mature pine plantations in Kavre and other similar regions. The key characteristics of SWS (Table 6) in Nepalese context have indicated clear merits of this system over other potential system.

Table 6. Key features of SWS.

Key features	Impact
Timber yield and quality	High-generally from larger diameter trees
Stand structure after treatment	Single stratum forest, good quality mother trees may be harvested but can be left for biodiversity purposes
Regeneration development potential	Large opening of the canopy will promote establishment and development of healthy regeneration
Potential product of diversification	Timber, fodder, and NTFPs can be established after stand treatment
Cost and return of silviculture operation	Positive return because of higher value timber from larger trees
Legal mandate	Scientific forest management guideline 2014
Ease of operation	Can be easily implemented guided by unit area control and stocking of mother trees

SWS has certain advantages. Firstly, it provides opportunity of removal mature trees and promotes the establishment of new stand. This generates significant amount of revenue which will in turn contribute to enhance livelihoods and food security of the community. Secondly, shelterwood is comparatively easy to apply than the selection system. This can then generate a powerful societal message that forest management is also a profitable. This is important when the whole forestry sector of Nepal is criticized for conservative and is not contribute economically to the local as well as national economy. Thirdly, the growth of seedling is greater than that of selection silviculture and in negative thinning.

References

Cedamon, E., Nuberg, I., Paudel, G., Basyal, M., Shrestha, K. and Paudel, N.S. 2017. Rapid silviculture appraisal to characterise stand and determine silviculture priorities of community forests in Nepal. *Small-Scale Forestry*: **16**(2): 195-218.

Dougill, A., Sousan, J., Kiif, E., Springate-Baginski, Yadav, N., Dev, O. and Hurford, P. 2001. Impacts of community forestry on farming system sustainability in the mid hills of Nepal, *Land Degradation and Development:* **12**(1):261-276.

Gilmour, D. 2014. Appropriate silviculture for community forestry. An unpublished report.

Herman, F.R. 1962. Shelterwood cutting. Portland: Pacific Northwest Forest and Range Experiment Station, US Forest Service, Portland, USA.

Hunt, S., Dangal, S. and Shrestha, S. 2001. Minimizing the Cost of Overstocking: Towards a Thinning Regime for Community - Managed Pine Plantations in the Central Hills of Nepal. *Journal of Forestry and Livelihoods*: **1**(1): 11-13.

Sapkota, B., Paudel, G. and Kunwar, G., 2017. Institutional Bottlenecks in Forest Management: Experience of Thinning Operation in Pine Plantations in Kavre District (Nepali script). *Workshop proceeding of First National Silviculture Workshop*. Kathmandu: Dept of Forests, Nepal.

Springate-Baginski, O, Dev, P., Yadav, N. and Sousan, J. 2003. Community forestry management in the middle hills of Nepal: the changing context. *Journal of Forest and Livelihood*: **3**(1): 5-20.

Yadav, N. P., Thakur, J. K. and Thapa, Y. B. 2011. Active Forest Management as a Means for Promoting Economic Development and Poverty Reduction in Community Forest User Groups, Nepal.

Yadav, N., Yadav, K., Yadav, K.K. and Thapa, N. 2009. Facilitating the transition from passive to active community forest management: lesson from Rapti Zone, Nepal. *Journal of Forest and Livelihood*: **2**(8): 51-66.