Silvicultural Systems and Their Practices in Terai Forests of Nepal: A Review

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ABSTRACT

It is more than eight decades that Nepalese foresters initiated appropriate silvicultural systems to obtain goods and services from forest, in perpetuity. Several forest management plans were prepared in the past. Unfortunately, these forest management plans were not implemented until 2012 AD. Government of Nepal had introduced a silviculture-based forest management procedure, known as Scientific Forest Management (SciFM) in 2014. One of the objectives of this procedure was to provide management guidelines for Community Forests (CFs) and government managed forests. It has been more than a decade that SciFM was implemented in Terai forests (CF and government managed forests) but how far the procedure supported in achieving its goal is not well documented. This paper examined the forest management system that was implemented in Terai districts of Nepal, irrespective of its management regime. For the study, field visits were carried out in five Terai districts (Morang, Kapilvastu, Dang, Kailali and Kanchanpur) during March and October 2021 to examine the procedure followed in managing the forests and observe the outcomes aimed by the procedure. Both published and unpublished literature on silviculture, silvicultural systems, and forest management, especially devoted to Nepalese context were reviewed. Operational Forest Management Plans (OFMPs) developed by government entities and Community Forests User Groups implemented "irregular shelter-wood system" of forest management in their respective forests, retaining some mother trees for shelter and obtaining quality seeds, based on 80 years of rotation period for Sal (Shorea robusta) although the basis of fixing the rotation is not very clear. The review indicates that, in most sites of Terai parts of Nepal, it may not be necessary to retain mother trees, for ensuring Sal regeneration. There is some possibility of estimating Sal rotation due to appearance of hollowness in the trees, which may help decide the harvestable age of Sal trees in future.

Keywords: *Community forests, forest management, Nepal, rotation, silvicultural system,*

INTRODUCTION

The major objective of forest management is to obtain goods and services from a given chunk of forests that would offer on a sustained basis, in perpetuity. The management of forests in a scientific way was initiated in Germany in the year 1713, with the publication of sylvicultura oeconomica (Innes & Tikina, 2017). Forests managed in a sustainable way offer social, environmental, and economic benefits to forest users. In the Nepalese

context, it has been more than 80 years by now that Nepalese foresters are trying to introduce appropriate silviculture system in the Nepalese forests to obtain various produces (timber, fuel wood, fodder, leaf litter, bark, resin, dyes) and ecosystem services (water harvesting, carbon, pollution) in perpetuity.

The first attempt to introduce scientific forest management in Nepal was made by Mr. E.A. Smith, who came to Nepal as a forest advisor in 1941 AD (Gautam, 1991). A forest-working scheme for the Terai forests was prepared. This working scheme introduced selection–cum–improvement system of felling focusing on the Sal (*Shorea robusta*), Sissoo (*Dalbergia sissoo*) and other mixed hardwood species. Sal trees were selected and harvested for construction purpose mainly for railway sleepers (Indian Railway) but improvement (regeneration and development of stand) part was left behind. Forest Resources Survey Office and Forest Survey and Research Office had prepared management plans for various forest divisions for managing forests following scientific principles. For instance, ten years forest management plan was prepared in the early 70s for Janakpur Forest Division (FRSO, 1971). During 90s, Government of Nepal, with the technical support from the Government of Finland, prepared Operational Forest Management Plans (OFMPs) for 21 Terai districts of Nepal. All these plans had emphasized only on Sal as the main species, with a few descriptions of Terai Hard Wood species Khair (*Senegalia catechu*) and Sissoo (FRSO, 1973). Unfortunately, none of these forest management plans were implemented.

The concept of managing forests through communities was initiated in the year 1976 when the first National Forest Plan was developed. The plan highlighted the need for peoples' participation in the forestry sector. Master Plan for Forestry Sector (MPFS) prepared in 1988 and subsequently approved in 1989 endorsed the concept of managing forests by communities to meet peoples' basic needs for forest products on a sustained basis (HMG/N, 2000). Almost all of our forests have originated naturally from seed. They are managed by different entities as national forest and private forests, based on their ownership. Community, collaborative and leasehold forests are some of the models being practiced in Terai districts of Nepal. Of the several forest management models, community forest is one of them. Forest User Groups (CFUGs) of the respective communities prepare Community Forestry Operational Plan to manage their forests and need to be approved by the Division Forest Offices. Community Forest Inventory Guideline was prepared during the fiscal year 2003/2004 by the Community Forest Division of the Department of Forests. This inventory guideline aims to support CFUGs' various elements of forest management principles including

the estimation of forest growing stock, annual increment and harvestable amount of forest products.

Government of Nepal introduced a silviculture-based forest management program, popularly known as Scientific Forest Management procedure (SciFM) in 2014, to increase the productivity and production of the forests (DoF, 2014). By August 2020, it was implemented in 792 forests covering 26 collaborative forests, 760 community forests and 6 government managed forests (RECOFTC, 2020). Community forests embrace more than 35% (23,59,577.60 hectares) of the forests in terms of total forest area of the country, while the share of collaborative forests is only about 1% (75,654.17 hectares) (MoFE, 2020). Yet, the SciFM was first piloted in Collaborative Forests, and then scaled-up after the promulgation of SciFM guideline in 2014.

The Government of Nepal abolished the SciFM guideline, 2014 in 2021 and the SciFM program has not been operational since then. However, the outcomes of the SciFM have not been thoroughly documented. There is a notable lack of knowledge on the silvicultural system applied to increase forest productivity and enhance the natural regeneration processes as well as learning opportunities available from this discourse. Therefore, a review of the entire process, following some field work was considered necessary and undertaken.

The primary objective of the review was to examine whether the Scientific Forest Management Procedure was followed by the respective forest entities in developing their operational forest management plan and implemented them. Specific objectives included evaluating the silvicultural system employed in forest management in Terai and adjoining district of Nepal, assessing the regeneration status of Sal forests following the implementation of prescribed silvicultural system, and exploring alternative approaches for determining the rotation period for Sal forests.

MATERIALS AND METHODS

Review of documents

We reviewed documents on silviculture, silvicultural system, and forest management, particularly related to Nepalese context. Reviewed documents were Procedure of Scientific Forest Management (SciFM) approved by the Government of Nepal in 2014, annual report (fiscal year 2076/77) published by Division Forest Office, Kapilvastu and publication of Tilaurakot Collaborative Forest Management Group, Kapilvastu, Tilaurakot Collaborative Forest Management Plan (2065/066), Kapilvastu, Baijalpur Jankalyan Community Forest Operational Plan, Kapilvastu, Community Forestry Operational Plan of Karri Forest User Group (073/074), Dang, Shivaganga Community Forest Operational Plan, Kailali, third

Table 1: *Some operational forest management plans prepared for managing forest resources*

SN	District	Major species listed by the OFMP in the respective plan	Source (as indicated in the respective OFMPs and year of visit)
1	Morang	Sal and other Hardwood species	District Forest Office, Morang. Forest Working Plan of Morang District (2013/14-2017/18).
2	Kapilvastu	Sal-Terai Hardwood, Main tree species are Sal, Asna, Banjhi, Barro, Teak, Sissoo, Tendu, Sandan, Siris, Mahuwa, Kusum etc.	District Forest Office, Kapilvastu, Tilaurakot Collaborative Forest Management Group, 2008/2009.
3	Kapilvastu	Sal-Terai Hardwood, Main tree species are Sal, Asna, Banjhi, Barro, Teak, Sissoo, Tendu, Sandan, Siris, Mahuwa, Kusum etc	Baijalpur Jankalyan Community Forest Operational Plan, FY 2017/18 to 2026/27, Kapilvastu.
4	Dang	Sal followed by Terai Sal Hardwood (Rohini/Sindure, Harro, Barro, and Asna)	Karri Community Forests Operational Plan Fourth Amendment, 2017. Lamahi Municipality, Dang.
5	Kailali	Sal-Terai Hardwood, Main tree species are Sal, Asna, Banjhi, Barro, Tendu, Sandan, Siris	Barahaban Collaborative Forest Operational Forest Management Plan, Kailali.
6	Kailali	Sal followed by Terai Sal Hardwood and Khair-Sissoo forests.	Shivaganga Community Forest Operational plan, Kailali, 2017
7	Kanchanpur	Sal followed by Terai Sal Hardwood (Rohini/Sindure, Harro, Barro, Asna)	Shinhapur community forest in Krishnapur Municipality, Kanchanpur,
8	Kanchanpur	Sal followed by Terai Sal Hardwood (Rohini/Sindure, Harro, Barro, Asna)	Shree Krishna Community Forest Operational plan, Suklaphanta, Kanchanpur, 2019.

amendment (2076) of Shri Krishna Community Forests Operation Plan, Kanchanpur, Sinhapur Community Forest Operational Plan, Kanchanpur, Scientific Forest Management Plan of Bhaluwa Community Forest (2018/19-2027/28, Morang, Forest Working Plan of Morang District, and booklet developed by World Wildlife Fund (2020).

Field visits

Field visits were carried out in five (Morang, Kapilvastu, Dang, Kailali and Kanchanpur) Terai districts of Nepal during March 2021 in western Terai and October 2021 in eastern Terai. The visited collaborative and community forests were: Tilaurakot Collaborative Forest, Tilaurakot, Kapilvastu, Karri Community Forest, Dang, Shivaganga Community Forest, Kailali, Ranifanta Community Forest, Kailali, Barahban Collaborative Forest, Kailali, Janachetana Community Forest, Kanchanpur, Shree Krishna Community Forest, Kanchanpur, Sinhapur Community Forest, Kanchanpur, Namuna Community Forest, Letang, Morang and Pathari-Sanischare Collaborative Forest, Morang. During the visit, discussions were held with the concerned authorities of collaborative and community forests on various aspects of forest management.

Data collection

At first, logs of bottom part of Sal tree were identified. Then diameters of 48 logs were measured at the lower end with a diameter tape at the premises of Division Forest Office in Kanchanpur district and Kumarkhat Sub-division Forest Office in Sunsari district and analyzed and determined average diameter of logs without and with hollowness and lower limit of diameter at which the hollowness was initiated. DBH of 40 Sal trees grown through root stocks were measured at Shankarnagar, Butwal in March 2021.

RESULTS AND DISCUSSIONS

Silvicultural system followed

It was observed that forests considered in this study, irrespective of their management regime, were managed under "irregular shelter-wood system". The focus was on Sal tree species only although there were other important hardwood associates, including *Dalbergia sissoo* (Sisso) and *Terminalia alata* (Saj) (Table 1).

For management purposes, the forest is divided into compartments. The number of compartments is determined by the number of felling series in the forest. Each compartment (periodic block) was composed of sub-compartments. The regeneration period of each sub-compartment is fixed at 10 years.

Sal regeneration status and function of mother trees

It was observed that there were profuse Sal seedlings coming up wherever the silvicultural system was being

Figure 1: *Profuse Sal seedlings under mother trees in Kanchanpur*

employed. The size of these seedlings differs as per the site and their stages of growth (Figure 1).

Young Sal saplings on the plots, reached the height of more than one meter in two years. It was observed that within two years of seeding felling, the saplings had obtained that height (Figure 1). Retention of mother trees, especially as seed source, does not carry any meaning rather it might create some destruction to the young growing seedlings when these mother trees die or fall naturally or harvested in the future. Mature trees, potential for producing high quality seeds, were retained for the purpose of Sal regeneration. On average 15 to 27 mother trees were retained in the harvested plots (Table 2).

Sal seedlings under mother trees might have developed (and or come out to a sapling stage during the field study period) from root stock previously available in the forest but was not able to come up because of biotic disturbances. It was observed that retained mother trees that are very old are not able to perform their primary function of providing seeds. These mother trees do not have to provide additional seeds in areas that are already well established by young sal saplings. Furthermore, it will be very difficult to take out and or harvest mother trees as there is a potential danger of killing and destroying young saplings already in the process of establishment.

Table 2: Number of mother trees retained as per the prescribed OFMP

District	Number of mother trees retained (per ha)
Kapilvastu	15-27 Source: District Forest Office, Kapilvastu, Tilaurakot Collaborative Forest Management Group, 2008/2009.
Dang	18 (e.g., Karri Community Forest, Lamahi)
Kanchanpur	27 (Jana Chetana Community Forest) 15 (Shree Krishna Community Forest)
Morang	15-20 Source: District Forest Office, Morang. Forest Working Plan of Morang District (2013/14 - 2017/18).

Sal rotation period

In all the forest areas where irregular shelter-wood system of forest management has been applied, the rotation of Sal is fixed at 80 years (Table 3).

The basis of fixing the rotation period is not consistent and not very clear. For example, rotation period of Sal in the forest management plans prepared by Forest Resources Survey Office in early seventies has been considered as 100 years (FRSO, 1971), while it was 90 years for the same species in Mechi Forest Division. Similarly, forest management plans prepared by Forest Resources Survey Office suggests different rotation period for Khair (*Senegalia catechu*) and Simal (*Bambox ceiba*) (70 and 40 years, respectively), while the Mechi Forest Division uses a common rotation period of 40 years for both species. Rautiainen (1994) suggested that the mean annual increment curve is one of the parameters to decide the rotation age of any tree species. He found that the mean annual increment of Sal saw logs (20 cm top diameter) is flat at what age. Thus, he suggested that depending on the size requirement, the optimum rotation age of Sal can vary from 60 to 80 years. But we do not have research-based data evidence to fix the rotation of Sal in Nepalese forests.

Table 3: Silviculture system applied and rotation period of Sal

District	Silviculture system applied	Rotation of Sal (year)
Kapilvastu	Irregular Shelter-wood system	80
Dang	Irregular Shelter-wood system	80
Kanchanpur	Irregular Shelter-wood system	80
Morang	Irregular Shelter-wood system	80

Source: Field survey (2021)

Table 4: *DBH of Sal logs with and without hollowness. Data collected from Kanchanpur and Sunsari districts*

SN	Logs without hollowness Diameter (cm)	Logs with hollowness Diameter (cm)
1	40.0	55.0
2	35.0	62.0
3	50.0	79.0
4	46.5	64.0
5	45.0	89.0
6	54	51.0
7	43.5	87.0
8	48	53.0
9	60	65.5
10	47	57.5
11	43	64.9
12	70	94.0
13	70	54.0
14	52	65.0
15	53	54.0
16	55	64.5
17	58	45.5
18	67	73.0
19	62	85.0
20		63.5
21		75.5
22		74.0
23		63.0
24		58.5
25		92.5
26		72.0
27		72.0
28		55.0
29		62.0
Mean	52.6 cm	67.3 cm
Standard deviation	10.0 cm	13.0 cm
Standard error	2.3 cm	2.4 cm
Coefficient of variation	18.9%	19.3%

Source: *Field data collected by Amatya and Thapa (2021).*

Possibility of fixing Sal tree rotation based on their respective defects

In the context that no reliable research-based evidence is available for fixing rotation of naturally growing timber species in Nepal, an alternative idea is purposed here. It is observed and experienced that hollowness appears in Sal trees once they are caught by wildfire and/or they get old enough to add any sort of increment. It is possible that we can fix rotation of Sal based on start of hollowness. It can be one of the methods of fixing Sal rotation (Figure 2 a and b). We found that diameter of first log of Sal within 45 cm did not have hollow in general, but we observed hollowness started to develop in logs with a diameter of more than 45 cm (Table 4, Figure 2).

These data are not adequate to provide any valuable and concrete conclusion in determining the rotation age. The rotation period of a species can be correlated with the under-bark diameter and the presence of hollowness in case of Sal. It is necessary to collect data of diameter of first log with and without hollowness from different parts of Nepal to find the upper limit of diameter for initiation of hollowness.

Sal plantations

In Tilaurakot collaborative forest in Kapilvastu district, Sal seeds were sown at a specified spacing after preparing the ground such as cleaning and ploughing. The site had no Sal trees despite the ground being prepared for ease of seed germination. Sal tree seedlings planted in the year 2061 BS at the compound of Division Forest Office at Kanchanpur showed that the diameter at breast height ranges from 14.0 to 30.8 cm (Table 5) at the age of 17-years. The estimated average height of trees was 15 m.

Table 5: *Diameter growth of planted and root socker regenerated Sal trees*

Observation No.	Average DBH (cm)	
	Planted trees	Trees regenerated from root stock
1	25.3	26.2 (0.82 cm per year DBH growth rate)
2	30.0	25.3 (0.79 cm per year DBH growth rate)
3	18.6	
4	27.7	
5	22.4	
6	30.8	
7	14.0	

Source: *Field data collected by Amatya and Thapa (March 2021).*

Figure 2: *Log of Sal; a) sound log in good condition, b) initiation of hollowness, c) distinct hollowness in Sal; d) Sal tree growing from root stock.*

It has been experienced that we don't need to plant Sal seedlings in areas having their root stocks. A sort of uniform, even- aged pole sized Sal trees were observed in Jogikuti, Butwal. As far as we remember, once this area was covered with Bhat plant (*Clerodendrum infortunatum*) and Sena tora (syn. *Cassia tora*) with tremendous biotic interference. After protection of this area in the late 80s, Sal regenerated profusely from root stock. Now it seems like a plantation forest (Figure 2d).

Growth of Sal from root stock

Sal trees need good sunlight for their optimal growth. The two plots of

36-year-old in Shankarnagar, Butwal, were measured in 2021. The trees were regenerated from root stock. The average DBH of two plots were found to be 26.2 and 25.3 cm (Table 5). The DBH of trees growing at the fringe of fire line were large in comparison to that in the middle of the area. Table 5 provides the average diameter of the regenerated stand.

Annual allowable cut (AAC)

This is one of the very important parameters in choosing a silviculture system. This parameter determined harvestable amount of forest and the condition of forest. It is one of the points to be taken into account in managing a given chunk of forest. It is very difficult to answer because of the paucity of data and a given eco-system governing the site. The fundamental principle of sustainable forest management connotes that the AAC of a forest should not permanently exceed the Current Annual Increment (CAI) of the forests. But the CAI for most of the tree species was not available. However, one of the fundamental principles is that the annual cut should not be greater than the annual increment of the forest. Yield can be regulated in three methods. The first is by area, the second is by volume and the third by both area and volume method. There are several formulae for calculating the yield employing them. These methods have been modified by various professional foresters over time. In the past, Von Mantle's formula was used to compute the AAC (FRSO, 1971). Government of Nepal, then Ministry of Forests and Soil Conservation approved Scientific Forest Management Guidelines in the year 2014 (2071 BS) (MoFSC, 2014). The estimation of yield, in this guideline, is based on the method developed by Hanzlik in 1922 (Eq 1).

Annual Production Quantity or Yield (Y)

$$= \frac{V}{R} + \frac{i}{2} \quad \text{..... Eq 1}$$

Where,

V = Total Growing Stock (volume of trees and poles as obtained from forest resource inventory)

R= Rotation age

i = Quantity of annual increment

The yield regulation method adopted in collaborative forests is somewhat different. For example, in Lohandra-Kerabari Collaborative Forest Management Scheme of Morang district, the yield is regulated by the formula (Eq 2).

$$\text{Yield per year(Y)} = \frac{V}{P} + \frac{i}{2} \quad \text{..... Eq 2}$$

Where,

V= Total volume (30 cm diameter and above)

P= Regeneration period

i= estimated 1% growing stock

The same yield regulating principles have been applied for Lumbini Collaborative Forest Management Scheme. This forest management scheme was initiated in the year 2066 BS. It was first renewed in the year 2071 BS for 10 years from fiscal year 2071-72 to 2080-2081 BS. But the yield calculation appears to be based on area and volume method. In most of the community and collaborative forests of Western and Far Western Terai region the annual harvest is carried out based on the concept of stem mapping and removing mother trees in a given management plan period.

CONCLUSION

The review suggests that "irregular shelter-wood system" was one of the commonly used silvicultural systems in Terai forests of Nepal to manage different categories of forests including community forests, collaborative forest and national forests. The value of silviculture system is very high, and its application is potential in providing goods and services from forests on a sustained basis in perpetuity. The then scientific forest management practices seemed to focus only on Sal tree and its natural regeneration notwithstanding that there were other important timber tree species on the plot. The review suggests that in areas where Sal root stocks were present, there was no point in carrying out regeneration felling and retaining mother trees because Sal trees sprout naturally if they are protected from grazing and other biotic interference. The selection of appropriate rotation age is one of the most important considerations in the scientific management of forests. Very long rotation results in decreased vigor of the crop and the production of smaller quantity of seed of doubtful viability. The rotation period fixed for Sal in Operational Forest Management Plan needs to be looked at based on the differences in site and locality. A few alternative means of estimating rotation of Sal have been suggested.

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