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Research Article

Regeneration and Diameter-Height Distribution Under Irregular Shelterwood System: A Case Study from Banke District

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Abstract

This study was aimed to assess the regeneration composition and status and species diversity of blocks of compartment C4S6 with 8 sub-compartment C4S1, C4S2, C4S3, C4S4, C4S5, C4S6, C4S7, And C4S8 under Irregular Shelterwood System (ISS) based scientific forest management in Samshergunj-Mathebas block forest, Banke district, Nepal. The systematic random sampling method was used for allocating circular sample plots (of radius 1.78 m for seedlings and 2.82 m for sapling) for collecting data from the field. Altogether 40 sample plots were taken to collect the required data from the blocks forest. The total regeneration per hectare in the block is 76870. In the blocks forest the total number of seedlings and saplings per hectare was 65150 and 11720 respectively. The IVI value showed that both seedling and sapling of *Shorea robusta* was dominant species and *Terminalia alata* was 1st codominant species in the blocks. Vegetation study is crucial for balancing the ecosystem as well as for biophysical environment. Forest inventories helps to determine the growing stock as well as annual increment in order to balance between harvesting and re-growth. In my study area there is abundant regeneration in the forest but their effective assessment is lacking and research on it is insufficient. Due to the lack of sustainable management, open grazing, illegal harvesting of wood, and forest fire, Productivity of forest is decreasing day by day. And at present, there can be seen Asna (*Terminalia alata*), and other Sal associates like Botdhairo instead of Sal. Graduation of seedling into sapling with time is key necessity in maintaining sustainable forest regeneration. Thus, this study was conducted for assessing regeneration composition and diameter and height class distribution after implementation of irregular Shelterwood system (ISS) in western terai. This study will be useful for policy makers working in conservation biology.

Keywords

Sustainable Forest Management, Richness, Evenness, Block Forest

1. Introduction

5.96 million hectares, or 40.36 percent, of Nepal are covered by forests [9]. In the past, Nepal's centralized institution structure for forest management prevented effective management of productive forests [25]. The process of tissue development, renewal, and restoration that makes genomes, cells, organisms, and ecosystems resistant to natural fluctua-

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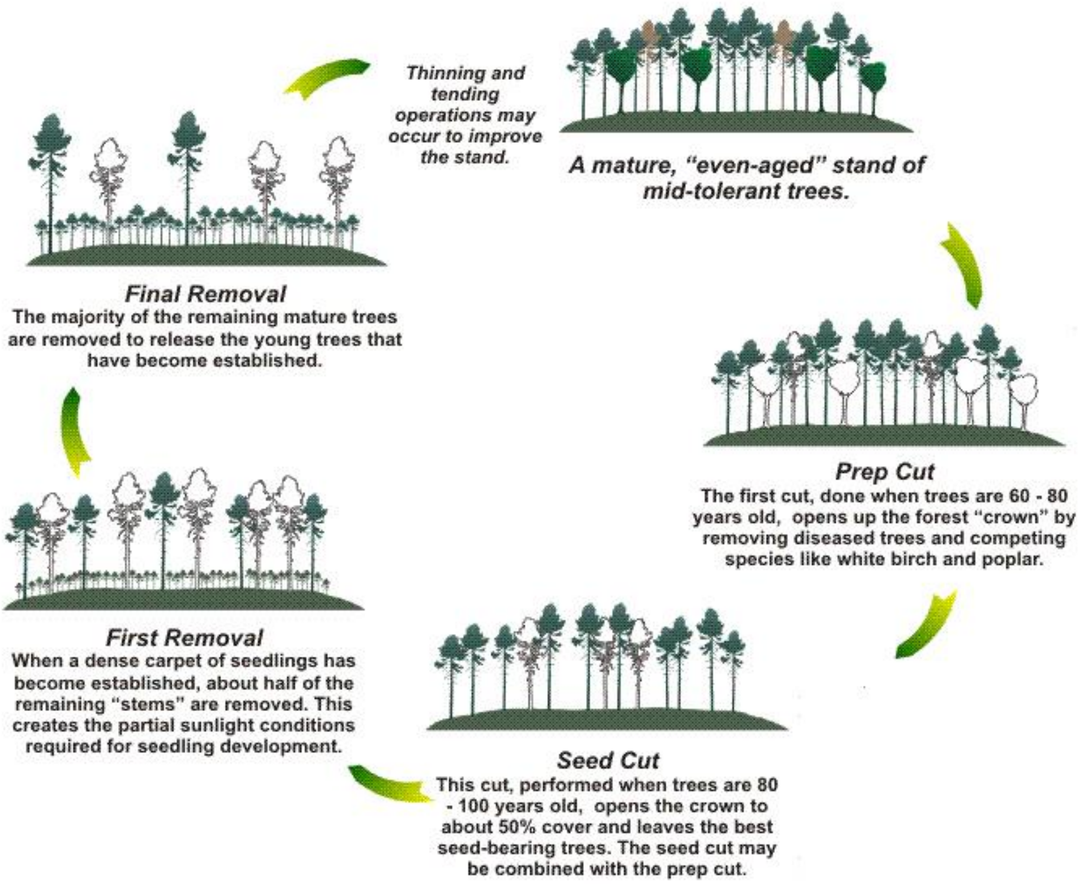
tions or events that cause damage is known as regeneration in biology. From germs to humans, every species has the ability to regenerate. Height and breast diameter at breast height are two crucial factors.

An irregular crop composition is produced by an irregular sheltewood system, a type of silviculture system in which trees—aside from a few number of mother/shelter trees—are cut down during felling operations and regeneration and poles are kept as future advanced crops [15]. This technique causes the crop to be regenerated to open up irregularly, resulting in an unevenly aged forest. This system is a hybrid of the uniform system and the selection system, rather than just a variation of the uniform system. There are no periodic blocks in the irregular shelterwood system, and the regeneration period is lengthy but indefinite. Every ten years, the regeneration areas are redistributed from their scattered locations. As long as the entire allotted volume for the ten-year period is not surpassed, this technique is effective not just in terms of choosing which regions to cut down but also in relation to the amount of material cut down each year [10].



(Source: https://tinyurl.com/2s38u2t6)

Figure 1. *Shelterwood System.*

Because it preserves the intended species composition and stocking following a variety of disturbances, regeneration is an essential component of forest management. A tree species' capacity to regenerate is contingent upon the survival and growth of its seedlings and saplings [12]. Forest management must maintain appropriate age class (age-gradation), normal increment, normal increasing stock, and adequate regeneration in order to be silviculturally sustainable [33]. Numerous attempts have been undertaken to create appropriate silvicultural systems, primarily focusing on creating sensible canopy openings for sal regeneration [34]. The population structure that exhibits satisfactory regeneration behavior is determined by the quantity of seedlings, saplings, and young trees. Poor regeneration is indicated by a forest's insufficient amount of a tree species' seedlings and saplings, and no regeneration is shown by their total absence [10]. The growing human population has put more strain on forest ecosystems than they can recover from, which results in the loss of biodiversity and the degradation of wilderness [31].

Ensuring forest productivity and production as well as forest stand rejuvenation is a key component of SciFM [20]. Researchers, forest residents, and politicians have questioned SciFM because to its long-term unpredictability and technological, social, and biological challenges, despite its growing popularity in participatory forest management [4, 28, 26]. The species composition, structure, interactions, and diversity of forest ecosystems are impacted by ongoing interventions and disturbances. In order to determine whether or not the objectives of sustainable forest management are met, as well as whether or not the forest's biological diversity and productive potential have been maintained, SciFM implements rigorous management and monitors regeneration [14]. More than 30% of the objectives of the United Nations' strategic plan for forests (2017–2030) are covered by forests. Even though it only makes up only 0.9% of the world's land area, Nepal has long been regarded as a biodiversity-rich nation [6] in terms of participatory forest management and governance [11]. To increase forest production in Nepal, however, sustainable forest management based on silvicultural systems has also been prioritized in the Forest Policy (2015) and the Forestry Sector Strategy (2016–2025) [16].

In natural forests, regeneration is crucial for biodiversity conservation and maintenance [13], as well as for preserving the stocking and composition of the desired species following many disturbances [18]. The most important element in attaining long-term forest sustainability is successful regeneration [29], so understanding the state of plant regeneration helps with setting priorities and creating management options [16].

2. Material and Method

Study Area

Map of Study Area

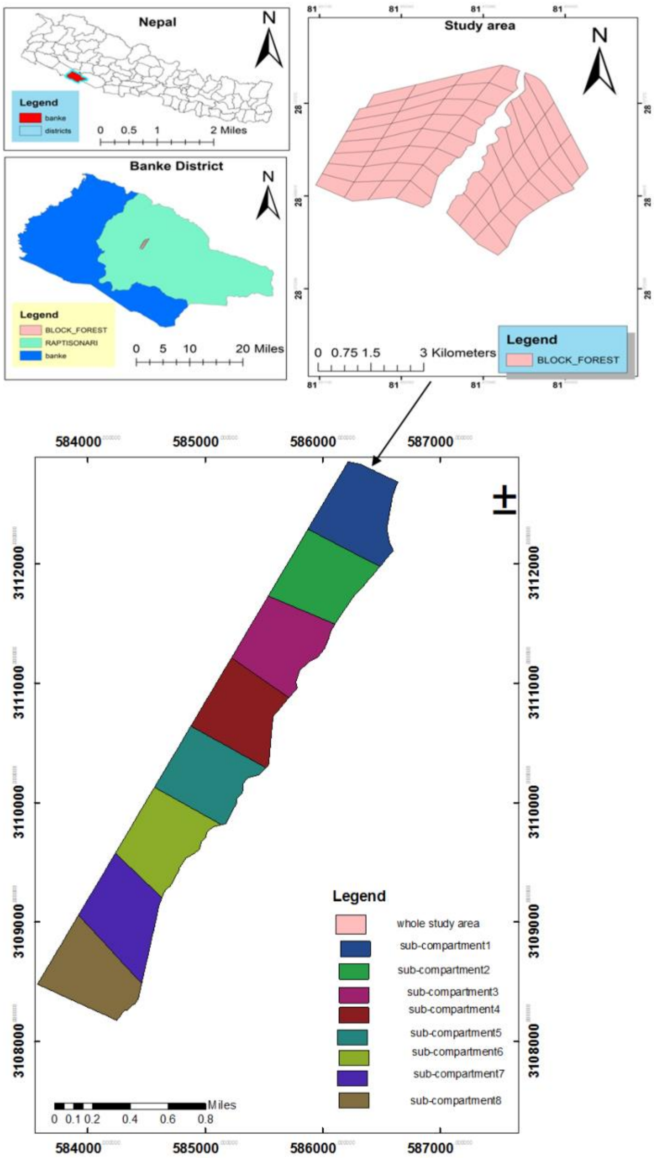


Figure 2. *Map showing study Area.*

Climate:

The climate is Tropical and sub-tropical. This area is located at an altitude between 127.5 m to 1236 m from the sea level; the majority land area of the CF is plain. It is located at 27°36 ΄ - 28°29 N and 82°2 ΄- 82°5΄E because it's the terai region; the climate here is hot and dry in the summer and cold in the winter. Minimum and maximum temperature ranges from 5.4°C to 46°C likewise atmospheric Humidity is 27% to 94% and average annual rainfall is 713 mm to 1510 mm.

Soil:

Soil is fertile, silty soil; soil covered with pebbles, shell/conglomerate, loamy soil, erosive soil.

Vegetation:

Though the Forest is a Sal forest (33% dominance), it is rich in vegetation diversity as it comprises Asna, Botdhayaro, Khayar (*Acaia catechu*), Karma (*Adina cardifolia*), Dudhilo (*Ficus nemoralis*), Sadan (*Cyrtidactylus sadanensis*), Barro (*Terminalia belarica*), Harro (*Terminalia chebula*), Dhauwa, Thateri, Bhalayo, Sine, Bel, Pyari, Rohini, Jamun, Amala (*Phyllanthus emblica*), Simal (*Bombax ceiba*), etc (Annual Work Plan Of Samshergunj Sub-division Forest Office Banke).

Fauna:

Not only in vegetation but it is also rich in faunal diversity. Some of the species are: Wild cat (Felis chaus), Bandel (Sus scrofa), Rabbit (Lepus nigricallis), Monkey, Fox (*Anis aureus*), Jangali Musa (*Rattuss spp*.), Dumsi (*Hystrix indica*), Malsyapro (*Marttes flarigulas*), Nyauri- musa (*Herpestes warsii*), Lokharke (*Funambulus spp*.), Hudar (*Hyeena hyena*), Barhasinga (*Cervus duvaucelii*), Deer (*Axis axis*), Bat, Leopard, Snakes, Bwaso (Canis lupus), Rato badar (*Macaca mulata*), Peacock, Wild hen, Parrot, Jureli, Koili, Vulture, Kalij, Sparrow, Crow, Eagle, Sarans, Owl, etc.

Ethnicity:

Different ethnic groups like: Brahmin, Chhettris, Magar, Tharu, Gurung, Thakuri, Giri, Musalman, Yadab, Kurmi, Chamar, Harijan, Ram, Damai, Kami, and others reside here are part of the Forest following Hindu, Muslim, Baudda, Christian, Kirat, Prakriti, Jain, Sikh, and other.(Annual Work Plan Of Samshergunj Sub-division Forest Office Banke)

Data Collection

Primary data Collection

Field Observation

Firstly field study was conducted to directly observe the study area and to better understand, internalize, and form perceptions about the research problems and the actual situation of this Community forest in which research was conducted.

Sampling design

Data on regeneration was collected form 8 sub-compartment C4S1, C4S2, C4S3, C4S4, C4S5, C4S6, C4S7 and C4S8 of compartment C4S6 of Samshergunj-Mathebas Block Forest. Systematic sampling method was used to allocate the circular sample plots (sapling was measured in 2.82 m radius and seedling was measured in 1.78 m radius as shown in Fig. below. Individual plants were categorized into seedlings (1 m in height & < 10 cm in DBH) to collect data on regeneration according to CF inventory guidelines, 2061. Different species under study were identified through the observation of morphology. Whereas photos were taken in case of unknown and confused plant species for later identification. The regeneration felled area (managed) blocks of CF was surveyed and mapped using GPS and Arc GIS respectively.

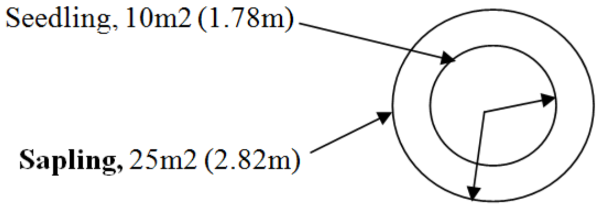


Figure 3. *Sample plot size for seedling and sapling.*

Secondary data collection

We did different article review, Google scholar using keyword, website like MOFE, DOF, and authorized data from DFO and subdivision office.

Data analysis

Diameter and height distribution of seedling and sapling within sub-compartment

Graphical representation of average height and diameter and interpretation of the data was done as bar diagram.

Plant species composition and their Important Value Index (IVI) under ISS

Species composition in seedling and sapling strata within the compartment was evaluated by calculating frequency, density, basal area for each species from the collected data. The dominance of the species was determined by using Importance Value Index (IVI) of these species. Importance value index is the degree of dominance and abundance of given species in relation to the other species in the given area [5]. The following Formulae will be used for calculation.

$$\text{Frequency (\%)} = \frac{\text{Number of quadrants in which an individual species occurred}}{\text{Total number of quadrants sampled}} \times 100$$

$$\text{Density (stem/m}^2\text{)} = \frac{\text{Total number of individual species in all plots}}{\text{Total number of plots studied} * \text{size of plot (m}^2\text{)}} \times 100$$

$$\text{Relative Frequency (\%)} = \frac{\text{Frequency of individual species}}{\text{Total frequency of all sq}} \times 100$$

$$\text{Relative Density (\%)} = \frac{\text{Density of individual species}}{\text{Total density of all specie}} \times 100$$

$$\text{Relative Basal area (\%)} = \frac{\text{Basal area of individual species}}{\text{Total basal area of all species}} \times 100$$

$$\text{Basal area (A)} = \pi(\frac{\text{Diameter}}{2})^2 \text{ (in } m^2)$$

IVI for seedlings = Relative density + Relative frequency

IVI for sapling = Relative density +Relative frequency + Relative basal Area

The following criteria was used to ascertain the status of regeneration: a) 'good', if seedling > sapling > trees, b) 'fair', if seedling > sapling ≤ trees, c) 'poor', if a species survives in only sapling stage but not as seedlings, d) 'none', if a species is absent in both sapling and seedling stages, e) 'new' if a species has no adults, but only saplings or seedlings or both [7].

The density of seedlings and saplings per hectare was also be assessed and compared with the community forestry inventory guideline 2061 to determine the regeneration status of the forest. The regeneration is good if seedlings density is above 5000 per hectare, fair if between 2000 and 5000 per hectare and poor if less than 2000 per hectare. Similarly, the regeneration is good if sapling density is above 2000 per hectare, fair if between 800 and 2000 per hectare and poor if less than 800 per hectare.

$$\text{Species density per hectare} = \frac{\text{Number of regeneration}}{\text{Area of sample plot } (m^2)} \times 10000$$

Table 1. *Condition of forest based on regeneration per hectare (CF Inventory Guideline, 2061).*

Plant type	Number per hectare		
Seedling	>5000	2000-5000	<2000
Sapling	>2000	2000 <800	<800
Condition of forest	Good	Fair	Poor

Species Diversity

1. Concentration of dominance was measured by Simpson's index of dominance (Simpsons, 1949): Simpson's index of dominance (D) = $\sum_{i=1}^{s}(\text{Pi})2$

Where, S= total number of species

Pi= proportion of all individual in the sample

That belong to species i

2. Simpson index of diversity = (1-D)
3. Shannon-Wiener Diversity index [30] was used for the calculation of species diversity as:

Shannon-Wiener Diversity index (H) = $-\sum_{i=1}^{s}(\text{Pi})2\ (\ln\ pi)$

Where, S= total number of species in the sample

Pi= proportion of all individual that are of species i

(1) Species richness index (d) indicates the mean number of species per sample [21] was calculated as:

Margalef's Species Richness Index (R) $= (s-1)/\ln N \sum_{i=1}^{s}(pi)^2$

Where, d= species richness index

S= number of species

N= number of individual of all species

(2) Equitability or evenness index (e) refers to the degree of relative dominance of each species in that area. Evenness index [23] was calculated as:

Equitability or Evenness Index (e) = $(\dot{H}')/\ln S$

Where, e = evenness

H= Shannon-Wiener's diversity index

S= Number of species

For the analysis of species diversity, Richness indicator ranging from -1, 0 and +1. Where -1 indictes negative or less diversity, 0 indicates neutral or no diversity and +1 positive or more diversity.

Material and tools used

GPS, Diameter Tape, Range Finder, Measuring Tape, Notebook, Pen, Laptop, Map, etc.

3. Result and Discussion

3.1. Result

Height Distribution of Seedling within sub-compartment

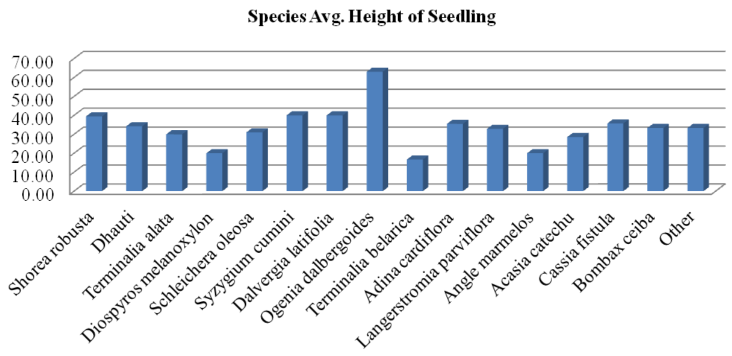


Figure 4. Height distribution of seedling within sub-compartment.

The species average height distribution is shown in figure 4. *Ogenia dalbergoides* showed highest average height as 63.04 followed by *Syzygium cumini* and *Dalbergia latifolia,* etc. Similarly, other species showed average height as like of other co-dominant species as 0.33 and other dominant species.

Diameter and Height Distribution of sapling within sub-compartment

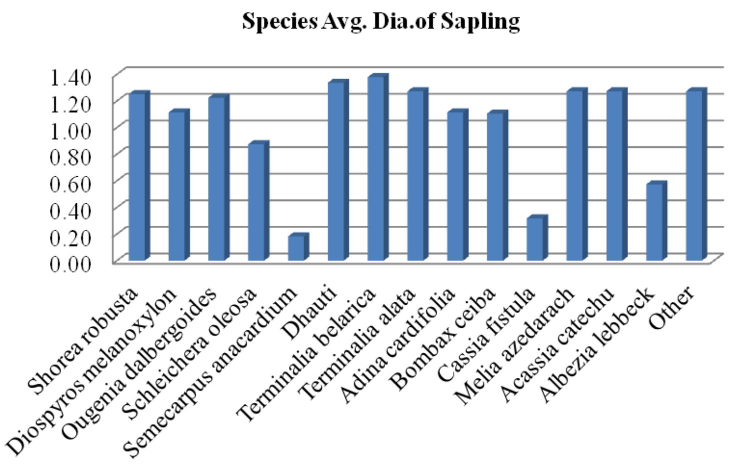


Figure 5. Diameter distribution of sapling within sub-compartment.

The highest mean sapling diameter found in study was of *T. belarica* i.e.1.38 followed by Dhauti, *T. alata, S. robusta Acassia catechu* and other species.

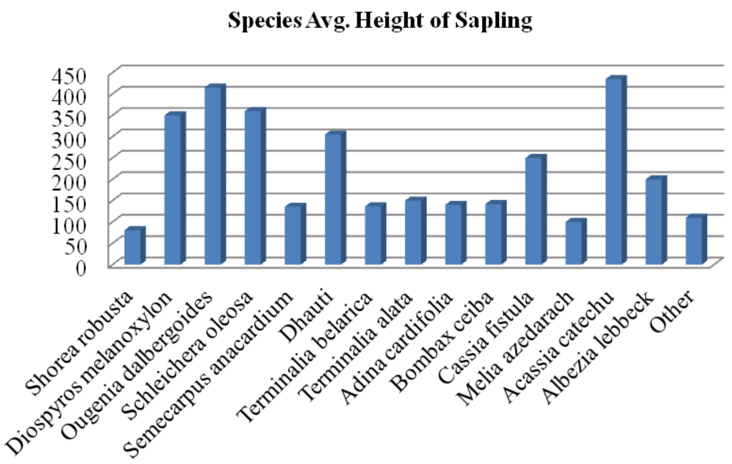


Figure 6. Height distribution of sapling within sub-compartment.

The highest mean sapling height found in study was of A. catechu which is 435 followed by O. dalbergoides, *D. melanoxylon, S. oleosa,* Dhauti, *Cassia fistula* and other species.

Plant species composition, status and their Important Value Index (IVI) under ISS

The regeneration of 16 and 15 species of seedling and sapling were recorded in whole compartment respectively. *Shorea robusta* was found to be dominant with highest IVI value of 69.12 for seedling and 83.44 for sapling in the blocks. Also the dominance of other species like Kadipatta, Dudhe, Tite, Rohini, Pyari, Tatari, Gandhe was immense. Similarly, seedling and sapling of *T.alata* was 1st co-dominant species in all study area.

Samshergunj-Mathebas Block forest is considered as S. robusta dominated forest, management plan is also focused with regeneration and growth of S. robusta. S. robusta had the highest number of seedling and sapling per ha in the entire stand followed by Dhauti, *T. alata*, *Diospyros melanoxylon*, etc. The dominance of other species like Kadipatta, Dudhe, Pyari was imence that covered nearly half of total species. The regeneration status of different species is highligheted in figure below:

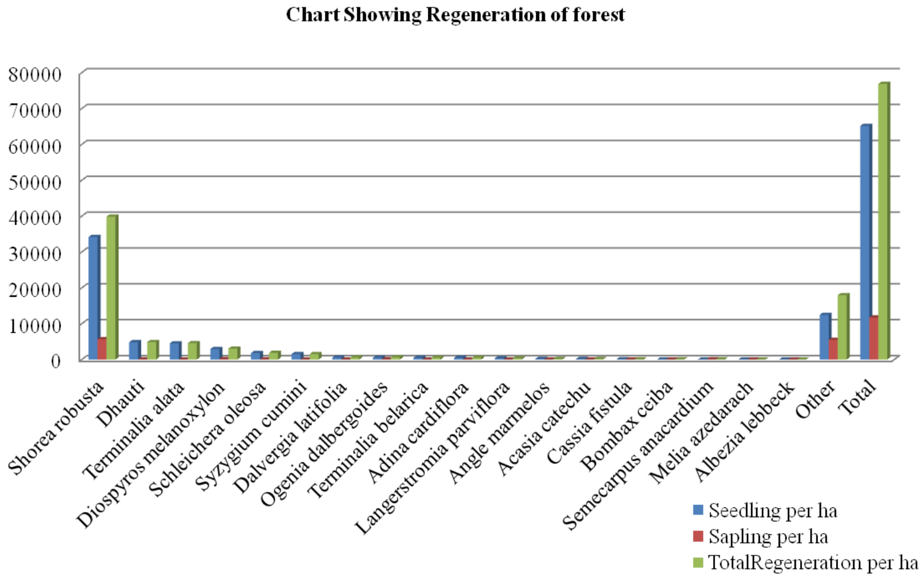


Figure 7. *Regeneration Status and composition of Seedling and Sapling of Different Species in the Block under ISS.*

Seedling

The study conducted in Sub-compartment C4S1, C4S2, C4S3, C4S4, C4S5, C4S6, C4S6, C4S7, C4S8 of Compartment showed that there was total of 65150 seedlings per hectare. The dominant species was *S. robusta* in the government managed forest with highest average density of 34175 per hectare. The data on seedling density (seedling per ha) of both are shown in figure 8.

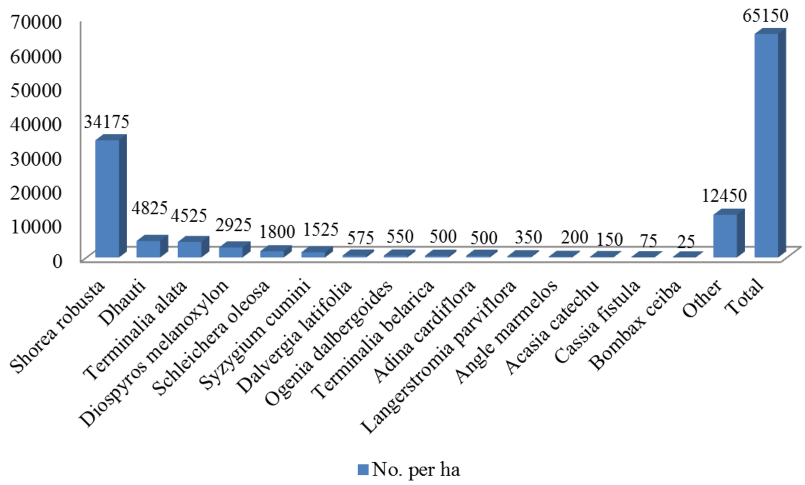


Figure 8. *Showing Seedling Density (Seedling per ha).*

Sapling

The study showed that there were total 11720 saplings per hectare in the forest. The highest average density of saplings is 5690. The essential data on sapling density (sapling per hectare) of different species on the block is given in Figure 9.

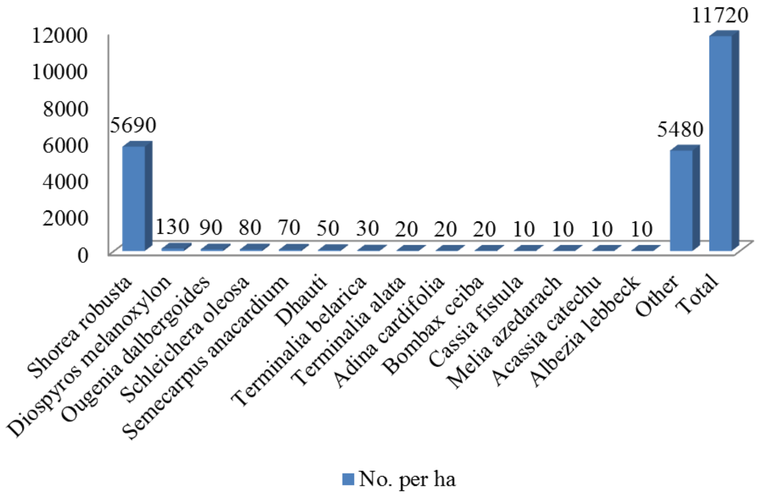


Figure 9. *Showing Sapling Density (Sapling per ha).*

Regeneration

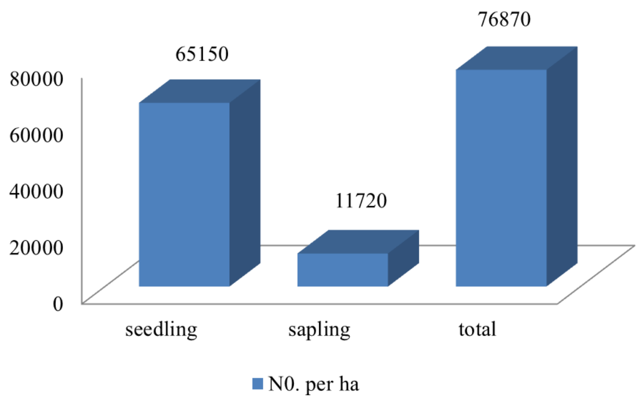


Figure 10. *Regeneration composition in block forest under ISS.*

The total regeneration per hectare in the forest is 76870 per hectare. Which includes 65150 per hectare of seedlings and 11720 saplings per hectare? According to CF inventory guideline (2061), the condition of forest is good if the number of seedlings and saplings per hectare exceeds 5,000 and 2,000 respectively. Here as per field data this criterion is fulfilled (as seedlings no. per ha is >5,000 and saplings no. per ha is >2,000) in managed blocks of CF so this forest is in good condition. Similarly, the total number of seedling per hectare is greater than sapling, therefore forest is good condition. Thus, the forest condition in Compartment C4S6 of Sam-shergunj-Mathebas Block forest is good. The data related to regeneration per hectare of different tree species found in study area are shown in Figure 10. Here; Also the number of seedling is greater than sapling, so the forest is good condition forest according to Loewenstein et al. [19].

Tables 2 and 3 shows total no. of species in the blocks were 40. The IVI value showed that both seedling and sapling of *S. rubusta* were dominant species and T. tomentosa was 1st codominant species in both managed and unmanaged blocks.

Table 2. *IVI of seedlings of different species under ISS.*

Seedling species	IVI value
Shorea robusta	69.12
Dhauti	17.90
Terminalia alata	20.53
Diospyros melanoxylon	17.45
Schleichera oleosa	13.87
Syzygium cumini	4.19
Dalvergia latifolia	5.82
Ogenia dalbergoides	6.40
Terminalia belarica	6.94
Adina cardiflora	4.47
Langerstromia parviflora	1.15
Angle marmelos	3.39
Acasia catechu	2.08

Seedling species	IVI value
Cassia fistula	1.35
Bombax ceiba	4.98
Other	33.31

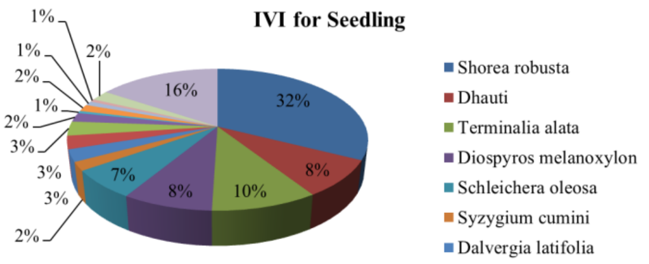


Figure 11. *Pie chart showing IVI value of seedling under ISS.*

Table 3. *IVI for sapling of different species under ISS.*

Sapling species	IVI value
Shorea robusta	83.44
Diospyros melanoxylon	13.05
Ougenia dalbergoides	9.73
Schleichera oleosa	9.64
Semecarpus anacardium	2.09
Dhauti	3.41
Terminalia belarica	4.73
Terminalia alata	1.66
Adina cardifolia	3.16
Bombax ceiba	3.16
Cassia fistula	1.58
Melia azedarach	1.58
Acassia catechu	1.81
Albezia lebbeck	1.58
Other	70.75

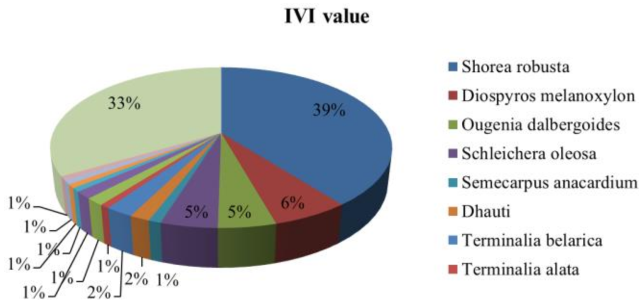


Figure 12. *Pie chart showing IVI value of sapling under ISS.*

Plant Species Diversity

Table 4. *Species diversity of seedling and saplings layer in the block forest.*

Species	Shannon weiner's diversity index (H´)	Simpson's Idex of concentration (D)	Simpson Index (1-D)	Pielou Eveness Index (e)	Margalef's Species Richness Index (R)
Seedling	0.277	0.3256	0.6744	0.0353	0.67463
Sapling	0.3378	0.45386	0.54614	0.33	0.54661

As per information presented in table below we can conclude that the value of Shannon Weiner's diversity index (H') of sapling is higher as compared to seedling. Similarly, the value of Pielou Evenness Index (e) is higher for sapling and Margalef's Species Richness Index (R) is higher for seedling. This directly indicates that greater species diversity is of sapling in the block. Whereas the value of Simpson's Index of concentration (D) is more in case of sapling which directly entails that there are highly diverse sapling species than seedling in the block due to application of ISS.

Here, species richness (D) of Seedling and Sapling are 0.3256 and 0.45386 which are greater than 0 and less than +1, indicating the positive or good diversity of both Seedling and Sapling.

3.2. Discussion

Regeneration status and distribution pattern

The present study showed that in managed blocks the number of seedlings was 65150 per hectare and the number of saplings was 11720 per hectare. Here the number of seedling per ha is greater than sappling. Which indicates that the forest is good condition forest and better regeneration.

After a year of regeneration felling, Khanal & Adhikari's results likewise revealed a 6.4-fold rise in seedlings and a 3.4-fold increase in saplings [15]. In a similar vein, Khadka et al. discovered that, possibly as a result of regeneration felling, managed areas had larger densities of seedlings and saplings than the uncontrolled zone, which did not have regeneration felling [14]. Furthermore, a similar finding was reported by the DFRS (2015) forest resource assessment, which found that there were few developed saplings in such stands despite a high density of Sal seedlings [8]. According to CF Resource Inventory Guideline 2061, the regeneration state of the sub-compartment under study is good for both managed and unmanaged blocks since the seedling and sapling densities are more than 5000 and 2000 per hectare, respectively. Compared to unmanaged blocks, managed blocks may have more regeneration per hectare because of the open canopy, less competition, and fencing that protects the managed area from grazing and careless tree harvesting. Regeneration is significantly impacted by canopy openings and the development of forest gaps [36, 3]. S. robusta was the most prevalent species in the study region, with the greatest IVI. Its dominance was likewise higher in managed blocks than in unmanaged ones. Likewise, Kharel et al.'s overall findings demonstrated that Shorea robusta regeneration was higher in the managed area [16]. After a year of regeneration felling in natural stands, a high density of Sal seedlings was seen in several other experiments conducted in various locations throughout Nepal [1]. In comparison to unmanaged blocks, the current study demonstrated an overall increase in the number, abundance, and frequency of regeneration in managed blocks. This study supports the findings of Shrestha et al., who found that the use of an irregular shelterwood system enhanced S. robusta's density, frequency, and IVI in the managed area in addition to its regeneration [31]. In unmanaged blocks, the distribution pattern of seedlings and saplings was primarily infectious, whereas in other blocks, it was random and regular, according to the current study. The viral pattern of species dispersal may be the reason why the majority of seedlings and saplings adapted to grow closer to their mother plants. Given that the distribution pattern of tree species varies depending on the type of treatment, more random patterns are preferred by greater management [14]. Contagious distribution patterns are the most prevalent patterns in nature, according to Odum (1971) [24].

According to Park et al., plant species' IVIs varied depending on the research block [22]. Specifically, the highest IVI was recorded for Shorea robusta in all study blocks.

Species diversity

According to this study, unmanaged blocks had a higher Shannon Weiner's diversity index for both seedlings and saplings than managed blocks. It implies unequivocally that unmanaged blocks have a higher species diversity. This outcome aligns with the research conducted by Awasthi et al. (2015). In their study in Nepal, (Kharel et al., 2021) and (Khatri et al., 2021) found that species diversity was lower in the managed block than in the unmanaged block [3, 16, 17]. However, in the Kanchancpur district of Nepal, Khadka et al. found that scientifically managed woods had a greater species diversity than conventionally managed forests [14]. Following the implementation of an irregular shelterwood system, Shrestha et al. discovered that species richness rose from 6 to 11 for seedlings and from 2 to 6 for saplings [30]. This study's findings differed from another's, which found that the Andaman Island's disturbed (3.5) and undisturbed (3.4) evergreen forests had nearly equal Shannon-Wiener indices [27, 7]. It also found that the unmanaged block had a higher species richness index or variety index than the managed block. This could be because unmanaged blocks had more grasses, shrubs, and other tree species, whereas managed blocks only allowed the desired species to grow because of frequent weeding and removal of unwanted species.According to Smith et al., species diversity in managed stands under irregular shelterwood systems first declines following regeneration felling and post-harvesting, but subsequently increases over time [32]. Unmanaged blocks have a higher value than managed blocks in the Simpson's Index (1–D) instance. In contrast, managed blocks had a greater Simpson's Index of Dominance (D) than unmanaged blocks. Since S. robusta was the dominating species in the managed stands, Khadka et al. also discovered a greater Simpson's index of dominance in the managed block, which they speculate could be due to a lower level of species diversity [14]. The undisturbed block's index (1-D) was higher (0.7) than the disturbed block's (0.68), according to Amatya (2016) [2]. In the Garhwal Himalaya region of India, however, Uniyal et al. found that Simpson's index was 0.24 for managed forests and 0.35 for non-managed forests [35].

4. Conclusion and Recommendation

4.1. Conclusion

In conclusion, height and diameter of other codominant species is greater as compared to S. robusta being dominant. Dominancy of other species like Kadipatta, Dudhe, Pyari, Tatari and other was high as like codominant. The regeneration of area is in good condition in terms of both seedling as well as sapling stage *S. rubusta* is the dominant species having highest IVI. Higher species diversity for sapling was found in block whereas species dominance was higher for seedling.

4.2. Recommendation

My study recommends that tending operation such as thinning, pruning, weeding, cleaning must be performed time to time so as to promote even better height diameter growth of high value species. The ISS should be applied to promote regeneration of the area as it facilitate adequate light reaching to ground which greatly escorts germination of seeds. While performing tending operation care should be taken not to harm new seedlings.

More study should be conducted on the silvicultural system for different types of forest so as to determine suitable management practice for different conditions. Further research on management practice under ISS should be done to determine its long term effects on plant species diversity.

Abbreviations

AFU	Agriculture and Forestry University
CF	Community Forest
CFUG	Community Forest User Groups
DFO	Division Forest Office
FOF	Faculty of Forestry
GPS	Global Positioning System
ISS	Irregular Shelterwood System
IVI	Important Value Index
MPFS	Master Plan for Forestry Sector
MFSC	Ministry of Forest and Soil Conservation
MS	Microsoft
SciFM	Scientific Forest Management
SDFO	Sub-division Forest Office
DBH	Diameter At Breast Height

Author Contributions

Kushma Kumari Malla: Conceptualization, Data curation, Formal Analysis, Methodology, Resources, Validation, Writing – original draft, Writing – review & editing

Sushil Subedi: Supervision, Validation, Writing – review & editing

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Conflicts of Interest

The authors declare no conflicts of interest.

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