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REGENERATION STATUS OF NATIVE TREE SPECIES IN THE NANTA FOREST, KOTA DISTRICT RAJASTHAN

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ABSTRACT

The present paper describes the regeneration status of native tree species at two sites in the Nanta forest region of Kota district, Rajasthan. To determine the density of trees, saplings, and seedlings standard size of quadrates were used. The total tree, sapling, and seedling densities were 16.11 ind/ha, 112.337 ind/ha, and 118.33 ind/ha recorded in the protective site respectively whereas in the non-protective site the tree, sapling, and seedling densities were 4.87 ind/ha, 46.67 ind/ha, and 1.33 ind/ha recorded. It was observed that in protected vegetation site 22.86% of tree species have good, 45.71 % have fair, 5.71 % have poor and 25.71 % of species are not regenerating (NR). In non-protected vegetation site only 12.5 % of trees have fair regeneration, 75 % have poor, and 12.5 % of species are not regenerating (NR). The results indicate that in protected vegetation site the regeneration status is better than in non-protected vegetation site where deforestation, grazing, lopping of trees for fodder and fuel-wood, removal of leaf and wood litter from the forest floor, and other anthropogenic disturbances have caused over-exploitation of plants in the herbaceous stage.

Keywords: Nanta, Native, Regeneration, Density.

1. INTRODUCTION

Forests are an asset for human life as they provide a diverse range of resources. The earth's biota is being altered at an alarming rate. The causes of losing species and biodiversity globally are a complex cluster of economic, social, political, and biological at various levels. Direct causes such as pollution, over-harvesting, and habitat change have been studied well, but the socioeconomic factors propelling people to damage their environment are less understood (Wood *et al*., 2013).

A native species is indigenous to a given region or ecosystem if it is present in that region and is the result of only natural processes, with no human intervention. They are well adapted to the climate, light, and soil conditions that characterize their ecosystem (Booth, & Jones, 2001). Native plants evolved slowly over time with relatively little interference from humans. Native plants provide the foundation for a healthy ecosystem, if they properly get their desired soil and light requirements, they can require less water, fertilizer, and maintenance to thrive (McKinney, 2002). Plantation of native tree species may activate forest succession; improve soil nutrients, promote the establishment of shrubs and trees, and restore ecological interrelationships (Ruiz-Jaen & Mitchell, 2005). Tree species' regenerative capability can predict the future composition of forests throughout time and space (Saikia & Khan 2013).

Regeneration can be defined as the reconstruction of vegetational and structural diversity back to the self-perpetuating climax stage (Debushe, 2008). The geographical location of the region, soil,

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climate, structure of vegetation, tree diversity, and regeneration pattern of species largely influence plant composition in a forest (Sarkar & Devi, 2014; Siregar *et al*., 2019). Regeneration is one of the major processes with significant effects on forest planning, conservation, and sustainable management (Bhuyan *et al.*, 2003). Thus, understanding the tree diversity, population structure, and regeneration state of forest communities is critical for the management of both natural and managed forests. As a result, information on the regeneration state is critical for determining an area's potential for biodiversity conservation, even though numerous research on regeneration status have been conducted by many workers in diverse forest ecosystems (Alamgir & Al-Amin, 2007).

In a community regeneration of trees largely depends on seed set, seed survivorship, and establishment of seedlings (Malik & Bhatt, 2016). Seed production of trees is severely affected by external factors like pollination failure, nutrient availability in soil, climatic factors, age, and size of trees (Tiwari *et al*., 2019). The general trend of population dynamics of seedlings, saplings, and adults of a plant species can reveal the regeneration pattern, which is used to evaluate their regeneration status (Bogale *et al.*, 2017).

Forest ecosystems mainly depend on the proper regeneration potential of all tree species (Tripathi & Khan, 2007). However, due to various disturbances, the regeneration potential of a forest is hindered. For the management of degraded forest patterns, basic knowledge about the regeneration status is necessary. The answer to the basic questions of forest management depends upon the knowledge about the pattern of natural regeneration (Hossain *et al*. 1999).

1.1 Study site

The study was conducted in the Nanta Forest area which is situated between 25.21525° latitude and 75.8311° longitude and comes under Ladpura Tehsil of Kota district (Rajasthan). Data was collected from January 2021 to December 2022 and two sites were taken for sampling one is the protective site (control site) and the other one is the nonprotective (experimental site).

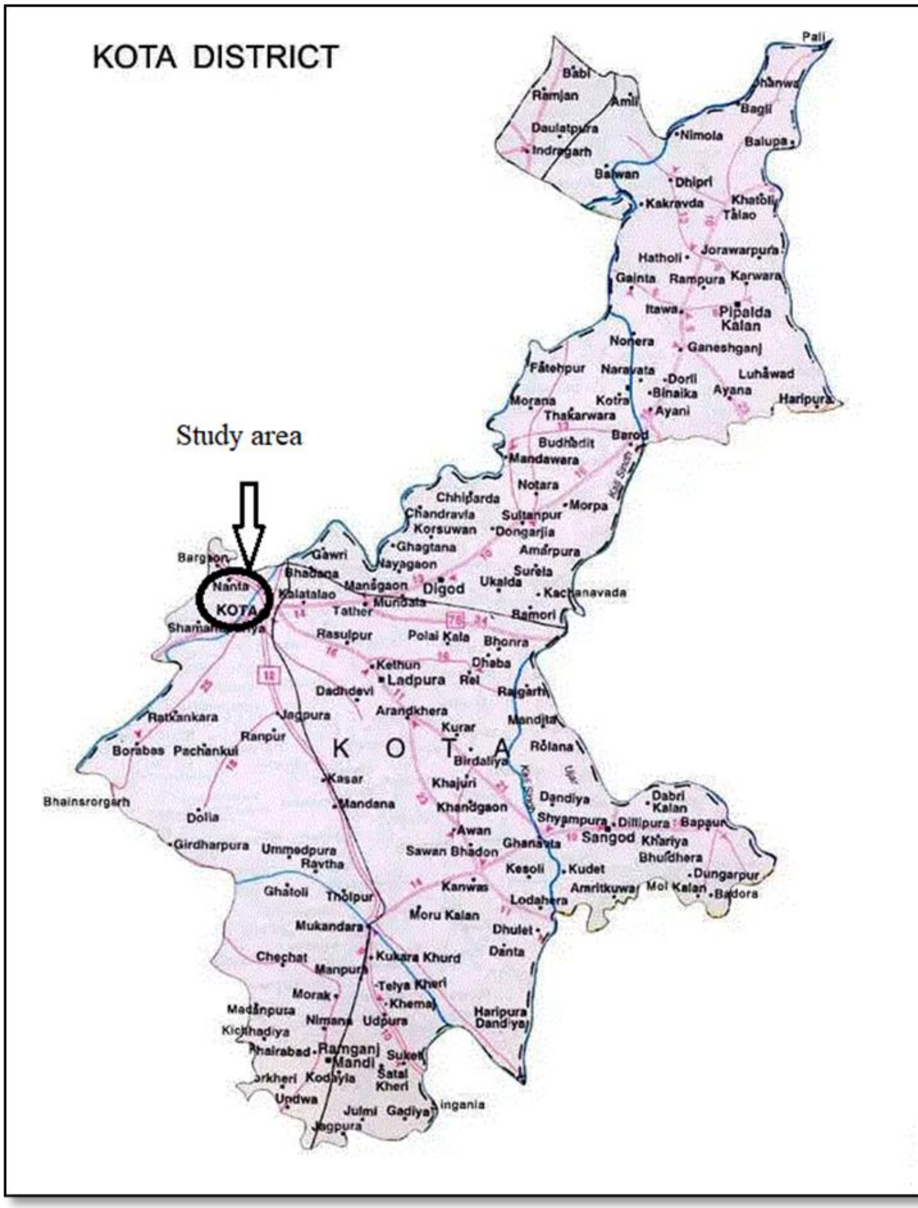

Figure 1: Map of Kota District showing study area (in circle).

2. MATERIALS AND METHODS

2.1 Sampling design

To determine the composition of vegetation in the forested area (control site and experimental site) sampling was done separately using the standard size of quadrates of different sizes for trees, saplings, and seedlings. For sampling trees 100 m x100 m (10000 m^2 or 1 hectare), for saplings 10 m x10 m (100 m^2), and for seedlings 1m x1m (1 m^2) sizes of quadrat were taken respectively. In each quadrat, trees were recorded with >30.1 cm cbh (the circumference at breast height *i.e.*, 1.37 m above the ground) individually measured. Individuals within the circumference at the ground level range of 10.5 to 30.0 cm were considered as saplings, and

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individuals < 10.5 cm circumference at ground level were considered as seedlings. The diameter at the ground level of seedlings was measured using Vernier callipers. The seedling, sapling, and adult stages of the individuals were categorized based on trunk-crown differentiation and the crown form.

2.2 Analysis of regeneration status of native species

The regeneration status of native species was analyzed by comparing saplings and seedlings with the matured trees according to Dhaulkhandi *et al*., (2008) and Tiwari *et al*., (2010).Good regeneration, if seedling>saplings>Adults; fair regeneration, if seedlings> saplings≤ adults; poor regeneration if the species survives only in the sapling stage, but no seedling (saplings may be <, > or= adults); and if a species is present only in an adult stage it is considered as not regeneration (NR)**.**

3. RESULTS

Regeneration status of tree species in protected vegetation sites (Table: 1) as well as in non-protected vegetation sites (Table: 2) have been calculated. In the protected vegetation site, the total seedling was recorded 118.33 ind/ha. The highest seedling density was recorded for *Anogeissus pendula* Edgew. (16.66 ind/ha) followed by *Mitragyna parviflora*. (Roxb.) Korth. (15.00 ind/ha). In the non-protected vegetation site, the total seedling was 1.33 ind/ha, and only one species *Prosopis juliflora* (Swartz) DC. had seedling density (1.33 ind/ha), no seedlings were recorded for other tree species.

Table 1: Regeneration status of tree species in protected vegetation site. (Density is given in ind/ha) (Good = seedling>saplings>Adults; Fair = seedlings> saplings≤ adults; Poor = saplings <, > or= adults but no seedling; NR = only adult)

Plant species	Family	Tree density	Sapling density	Seedling density	Regeneration status
Anogeissus pendula Edgew.	Combretaceae	3.33	13.33	16.66	Good
Mitragyna parviflora. (Roxb.) Korth.	Rubiaceae	1.33	13.33	15.00	Good
Dichrostachys cinerea (L.) Wight & Arn.	Fabaceae	1.33	10	8.33	Fair
Acacia nilotica (L.) subsp. *indica* (Benth.) Brenan	Fabaceae	0.67	6.67	10.00	Good
Azadirachta indica A. Juss.	Meliaceae	2.33	13.33	11.66	Fair
Acacia leucophloea (Roxb.) Willd.	Fabaceae	1.33	8.33	6.67	Fair
Leucaena leucocephala (Lam.) de Wit.	Fabaceae	0.67	8.33	7.33	Fair
Acacia catechu (L.f.) Willd.	Fabaceae	1.00	3.33	7.00	Good

Pongamia pinnata (L.) Pierre	Fabaceae	0.07	4.33	5.00	Good
Securinega leucopyrus (Willd.) Müll.Arg.	Phyllanthaceae	0.33	3.33	5.33	Good
Ficus racemosa L.	Moraceae	0.13	3.33	2.33	Fair
Dalbergia sissoo Roxb. ex DC.	Fabaceae	0.17	1.67	3.33	Good
Butea monosperma (Lam.) Taub.	Fabaceae	0.33	6.67	5.33	Fair
Sesbania sesban (L.) Merr.	Fabaceae	0.10	1.67	3.33	Good
Kirganelia reticulata (Poir) Baill.	Phyllanthaceae	0.07	3.33	2.66	Fair
Tamarindus indica L.	Fabaceae	0.17	1.67	0.66	Fair
Ficus religiosa L.	Moraceae	0.10	0.00	3.00	NR
Albizia procera (Roxb.) Benth.	Fabaceae	0.67	1.67	1.00	Fair
Holoptelea integrifolia (Roxb.) Planch.	Ulmaceae	0.13	0.67	0.33	Fair
Cassia fistula L.	Fabaceae	0.17	0.67	0.33	Fair
Cassia siamea (Lam.) H.S. Irwin & Barneby	Fabaceae	0.17	0.67	0.45	Fair
Dolichandrone falcate (Wall.ex Dc.) Seem.	Bignoniaceae	0.10	1.67	1.33	Fair
Acacia senegal (L.) Willd.	Fabaceae	0.33	0.67	0.30	Fair
Bombax ceiba L.	Fabaceae	0.10	0.00	0.00	NR
Phoenix sylvestris (L.) Roxb.	Arecaceae	0.10	1	0.67	Fair
Pithecellobium dulce (Roxb.) Benth.	Fabaceae	0.07	0.667	0.30	Fair
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	0.17	0.00	0.00	NR
Bauhinia racemosa Lam.	Fabaceae	0.10	1.33	0.00	Poor
Limonia acidissima (L.)	Rutaceae	0.07	0.00	0.00	NR
*Manilkara hexandra (*Roxb.) Dubard	Sapotaceae	0.07	0.00	0.00	NR

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Aegle marmelos (L.) Correa	Rutaceae	0.10	0.00	0.00	NR
Guazuma ulmifolia Lam.	Malvaceae	0.03	0.00	0.00	NR
Ailanthus excelsa Roxb.	Simaroubaceae	0.03	0.00	0.00	NR
Ziziphus mauritiana Lam.	Rhamnaceae	0.07	0.67	0.00	Poor
Dendrocalamus strictus (Roxb.) Nees.	Poaceae	0.17	0.00	0.00	NR
Total		**16.11 ind/ha**	**112.37 ind/ha**	**118.33 ind/ha**	**Fair**

Table 2: Regeneration status of Tree species in non-protected vegetation site. (Density is given in ind/ha) (Good = seedling>saplings>Adults; Fair = seedlings> saplings≤ adults; Poor = saplings <, > or= adults bur no seedling; NR = only adult).

Plant species	**Family**	**Tree density**	**Sapling density**	**Seedling density**	**Regeneration status**
Acacia leucophloea (Roxb.) Willd.	Fabaceae	0.93	13.33	0	Poor
Acacia nilotica (L.) subsp. *indica* (Benth.) Brenan	Fabaceae	0.5	6.67	0	Poor
Azadirachta indica A. Juss.	Meliaceae	0.16	3.33	0	Poor
Dichrostachys cinerea (L.) Wight & Arn.	Fabaceae	1.16	11.67	0	Poor
Securinega leucopyrus (Willd.) Müll.Arg.	Phyllanthaceae	0.26	6.67	0	Poor
Phoenix sylvestris (L.) Roxb.	Arecaceae	0.1	1.67	0	Poor
Ficus racemosa L.	Moraceae	0.1	0	0	NR
Prosopis juliflora (Swartz) DC.	Fabaceae	1.66	3.33	1.33	Fair
Total		**4.87 Ind/ha**	**46.67 ind/ha**	**1.33 ind/ha**	**Poor**

It is observed that in protected vegetation site 22.86% of tree species have good, 45.71 % have fair, 5.71 % have poor and 25.71 % of species are not regenerating (NR) (Figure: 2). In nonprotected vegetation site only 12.5 % of trees have fair regeneration, 75 % have poor, and 12.5 % of species are not regenerating (NR) (Figure: 2).

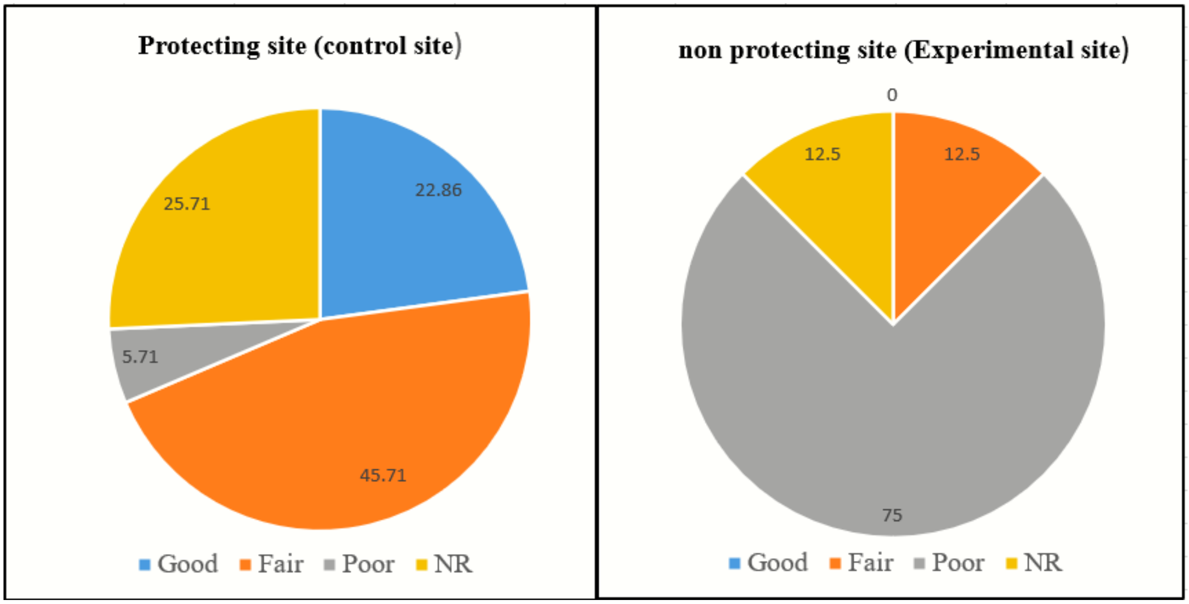

Figure 2: Percentage distribution of regeneration status of tree species in protected and non-protected vegetation sites of Nanta forest region.

The overall regeneration in the studied protected forest area is fair, 45% of tree species have fair regeneration, 22.85% of tree species have good regeneration and 5.71% of tree species have poor regeneration. Dominant species like *Anogeissus pendula* Edgew. *Mitragyna parviflora*. (Roxb.) Korth. *Dichrostachys cinere*a (L.) Wight & Arn., *Acacia nilotica* (L.) subsp. *indica* (Benth.) Brenan, *Azadirachta indica* A. Juss. have fairly-good regeneration. Species like *Bauhinia racemosa* Lam., *Limonia acidissima* L., *Manilkara hexandra* (Roxb.) Dubard, *Aegle marmelos* (L.) Correa, *Guazuma ulmifolia* Lam., *Ailanthus excelsa* Roxb., *Dendrocalamus strictus* (Roxb.) Nees., *Ficus religiosa* L. have shown no regeneration and are represented by only the tree stage. In non-protective sites 12.5% of species are fairly regenerated,12.5% of species are not regenerating and 75% of species show poor regeneration. The seedling density and sapling density in the protected vegetation site were 118.33 ind/ha and 112.37 ind/ha respectively whereas in the non-protective site the seedling density and sapling density were 1.33 ind/ha and 46.67 ind/ha recorded.

4. DISCUSSION

The results of the present study are in accordance with Pokhriyal *et al.*, (2010); Senbeta *et al.*, (2014); Chaturvedi *et al.*, (2017), and Sharma *et al.*, (2018) who reported that higher density of seedlings and saplings, and the presence of young trees in lower girth class indicate a good regeneration status of forest whereas the absence of seedlings results in no regeneration.

In protective site members of family Fabaceae have fair regeneration status this shows the ecological importance of this family. The results are in accordance with earlier studies in this region (Jaiswal & Dadhich, 2010; Dadhich & Jaiswal, 2023; Malav & Jaiswal, 2023). These families may be more tolerant and adaptable to harsher environments, others may require more protection and specific growing conditions (Yadav *et al*., 2018; Andrew, 2020).

In the non-protective site only *Prosopis juliflora* (Swartz) DC. has fair regeneration, the same result was found in the study done by Parandiyal *et al*., (2000) in the Chambal ravine area. It indicates that exotic species can grow faster than other species and spread over the land that is barren and non-protected (Parandiyal *et al.*, 2000). Species like *Dichrostachys cinerea* (L.) Wight & Arn., *Acacia leucophloea* (Roxb.) Willd., *Acacia nilotica* (L.) subsp. *indica* (Benth.) Brenan are native species of this region but due to cutting and long-term grazing by cattle their seedlings are not germinating, hence their density is lower than *Prosopis juliflora* (Swartz) DC.

The presence of species having a 'not regenerating' status would have a direct effect on species richness decline (Baidya *et al.*, 2022). The existence of such non-regenerating or poorly-regenerating individuals will have an immediate impact on the species composition (Sharma *et al*., 2023). Many tree species may eventually have little or no regeneration capability which indicates that these are damaged forests with no restrictions on anthropogenic activity that are causing hindrance to the regeneration of tree species. Furthermore, poor soil qualities make these species' growth unfavorable. Both geological (soil erosion) and anthropogenic (deforestation, grazing, lopping of trees for fodder and fuel-wood, removal of leaf and wood litter from the forest floor) disturbances affect ecosystem stability and slow successional processes (Kumar & Ram, 2005).

Uncontrolled tree clearance and land disturbances including grazing, land cultivation, and firewood collecting drastically diminish species density and have an adverse effect on regeneration. Numerous interconnected and covarying biotic and abiotic ecosystem variables influence the regeneration process (McEwan *et al*., 2011). The degree of anthropogenic pressure and varying climatic conditions influence a species' regeneration status, which causes it to vary at the species level both within and across research sites. Different biotic and abiotic variables have a species-specific impact on the natural regeneration of organisms. Forest area in the non-protected region of Nanta forest has greater influence by various anthropogenic and climatic factors so the overall regeneration status is poor.

The most significant challenges to forest regeneration in degraded areas are seed bank losses, fruit dispersal limitations, intense seed predation, soil nutrient decline, and invasive species competition (Sansevero *et al*., 2011). Many interconnected biotic and abiotic ecosystem variables have a direct influence on the early development stages (seedling and sapling stage) of the trees that may result in the composition of vegetation at the tree regeneration layer (McEwan *et al*., 2011). The survival rate of various tree species during regeneration might range greatly. As a result, composition variations are seen throughout the whole regeneration process (Petritan *et al*., 2007).

According to Saxena *et al*., (1984), a community is showing strong regeneration when there are enough seedlings, saplings, and young trees. The destruction of mature trees, their stumps, and roots, the absence of soil seed banks and seedlings, and the ineffective long-distance dispersal would have detrimental effects on the regeneration of the woody vegetation. The numerous anthropogenic disturbances were shown to have a greater impact on forests growing at non-protected (close to human interference sites), which led to a further decline in seedling and sapling growth. Since the area was not protected, locals were free to engage in uncontrolled wood cutting and other similar activities like the collection of fodder, timber, and firewood, consequently, regeneration of most of the species suffered. Their saplings and seedlings were

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missing. The absence of saplings and seedlings in these species suggested that the population of these species should be raised for long-term persistence. The lack of regeneration may have been brought on by some disturbances already present in the research areas, such as grazing, the removal of fuel wood, and the felling of particular tree species, all of which either influence fruiting or seed germination. Benton & Werner (1976) hypothesized that these populations may go extinct if this trend persists.

In non-protected areas seedling density is negligible (1.33 ind/ha) as compared to sapling density (46.76 ind /ha). Moreover, large tree size is also missing across the non-protected sites. The region behind the absence of regeneration is due to high anthropogenic pressure which has continued for many years. According to Bhuyan *et al*., (2003), no regeneration was seen in the substantially disturbed stand. The establishment of new seedlings and their transition to mature stands are particularly poor as a result of human intervention. If this continues, local species variety will decrease and invasive species will be introduced (Dey & Akther, 2020). In the non-protected vegetation site, anthropogenic disturbances such as fuelwood collecting, cutting, and grazing were found to be the leading cause of poor regeneration. Overgrazing destroys ground flora and prevents the regeneration of important tree species such as *Dichrostachys cinere*a (L.) Wight & Arn., *Acacia nilotica* (L.) subsp. *indica* (Benth.) Brenan, *Azadirachta indica* A. Juss. There could be other reasons for these trees' poor regeneration status, such as low biotic potential, which inhibits fruiting or seed germination, or successful seedling to sapling stage conservation (Sharma *et al.*, 2023).

There are various factors for low seed germination in non-protective site. Abiotic factors like shade, drought, and encroaching, as well as biotic factors like herbivores, root competition, and lack of safe sites for seed recruitment. The tendency of some trees' seeds to seek out dormancy periods, litter accumulation, pathogens, species specificity, and moisture stress, are possible causes of seedling mortality (Atinafe *et al*., 2020). Therefore, more research and ongoing observation of natural regeneration in the study region are required; in particular, it is necessary to look into the condition of soil seed banks to determine regeneration potential. For natural regeneration, local administration should develop monitoring protocols that can be assisted by regional communities (Chazdon *et al.*, 2017).

5. CONCLUSION

The study reveals that anthropogenic activities within the non-protective areas of the Nanta forest region were found to hinder the regeneration potential of many plant species, resulting in a reduction in species diversity. A good number of tree species present in shrub and herb layers represent good regeneration in protected vegetation sites whereas many trees are present only in the shrub layer (sapling state) but not in the herb layer (seedling state) showing very poor regeneration of the natural vegetation. This also proves that grazing and other anthropogenic disturbances have caused over-exploitation of plants in the herbaceous stage. The overall regeneration in the studied protected forest area is fair, 45% of tree species have fair regeneration in this site, but in the non-protective site, 12.5% of species are fairly regenerated, and 75% of species show poor regeneration. Lower regeneration or absence of regeneration is due to high anthropogenic pressure which has continued for many years. In protected site also requires immediate conservation priorities and management for the not regenerating species.

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