

Environmental Restoration Plan for the Conservation of Native Species in the Nanta Forest Region, Kota District, Rajasthan

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ABSTRACT

This paper proposes an environmental restoration plan for conserving native species in the study area. The study was conducted in the Nanta forest area, Kota district, Rajasthan. Sampling was conducted separately using quadrats of varying sizes for trees, shrubs, and herbaceous plants, and a phytosociological analysis of the vegetation was performed. The revegetation plan was recommended on two main principles: ecosystem-based eco-restoration and human-system-based eco-restoration. For ecosystem-based eco-restoration, legume (family Fabaceae), non-legume tree species, and grasses (Family Poaceae) were proposed for revegetation purposes based on IVI. IVI is useful to compare the ecological importance of the species and determine their priority for conservation. For human-system-based eco-restoration, multipurpose tree and shrub species are suggested based on analysis of native vegetation for revegetation purposes.

Keywords: Environmental Restoration Plan (ERP), Ecosystem-Based Eco-Restoration, Human-System-Based Eco-Restoration.

Introduction

Ecological restoration is a method of restoring and rehabilitating degraded ecosystems through the recreation of natural processes and interactions (SER, 2004). This method focuses on re-establishing the pre-disturbance structure, productivity, and species diversity of the forest; thus, the ecological processes and functions of the restored forest will closely match those of the original vegetation. This method focuses on the need to reestablish functional and resilient ecosystems by working with existing biological and environmental circumstances.

Ten golden rules given by Di Sacco et al. (2021) and international standards for ecological restoration (Gann et al., 2019) may prove beneficial for the degraded vegetation. This guideline emphasizes the selection of appropriate sites and the choice of suitable species from native vegetation for the restoration and conservation of local threatened species.

Ecosystem-based eco-restoration helps to conserve biodiversity, improve ecosystem services, and promote long-term environmental sustainability by focusing on restoring the natural dynamics and interactions within ecosystems. To achieve the goal of ecosystem-based eco-restoration, a holistic approach tries to restore the original ecosystem's ecological linkages, functions, and services. This approach involves all the aspects of a functional ecosystem; all the species and components, biotic and abiotic factors that form the complex, interrelated ecosystem. This method aims to imitate the natural processes that formerly shaped and maintained the environment. Nutrient cycling, hydrological cycles, succession, and disturbance regimes are examples of these processes.

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There are numerous ways for eco-restoration of degraded lands, including mechanical and biological treatments, soil amendments to increase productivity, proper land use planning, native plantation, and agroforestry (Mishra et al., 2014). The objective of this paper is to propose plant species for revegetation in the study area (Figure 1).

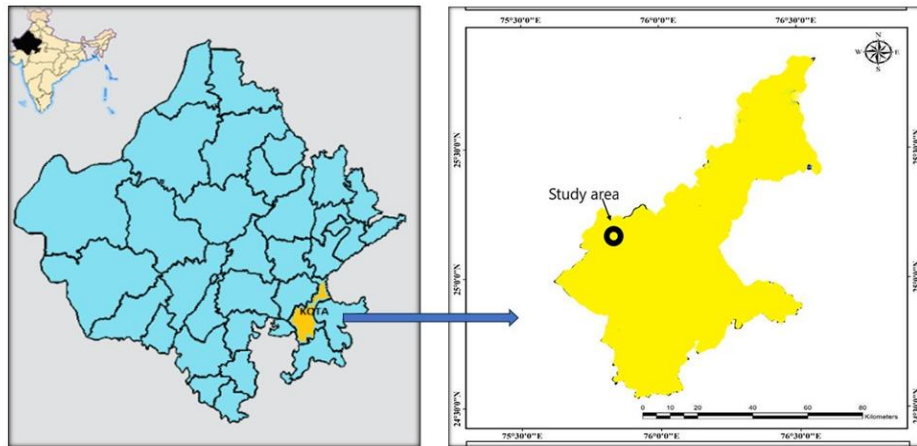


Figure 1: Map of Study Area

Material and Method

Sampling Design & Data Collection

Sampling is done separately using quadrats of different sizes for trees, shrubs, and herbaceous plants. The standard size of the quadrates for sampling trees; shrubs, woody climbers + saplings, and herbs + seedlings taken are 100 m x 100 m (10000 m² or 1 hectare), 10 m x 10 m (100 m²), and 1m x 1m (1 m²) respectively.

- **Phytosociological Analysis of Vegetation:** The vegetation data were quantitatively analyzed for frequency, density, basal area, and IVI (Importance Value Index) following Mueller-Dombois and Ellenberg (1974) and Magurran (1988).

$$\text{Basal area} = \pi r^2 \quad \text{where, } \pi = 3.14$$

$$D(\text{density}) = \frac{\text{Number of aboveground stems of species counted}}{\text{Sample area (ha)}}$$

$$RD(\text{relative density}) = \frac{\text{Density of species A}}{\text{Total density of all species}} \times 100$$

$$F(\text{frequency}) = \frac{\text{The number of plots where that species occur}}{\text{Total number of plots}} \times 100$$

$$RF(\text{relative frequency}) = \frac{\text{frequency of species A}}{\text{Total frequency of all species}} \times 100$$

$$\text{Dominance} = \frac{\text{Basal area of a species A}}{\text{Area sampled(m}^2\text{)}}$$

$$RDo(\text{Relative Dominance}) = \frac{\text{Dominance of species A}}{\text{Total dominance of all species}} \times 100$$

$$IVI = \text{Relative density} + \text{Relative frequency} + \text{Relative Dominance}$$

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Result and Discussion

Ecological restoration through natural forests is a potential option for rejuvenating damaged and degraded areas triggered by active human intervention (Mukhopadhyay et al., 2013). The revegetation plan should be based on two main principles: ecosystem-based eco-restoration and human-system-

based eco-restoration. Though the concepts of these approaches differ, their execution is more or less similar. We propose an integrated revegetation plan that incorporates both of these approaches to make restoration economically feasible as well as ecologically sustainable.

• **Ecosystems-based Restoration of Vegetation**

Selection of plant species for ecosystems-based restoration of vegetation, basic knowledge about the native vegetation (pre- disturbance state) is necessary to identify, dominant species, species distribution pattern, and species resilient to disturbances in the site.

Ecosystem-based restoration prioritizes the use of native species that have coevolved with the ecosystem and are adapted to the local environmental conditions (Le Stradic et al., 2014). Native species are better suited to providing habitat, food, and ecological functions to other organisms in the ecosystem. The species chosen for revegetation are mainly determined by plant adaptability, soil conditions, and climate. Because the restoration goal is usually to restore natural vegetation, the vegetation species are predetermined. Species to be employed in restoration projects should be selected from the local vegetation based on their frequency of occurrence throughout the succession process, which will represent their adaptability to local conditions and relevance to restoration aims (Khater et al., 2003). In non-protective as well as in protective sites native tree species along with herbaceous species should be chosen for revegetation purposes. Introduce companion plants or nurse plants that can provide shade, protection, and habitat for desired native plants as they develop.

Growing grasses is one of the finest practices for increasing soil organic matter content and, as a consequence, for improving soil health and quality. Vegetation layers not only contribute to its organic matter restoration but also fix nitrogen in the soil, regulate soil temperature, maintain soil organisms, and supply habitat for beneficial insects and other species (Buta et al., 2019).

Planting cover crops such as grasses, legumes, or other vegetation can help to prevent soil erosion by stabilizing the soil with their root systems. Revegetation is the procedure of restoring vegetation to infertile or degraded land, frequently intending to improve soil health, avoid erosion, increase biodiversity, and provide ecosystem services. Climate, soil type, available resources, and intended goals will all influence the specific tactics employed. Here are several ways to revegetate barren land: Plantations in degraded areas can perform a variety of ecosystem services, including carbon sequestration, substrate improvement, rehabilitation, and pollutant elimination (Singh et al., 2012). By seeding a grass-legume combination (Tables 1 & 2), we may minimize soil erosion, increase in-place moisture conservation, supply organic matter, stimulate nutrient cycling, and fix nitrogen from the air (Maiti et al., 2021). Legumes are well-known for their beneficial effects, which include biological nitrogen fixation, weed reduction, erosion management as a cover crop, and soil health enhancement (Meena & Lal, 2018). Legumes contribute not only in terms of nourishment, livestock feed, and fertility but also as a source of fuel wood and with their role in carbon sequestration. They assist in increased carbon sequestration and the delivery of co-benefits like a rise in biodiversity, reduced greenhouse gas emissions, and improved soil properties (Yuvaraj et al., 2020). The importance value index is the extent of abundance and dominance of a particular species with respect to the other species in the region. It is useful to compare the ecological importance of the species and determine their priority for conservation (Bogale et al., 2017).

Tree species are recommended for deforested land based on vegetation analysis shown in Table 1. Grass- species were proposed for revegetation purposes shown in Table 2.

Table 1: Density (ind/ha), Basal area (m²/ha), Relative frequency (RF), Relative density (RD), Relative dominance (RDo), and Important value index (IVI) of top 15 tree species for deforested land based on the study of analysis of vegetation.

S.N.	Name of Species	Family	Density (ind/ha)	Basal Area (m ² /ha)	A/F ratio	RF	RD	RDo	IVI
1	<i>Anogeissus pendula</i> Edgew.	Combretaceae	3.33	0.227	0.13	7.32	20.7	29.45	57.47
2	<i>Azadirachta indica</i> A. Juss.	Meliaceae	2.33	0.154	0.08	7.8	14.49	20	42.29
3	<i>Mitragyna parviflora</i> . (Roxb.) Korth.	Rubiaceae	1.33	0.048	0.05	7.32	8.28	6.19	21.79

4	<i>Dichrostachys cinerea</i> (L.) Wight & Arn.	Fabaceae	1.33	0.034	0.05	7.32	8.28	4.4	20
5	<i>Acacia leucophloea</i> (Roxb.) Willd.	Fabaceae	1.33	0.043	0.19	3.9	8.28	5.56	17.74
6	<i>Acacia catechu</i> (L.f.) Willd.	Fabaceae	1	0.04	0.09	4.88	6.21	5.16	16.25
7	<i>Leucaena leucocephala</i> (Lam.) de Wit.	Fabaceae	0.67	0.017	0.03	7.32	4.14	2.16	13.62
8	<i>Acacia nilotica</i> (L.) subsp. <i>indica</i> (Benth.) Brenan	Fabaceae	0.67	0.014	0.03	7.32	4.14	1.84	13.3
9	<i>Albizia procera</i> (Roxb.) Benth.	Fabaceae	0.67	0.017	0.12	3.41	4.14	2.18	9.74
10	<i>Butea monosperma</i> (Lam.) Taub.	Fabaceae	0.33	0.023	0.06	3.41	2.07	3.02	8.51
11	<i>Acacia senegal</i> (L.) Willd.	Fabaceae	0.33	0.009	0.03	4.88	2.07	1.22	8.17
12	<i>Bombax ceiba</i> L.	Fabaceae	0.1	0.01	0.01	4.88	0.62	1.31	6.81
13	<i>Securinegaleucopyrus</i> (Willd.) Müll. Arg.	Phyllanthaceae	0.33	0.004	0.06	3.41	2.07	0.56	6.05
14	<i>Tamarindus indica</i> L.	Fabaceae	0.17	0.015	0.17	1.46	1.04	1.99	4.48
15	<i>Dalbergia sissoo</i> Roxb. ex DC.	Fabaceae	0.17	0.006	0.06	2.44	1.04	0.82	4.29

Table 2: Density (N/m²), Basal area(cm²/m²), Relative frequency (RF), Relative density (RD), Relative dominance (RDo), and Important value index (IVI) of the top 10 grass species identified for revegetation as native ground cover flora based on the study of vegetation analysis.

Name of species	Family	Density (N/ m ²)	Basal Area cm ² /m ²	RF	RD	RDo	IVI
<i>Apluda mutica</i> L.	Poaceae	6.50	7.348	1.19	7.50	10.00	18.70
<i>Themeda quadrivalvis</i> (L.) Kuntze	Poaceae	4.00	3.140	0.30	4.62	4.28	9.19
<i>Brachiaria ramosa</i> (L.) Stapf	Poaceae	3.40	2.669	0.48	3.93	3.63	8.04
<i>Dactyloctenium aegyptium</i> Link	Poaceae	2.80	1.780	0.54	3.23	2.42	6.19
<i>Bothriocholapertusa</i> (L.) A. Camus	Poaceae	3.00	1.507	0.60	3.46	2.05	6.11
<i>Dichanthium annulatum</i> (Forssk.) Stapf	Poaceae	2.00	1.900	1.19	2.31	2.59	6.09
<i>Eragrostis pilosa</i> (L.) P. Beauv.	Poaceae	2.00	1.900	1.07	2.31	2.59	5.97
<i>Aristida adscensionis</i> L.	Poaceae	2.48	1.577	0.60	2.86	2.15	5.61
<i>Setaria pumila</i> (Poir.) Roem. & Schult.	Poaceae	1.98	1.318	1.19	2.29	1.80	5.27
<i>Chloris virgatus</i> SV.	Poaceae	1.97	1.546	0.54	2.27	2.11	4.92

- Human systems-based eco-restoration:** Human system-based eco-restoration is the practice of restoring and revitalizing ecosystems while taking into consideration and including human activities, demands, and interactions. To meet the demand and requirements of local inhabitants, land productivity must be increased in a way that is both economically feasible and socially acceptable, as well as ecologically viable. For disturbed land, native fruit and timber plants may be chosen (Maiti et al., 2021). Multipurpose tree and shrub species identified based on analysis of native vegetation for revegetation purposes are suggested in Table 3.

Table 3: Multipurpose tree and shrub species identified based on phytosociological analysis of native vegetation for revegetation purposes.

Multipurpose tree and shrub species	Uses
<i>Phoenix sylvestris</i> (L.) Roxb.	Food and raw material for cottage industries
<i>Calotropis procera</i> (Alton) W.T. Alton	Fiber, latex, and medicine
<i>Anogeissus pendula</i> Edgew.	Timber and leaves used in dying
<i>Jatropha curcas</i> L.	Biofuel

<i>Acacianilotica</i> (L.)subsp. <i>indica</i> (Benth.)Brenan	Food,gum,and timber
<i>Acacia senegal</i> (L.) Willd.	Fodderandgumarabica
<i>Butea monosperma</i> (Lam.) Taub.	Leaves for the preparation of eco-friendly plates, food
<i>Bauhinia racemosa</i> Lam.	Timber, fuel, fodder, and medicine
<i>Dalbergia sissoo</i> Roxb.	Timber and medicine
<i>Leucaena leucocephala</i> (Lam.) de Wit.	Fodder and biomass
<i>Pongamia pinnata</i> (L.) Pierre	Biofuel
<i>Azadirachta indica</i> A. Juss.	Timber, medicine, and pesticides
<i>Ziziphus mauritiana</i> Lam.	Food, timber, and medicine
<i>Ziziphus nummularia</i> (Burm.f.) Wight. & Arn.	Food, fuel, and medicine

Establishing biofuel plantations (e.g., *Jatropha curcas* L., *Pongamia pinnata* (L.) Pierre) on degraded soils can be beneficial in many ways as specific problems (e.g., nutrient and water imbalance, loss of topsoil, shallow rooting depth, drought stress, salinization, compaction, crusting) are managed (Lal, 2006). *Leucaena leucocephala* (Lam.) de Wit. produced a significant amount of biomass (Mishra and Nayak, 2000). While investigating the flora of the study area, it was discovered that *Acacia* is the most dominant genus, hence the production of plant's biomass potential may be analyzed. Fast-growing exotic tree species brought into the environment resulted in the loss of ecosystem services, biodiversity, and the ability to sequester CO₂ (Ghosh & Maiti, 2021). So, revegetation through native vegetation is more beneficial.

Conclusion

Through forestry, selected native species like members of the family Fabaceae can be chosen for planting and seeding. Plantation of native Grass-Legume combinations in the experiment sites not only increases the soil fertility but also, these species can survive in the present environmental condition. The quantitative analysis carried out in the present research work may provide a foundation for developing future conservation and management plans for these forest stands. Strong regulating mechanisms against woody species harvesting and the development of area enclosures to limit livestock grazing would also promote natural regeneration and rehabilitation of the investigated forest. For the revegetation purpose multipurpose plant species that fulfil the requirements of food, fodder, timber, etc of the local community must be selected and local inhabitants must be engaged in revegetation, monitoring, and maintenance of the forest areas under restoration.

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