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HARNESSING THE ECOLOGICAL POTENTIAL OF REGENERATING TREE SEEDLINGS IN SEMI-NATURAL URBAN ENVIRONMENTS

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ABSTRACT

With increasing awareness of the adverse impacts of climate change, pollution, wildfires, and deforestation, semi-natural environments (SNEs) have garnered significant attention, particularly in urban areas. Tree planting has emerged as a central activity in initiatives led by governments, NGOs, and institutions, expanding urban greenery and green spaces especially in SNEs. However, naturally regenerating tree seedlings in these SNEs resulting from seed dispersal, germination, and growth without direct human intervention face numerous challenges, including removal during sanitation activities, mechanical destruction, and neglect. This study investigates the ecological potential of naturally regenerating tree seedlings in urban SNEs, focusing on sustainable management strategies that enhance ecosystem services, urban forestry, and biodiversity conservation. The findings emphasize the benefits of these seedlings, such as reducing reliance on commercially purchased saplings, fostering acceptance of native species, and encouraging greater community involvement in urban greening initiatives. In urban SNEs, naturally regenerating tree seedlings can be utilized for community-based agroforestry, urban reforestation, protecting biodiversity, nursery development, and educational initiatives. The study comes to the conclusion that utilizing these seedlings ecological, financial, and social advantages can greatly help to create greener, healthier, better and more sustainable urban environments.

Keywords: Semi-natural habitats, Aesthetic Benefits, Urban Wildlife, Seedling Transplantation, Nursery, Reforestation.

INTRODUCTION

Semi-natural environments (SNEs) refer to areas where natural ecosystems have been modified by human activities but where energy and nutrient flow still depend on natural factors (Riechers et al. 2016). These environments, often found in urban/ peri-urban areas, blend human influence with natural elements, such as memorial, ornamental, biodiversity, and botanical gardens; urban parks; school, college, and institutional campuses; and plantations like avenue, agroforestry, and social forestry (Dobhal and Uniyal, 2023; Nandal et al. 2023). These SNEs are crucial for urban populations and biodiversity, especially in areas where natural forests are nearly absent due to habitat fragmentation and construction activities such as building roads and infrastructure development (Tscharntke et al. 2016; Bartual et al. 2019). Such SNEs play a vital role in preserving biodiversity, mitigating environmental issues, and enhancing human well-being by providing access to green spaces. Additionally, they offer economic benefits, improve climate resilience, and encourage community engagement, contributing to the sustainability and livability of urban areas (Sharma et al., 2024). In some cases, apart from providing nesting and food sources, urban avenue and garden trees serve as the only available habitat for birds, bees, butterflies, insects, and small animals (Pautasso et al. 2011; Holland et al. 2017). A famous example is the Great Banyan Tree (GBT), located in the AJC Bose Indian Botanic Garden (Shibpur, Howrah), a globally renowned marvel. With its vast canopy spanning approximately 18,918 square meters, it resembles a

miniature forest rather than a single tree and provides numerous ecological and socio-economic services (BSI 2024).

With increasing awareness of the adverse impacts of climate change, pollution, wildfires, deforestation, and different natural calamities, semi-natural urban ecosystems have gained significant attention, particularly in metropolitan cities. Tree planting has become a key component of various initiatives, celebrations, and programs led by governments, NGOs, and institutions at individual or community level, contributing to the expansion of urban greenery and green spaces. The acclimatized and adapted trees in these SNEs yield fruits and seeds, some of which disperse, germinate, and develop into seedlings. Such regeneration occurs naturally without direct human intervention, encompassing processes like seed dispersal, germination, and seedling growth to the sapling stage (Bongers 1995). At the ecosystem level, it refers to the initial phases of forest establishment and development within the forest growth cycle. However, without proper management, these seedlings face numerous challenges. They are often removed during sanitation, weeding, or pruning activities, neglected, or mechanically destroyed, limiting their potential to support urban SNEs.

Despite their ecological and economic potential, the use of naturally regenerating tree seedlings in SNEs is hindered by several factors. These include limited awareness among campus/garden authorities and local communities regarding the value of these seedlings, a lack of space for transplantation in densely populated urban areas, and threats from routine sanitation practices that result in premature seedling removal. This study aims to address these challenges by proposing strategies for the effective management and utilization of naturally regenerating seedlings. These efforts can enhance biodiversity conservation, ecosystem services, and the development of sustainable urban greenery.

MATERIALS AND METHODS

The authors' perspectives, knowledge, and experiences gained through in-depth fieldwork and in-person visits to various metropolitan locations, such as Dehradun, Haridwar, Roorkee, Rishikesh, Kotdwar, Pantnagar, etc. form the foundation of this study. The primary objective of these visits was to randomly observe naturally regenerating tree seedlings in urban in SNEs, including parks, school campuses, road plantations, and residential neighborhoods **(Figure 1-2).** Particular attention was given to factors influencing seedling growth, such as community involvement, adequate space, and sanitation practices. In addition to field observations, informal interviews and discussions were conducted with urban planners, municipal employees, gardeners, and local community members to gather insights into current practices, challenges, and attitudes regarding the management of naturally regenerating seedlings. These interactions enriched the understanding of regional urban greening approaches and contextualized the field findings. Data collection involved visual observations and photographic documentation to record the condition and growth of seedlings. To support the core findings, secondary data such as relevant reports, case studies, and literature were also analyzed. These sources were appropriately cited to ensure the study's reliability and provide additional context.

OBSERVATIONS AND DISCUSSION

NURSERY DEVELOPMENT

Naturally regenerating tree seedlings in various SNEs have significant potential for use in nursery development, which can be approached in several ways:

On-Site Seedling Banks

Owners, staff, or agencies managing their SNEs can directly utilize these seedlings as a ready-made ‘seedling bank’. These seedlings can be transplanted within the same area to fill gaps or distributed among various stakeholders for planting in other locations.

Educational Institution Nurseries

A small-scale nursery can be established using the shed seeds or germinated seedlings within SNEs, particularly in educational institutions like colleges and universities. Biology students can maintain and manage these nurseries as part of their curriculum or research projects. This approach not only integrates hands-on learning but also fosters environmental stewardship. Instead of purchasing seedlings for “Environmental Events,” stakeholders such as students, teachers, and the general public can use these small-scale nurseries with naturally regenerating seedlings for direct transplantation.

Community Engagement and Distribution

Seedlings collected from various SNEs can be distributed to different stakeholders, including schools, residential societies, and community groups, for planting during events or celebrations. This ensures the efficient utilization of seedlings that might otherwise be neglected or removed

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Commercial and Forest Nurseries

Governmental, semi-governmental, or private nurseries can incorporate an additional section specifically for transplanted seedlings sourced from various SNEs. Nursery staff can maintain a record of seedling sources and manage their care.

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Figure 1: (a)-(f) Different tree species growing a Semi-natural environment (Pt. L. M. S. Campus, SDSUU, Rishikesh, Dehradun, Uttarakhand).

These seedlings can then be distributed or transplanted during plantation drives, ensuring a sustainable and cost-effective supply for large-scale greening efforts.

ECOLOGICAL POTENTIAL

The spontaneous growth of naturally regenerating tree seedlings in SNEs offers immense ecological benefits. These seedlings, often native species, are well-adapted

to local conditions and contribute to urban biodiversity. By utilizing these seedlings, urban planners can promote cost-effective, sustainable greening initiatives, reduce dependency on nursery-grown saplings, and ensure ecological resilience.

Urban Reforestation and Greening Projects

Naturally regenerating seedlings serve as a cost-effective resource for urban reforestation, social forestry, and greening initiatives. They can be relocated to urban parks, gardens, and other SNEs to boost biodiversity, provide shade, and enhance visual appeal. Additionally, these plantations contribute to mitigating air pollution and alleviating the urban heat island effect (Yadav et al. 2024). Similarly, institutional campuses benefit from green spaces that promote mental well-being and create serene environments (Nandal et al. 2023). This approach not only reduces costs but also encourages the use of native species, strengthening their role in urban ecosystems.

Figure 2: (a) Mature tree of *Syzygium cumini*. **(b)** Broad Close-up view of growing seedling population. **(c & d)** Broad view of the seedling population beneath the *S. cumini* tree located.

Community-Based Agroforestry

Many SNE trees, such as Jamun (*Syzygium cumini*), Imli (*Tamarindus indica*), Neem (*Azadirachta indica*), Bel (*Aegle marmelos)*, Amla (*Phyllanthus emblica*), Ber (*Ziziphus mauritiana*), Mango (*Mangifera indica*), Peepal (*Ficus religiosa*), Kadamba (*Neolamarckia cadamba*), Mahua (*Madhuca indica*), etc. offer edible fruits rich in antioxidants and medicinal properties. These seedlings can be distributed to local communities for agroforestry, where they can be integrated with crops to improve soil fertility, provide shade for shade-tolerant plants, and enhance agricultural yields (Rawat and Gaur 2024; Rawat et al. 2024). Additionally, the sale of tree-derived products like fruits, seeds, and leaves can generate income for communities. This practice fosters sustainable land use and strengthens connections between urban populations and their ecosystems.

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Biodiversity Conservation and Habitat Restoration
Naturally regenerating seedlings play a critical role in biodiversity conservation and habitat restoration (Das et al. 2021). Many tree species in SNEs act as keystone species, supporting urban wildlife, including birds, mammals, and insects. Transplanting these seedlings into degraded or fragmented habitats can restore ecosystems by creating food sources and microhabitats for pollinators and seed dispersers. These seedlings can also be used for social forestry projects, forest conservation, and wasteland restoration, contributing significantly to biodiversity and ecosystem stability.

Educational and Research Opportunities
The presence of naturally regenerating seedlings offers numerous educational and research opportunities. Schools and universities can engage students in hands-on learning about plant ecology, biodiversity, and sustainable urban development. Seedlings can be incorporated into botanical gardens or used for reforestation studies to explore growth patterns and ecological roles. As '*open field botanical experimesntal laboratories'*, these spaces can provide invaluable insights into ecological dynamics and plant responses to urban environments. Workshops, tree-planting drives, and citizen science initiatives can raise awareness about urban green space conservation while inspiring active participation in environmental stewardship.

Contribution to Urban Carbon Sequestration
Trees in SNEs contribute significantly to urban carbon sequestration, helping mitigate climate change (Fares et al. 2017). Their fast growth and dense foliage capture atmospheric carbon dioxide, store it in biomass, and improve air quality by filtering pollutants (Velasco et al. 2016). Additionally, these trees regulate the urban climate by lowering temperatures, increasing humidity, and reducing dust levels (Kumar et al. 2019). Integrating SNEs seedlings into urban forestry programs enhances the carbon sequestration capacity of cities, making them a critical component of climate change mitigation strategies.

CONCLUSIONS

Naturally regenerating seedlings in SNEs often germinate readily under favorable conditions, requiring little to no human intervention. By adopting sustainable management practices and actively engaging local communities, these seedlings can play a significant role in enhancing urban forestry, conserving biodiversity, and mitigating climate change, ultimately transforming urban landscapes into thriving ecosystems. Key recommendations include launching awareness campaigns to educate stakeholders about the benefits of utilizing naturally regenerating seedlings, establishing dedicated nursery areas to temporarily house seedlings before transplanting, and collaborating with local governments and NGOs to identify suitable sites for transplantation and secure funding for urban greening projects. Additionally, incorporating seedling management into the regular maintenance of urban green spaces can ensure the survival and growth of these valuable resources, fostering healthier and more sustainable urban environments.

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