



CSIR - NEERI
*A constituent laboratory of Council of
Scientific & Industrial Research (CSIR)*

2025 ENVIRONMENTAL SUSTAINABILITY & GOVERNANCE REPORT



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In association with



Indian association of Environmental Managements



NEERI
Sustainability Hub

Science to Solutions for Environmental Resilience

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निदेशक
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FOREWORD



Climate change, pollution, and resource depletion are transforming how society operates, requiring urgent science-based actions from environmental stewardship institutions. As a leading national laboratory devoted to environmental research and innovation, CSIR-NEERI recognises its responsibility not only to generate knowledge but also to demonstrate sustainability in practice. In this direction, the institute is advancing the concept of a sustainable campus as a living laboratory, where research, operations, and community engagement are seamlessly integrated.

CSIR-NEERI has long been at the forefront of research on air quality, water and wastewater management, solid and hazardous waste, environmental biotechnology, climate change, and environmental impact assessment. Building on this tradition, we are expanding our research into clean technology, circular economy models, nature-based solutions, and climate resilience. Central to this vision is the concept of a Living Lab, where our campus functions as a dynamic test bed integrating research, innovation, and real-world application to foster sustainability. Through collaborative engagement among researchers, stakeholders, and users, and by drawing upon the principles of the Panch Bhoota we aim to develop balanced, nature-aligned solutions for emerging environmental challenges.

This report aims to advance environmental research and serve as a model for others. More significantly, it summarises the lessons learned from implementing sustainability practices within a real-world institutional setting.

As a research institute, we believe in the integration of sustainability principles into our institute. Recognising sustainability as a collaborative effort, we actively encourage engagement from our academic community. We aim to develop a shared feeling of responsibility and engagement at all levels of the institution.

With all good wishes.

(Dr. S. VENKATA MOHAN)



ACKNOWLEDGEMENTS

We are grateful to the Director, CSIR-National Environmental Engineering Research Institute, Nagpur, for his continuous encouragement and his visionary leadership in advancing campus sustainability goals.

We sincerely acknowledge CSIR-National Environmental Engineering Research Institute for the financial support through the OLP-74 Project, "Living Lab @ CSIR-NEERI: A Sustainable Campus Initiative" which made this work possible.

We also thank all scientist and project staffs for their valuable contribution to this report.

Our appreciation extends to BDPMD, finance, store-purchase, and security teams for their steadfast support throughout our sustainability initiatives.

Their collaborative efforts have been instrumental in driving meaningful progress on campus.

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CSIR-NEERI campus demonstrates a progressive transition toward sustainability through its Living Lab approach, integrating environmental management, research, and operational practices. Spread across 46 hectares, the campus demonstrates a strong commitment to environmental stewardship through its focus on biodiversity conservation, resource efficiency, and climate resilience. The baseline assessment indicates an overall sustainability score of 77.5/100, with notable strengths in energy conservation, water stewardship, biodiversity, and mobility management.

The campus supports rich ecological diversity, hosting 83 tree species along with diverse fauna, contributing significantly to ecosystem services such as carbon sequestration, microclimate regulation, and air purification. Renewable energy initiatives, particularly solar installations, and energy-efficient infrastructure highlight progress toward decarbonisation, although renewable energy contribution remains moderate (10–25%). Water management practices, including rainwater harvesting and partial reuse, are well established, though wastewater treatment systems require improvement. Key gaps are identified in solid waste management, policy formalisation, and sustainability reporting. Spatial analysis also indicates a gradual increase in built-up areas with a corresponding decline in dense vegetation, underscoring the need for balanced land-use planning.

Overall, the report positions CSIR-NEERI as a model for sustainable campuses in India, while emphasizing the need for strengthened governance, circular waste practices, and enhanced integration of sustainability into institutional frameworks for long-term impact.



TOTAL CARBON FOOTPRINT

3174.18
tCO₂e/year



RENEWABLE ENERGY

~22–25%



WATER RECYCLING

<25%



GREEN COVER

~54%
of campus area



About the Campus

The CSIR-National Environmental Engineering Research Institute (CSIR-NEERI) in Nagpur is a national research institute established in 1958 by the Council of Scientific and Industrial Research (CSIR). The campus promotes interdisciplinary research to tackle environmental issues, including air and water pollution control, waste management, climate change mitigation, environmental monitoring, impact assessment, and ecosystem services. The institute also plays a crucial role in national priority missions such as water and sanitation initiatives, sustainable waste practices, clean air programs, and rural development projects, while encouraging knowledge sharing, capacity building, and partnerships with industries, government agencies, and international organisations.

The CSIR-NEERI campus, spanning about 46 hectares, exemplifies sustainable campus design as a Living Laboratory and Long Term Urban Ecological Observatory (LTUEO), integrating Nature-based Solutions for urban resilience. This is an ecological hotspot with 83 tree species and a diverse range of flora and fauna, fostering biodiversity. Key sustainability pillars include renewable energy initiatives such as rooftop solar infrastructure, drone-aided systems for gas scanning, Thermal walls, etc. The campus's first eco-friendly local building got registered with Griha, a scheme launched by the Ministry of New and Renewable Energy, inaugurated years ago, uses 70% recyclable materials, saves 60% water and 30% electricity via natural light optimisation and courtyard-centric design, setting a precedent for all future constructions.

Decarbonisation activities, low-impact resource management, and real-world experimentation enable revolutionary innovations, establishing CSIR-NEERI as India's framework for nature-positive, climate-adaptive campuses that combine research, teaching, and implementation to achieve complete sustainability.





Vision

Leadership in Environmental Science and Engineering for Sustainable Development.

Mission

CSIR-NEERI would continue to strive for providing innovative and effective solutions for environmentally sustainable development and to help Government, industry and the society, especially the 800 million underprivileged people of India.



Spatial Distribution

The spatial analysis of the CSIR-NEERI campus indicates a gradual increase in built-up area from 50.94% in 2015 to 52.49% in 2025, followed by a decline in dense vegetation from 47.1% to 40.71%, while sparse vegetation shows a marginal increase as shown in Figure: 1. NDVI (2025) reflects a similar pattern, with built-up areas dominating (52.2%) and dense vegetation reduced (44.1%), confirming a shift in land cover towards infrastructure (Figure: 2). NDBI as in Figure: 3 further reinforces this trend, highlighting expansion of built surfaces. NDMI (Figure: 4) patterns reveal that areas with dense vegetation retain higher moisture (bluish tones), whereas built-up zones exhibit lower moisture and higher dryness (yellowish-red tones), indicating reduced ecological function in developed areas.

Despite the slight decrease in dense vegetation, the campus retains significant green cover, which plays a crucial role in moderating microclimate conditions. The presence of dense vegetation contributes to evapotranspiration, shading, and moisture retention, thereby reducing land surface temperature (Figure: 5). As a result, the CSIR-NEERI campus experiences comparatively lower temperatures, typically 2–3°C cooler than surrounding urban areas of Nagpur, demonstrating the effectiveness of green infrastructure in mitigating urban heat island effects and enhancing campus sustainability.



Photoplate 1:
Drone based
image showing
campus dense
vegetation





Figure 1:
Land use
Land Cover
Maps of
CSIR-NEERI



Figure 2:
Normalized
Difference
Vegetation
Index of
CSIR-NEERI

Figure 3:
Normalized
Difference
Build-up
of
CSIR-NEERI



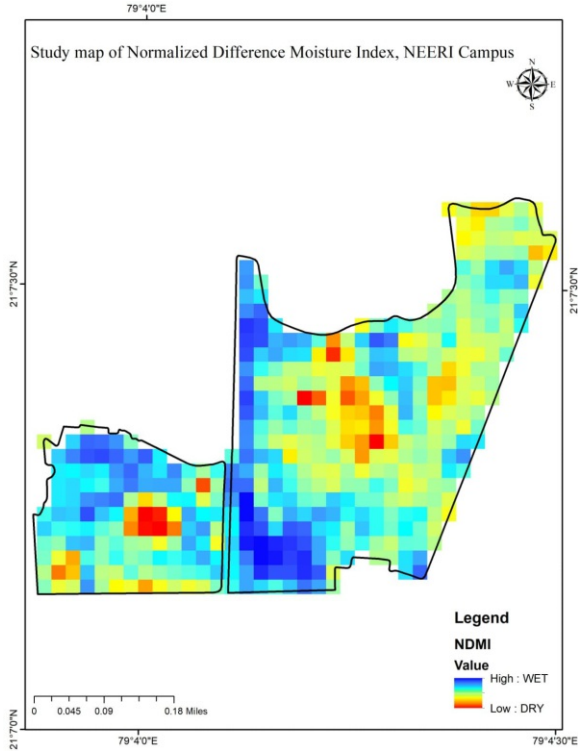


Figure 4:
Normalized
Difference
Moisture
Index of
CSIR-NEERI

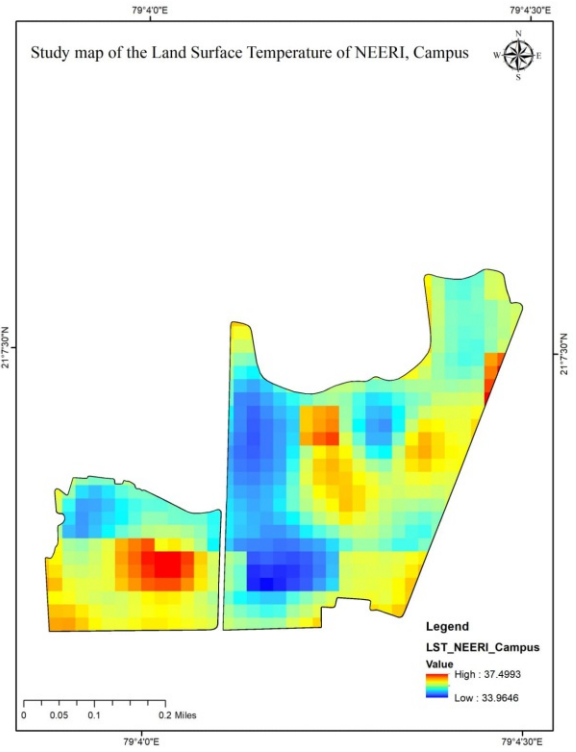


Figure 5:
Land
Surface
Temperature
of
CSIR-NEERI



BASELINE ASSESSMENT OF CAMPUS

The baseline assessment of the campus was carried out through a structured questionnaire survey administered to scientists and representatives of various functional sectors. The questionnaire was designed to capture key information on existing sustainability practices, resource use, infrastructure, and management systems. Responses included both attempted and unattempted questions, providing insights into areas with adequate data as well as gaps requiring further attention. Additionally, at the end of the questionnaire a benchmarking matrix of campus sustainability represents framework used to align the campus sustainability questionnaire with recognized national and international standards and assessment systems. This serves as a comprehensive mapping tool that integrates the questionnaire with standardized metrics for evaluation, benchmarking, and future planning.

1. Governance & Policy

(Weightage: 10/ Marks Obtained: 10)

1. Does the institute have a formally adopted sustainability/environmental/climate policy aligned with ISO 14001 or equivalent?
 Yes No Not Sure
2. Is there a dedicated Sustainability/Green Campus Cell or Committee with defined roles?
 Yes No Not Sure
3. Does the institute publish annual sustainability or SDG progress reports?
 Yes No Not Sure
4. Are institutional sustainability guidelines, SOPs, or measurable targets available?
 Yes No

2. Energy & Resource Efficiency

(Weightage: 25/ Marks Obtained: 17.5)

1. Annual electricity consumption: 1,53,968 kWh/year
2. Does the campus use on-site or procured renewable energy?
 Yes No Not Sure
3. If yes, specify:
 Solar Wind Biomass Geothermal
 Other: _____
4. % of renewable energy in total energy mix:
 >50% 25–50% 10–25% <10%
5. Energy efficiency measures in place (tick all that apply):
 LED lighting Motion sensors
 Energy-efficient appliances (Energy Star/5-star rated)
 Building insulation Energy audits (ISO 50001 aligned)
 Smart meters/IoT energy tracking BLDC Fans
6. CO₂ savings in tons(T) each year due to renewable energy sources
 >100T 75–100T 50–75T <50T
7. Share of 5-star rating ACs on the campus
 >50% 25–50% 10–25% <10%
8. Does the campus use a solar water heater for water heating?
 Yes No Not Sure
9. Share of solar water heater in the campus from all water heaters
 >50% 25–50% 10–25% <10%



10. Energy literacy of the campus :
 >50% 25–50% 10–25% <10%

3. Water Stewardship

(Weight: 15 / Marks Obtained: 15)

1. Annual water consumption in your building/department (if known):
232696 m³/year
2. Rainwater harvesting structures exist: Yes No Not Sure
3. Wastewater treatment & reuse system in place: Yes No Not Sure
4. Recycled water is used for:
 Gardening Cooling towers Toilets
 Laboratory processes Others: _____
5. Frequency of observed water leakage/wastage:
 Never Rarely Sometimes Often
6. Water management plan aligned with ISO 46001
(Water Efficiency Management Systems):
 Yes No Not Sure

4. Solid Waste & E-Waste Management

(Weightage: 15/Marks Obtained : 3)

1. Approximate total solid waste generated in the campus per day/week/month: ____ kg
2. Waste segregation at source:
 Yes No
3. Percentage of recyclables recovered and sent to authorized recyclers:
 >75% 50–75% 25–50%
 <25% Not Tracked
4. Does the campus have tie-ups with local recyclers or material recovery facilities (MRFs)?
 Yes No
5. Organic waste composting/biogas plant:
 Yes No Not Sure
6. E-waste collected & disposed through authorised recyclers (as per Basel Convention compliance):
 Yes No Not Sure
7. Single-use plastic reduction/elimination policy:
 Yes No Not Sure
8. Hazardous waste management in line with international standards:
 Yes No Not Sure
9. Are students and staff regularly sensitized/trained on waste segregation and reduction?
 Yes No
10. Participation rate in campus waste segregation (based on audits or observation):
 >80% 50–80% <50% Not Known
11. Are there initiatives for circular economy practices (e.g., upcycling, repair cafés, refill stations)?
 Yes No
12. Does the campus encourage green procurement (e.g., products with minimal packaging or recyclability)?
 Yes No



13. Does the institute conduct periodic waste audits to quantify and classify solid, hazardous, and e-waste streams?
 Yes No Not Sure
14. Is there a designated on-campus waste storage or transfer facility that complies with CPCB/Basel Convention standards?
 Yes No Not Sure
15. Does the institute promote zero-waste or low-waste events (e.g., conferences with reusable utensils, paper-free meetings)?
 Yes No Not Sure

5. Campus Ecosystem & Biodiversity

(Weightage: 15/Marks Obtained : 15)

1. Estimated green cover (% of campus area): 54 %
2. Green spaces you use/observe:
 Gardens Lawns Herbal garden
 Tree belts Wetlands/Water bodies
3. Number of tree/plant species known in campus: 83
4. Preference for native/endemic species in landscaping:
 Yes No Not Sure
5. Existence of biodiversity monitoring and conservation programs:
 Yes No Not Sure
6. Integration with IUCN Red List or national biodiversity registers:
 Yes No Not Sure

6. Mobility & Pollution Control

(Weightage: 10/Marks obtained:10)

1. Primary mode of commuting:
 Walking Bicycle Public Transport
 Private Vehicle Institute Shuttle Other: _____
2. EV charging stations available:
 Yes No Not Sure
3. Measures to reduce vehicular emissions:
4. Car-pooling incentives Restricted vehicle zones
 EV promotion Cycling infrastructure: NIL
5. Air quality monitoring (aligned with WHO/ISO AQ standards):
 Yes No Not Sure

7. Academic & Research Contributions

(Weightage: 20/Marks Obtained:12)

1. Number of sustainability/environment-related research projects you are involved in: _____
2. Integration of sustainability topics into academic curriculum & thesis work:
 Yes No
3. Patents/publications/technologies developed for sustainability: _____
4. Community outreach/training on sustainability:
 Yes No
5. Research aligned with UN SDGs and national climate commitments:
 Yes No



8. Social & Cultural Indicators (Weightage: 10/Marks Obtained:10)

1. Gender diversity (% female staff): **22.7 % (Only in Headquarters)**
2. Accessibility of campus for differently-abled persons:
 - Fully accessible (Universal Design compliant)
 - Partially accessible Not accessible
3. Health, safety & wellness programs attended in last year:
 - Yes No
4. Institute participation in local community development projects (aligned with SDG 11 & 17):
 - Yes No Not Sure

9. Perceptions & Suggestions :

1. Overall campus sustainability rating (1–5): **3.8 (77.5/100)**
2. Strongest sustainability practice in the institute: **Energy conservation**
3. Suggestions for improvement: **Focus on water conservation/recycling/ reuse, and waste management**



LINK:

https://docs.google.com/document/d/1tdtpznuQUZEUgfvWQJ0MNAkSgCqcqSY14aN0_dEI-cM/edit?usp=sharing

BENCHMARKING MATRIX FOR CAMPUS SUSTAINABILITY QUESTIONNAIRE

Section	Key Indicators in Questionnaire	UI GreenMetric Category	AASHE STARS Credits	Relevant ISO Standards	UN SDGs
Governance & Policy	Sustainability policy, green campus cell, SDG reporting, awareness of SOPs	Setting & Infrastructure (SI)	Planning & Administration (PA), Coordination & Planning	ISO 14001 (Environmental Mgmt), ISO 50001 (Energy Mgmt)	SDG 13 (Climate Action), SDG 17 (Partnerships)
Energy & Resource Efficiency	Electricity use, renewable energy %, energy efficiency measures	Energy & Climate Change (EC)	Operations (OP 5 – Building Energy Consumption, OP 6 – Clean Energy)	ISO 50001 (Energy Mgmt)	SDG 7 (Affordable & Clean Energy), SDG 13
Water Stewardship	Water consumption, rainwater harvesting, wastewater treatment & reuse	Water (WR)	OP 21 – Water Use, OP 22 – Rainwater Mgmt	ISO 46001 (Water Efficiency Mgmt)	SDG 6 (Clean Water & Sanitation)
Solid Waste & E-Waste	Waste segregation, composting, authorised e-waste disposal, plastic reduction	Waste (WS)	OP 20 – Waste Minimisation, OP 23 – Hazardous Waste Mgmt	ISO 14001 (Waste Mgmt), Basel Convention compliance	SDG 12 (Responsible Consumption & Production)
Ecosystem & Biodiversity	Green cover %, native species, biodiversity monitoring	Setting & Infrastructure (SI), Education & Research	OP 10 – Biodiversity	ISO 14001 (Biodiversity Mgmt)	SDG 15 (Life on Land)
Mobility & Pollution Control	Commuting modes, EV charging, emission reduction, air quality monitoring	Transportation (TR)	OP 17 – Campus Fleet, OP 18 – Commuting	ISO 14001 (Air Quality Mgmt)	SDG 11 (Sustainable Cities), SDG 13
Academics & Research	Research projects, curriculum integration, patents/publications, community outreach	Education & Research	AC 1 – Academic Courses, AC 2 – Learning Outcomes, AC 3 – Undergraduate Programmes, AC 4 – Graduate Programmes	–	SDG 4 (Quality Education), SDG 9 (Industry, Innovation)
Social & Cultural Indicators	Gender diversity, accessibility, health & wellness programs, community engagement	Education & Research, Social Engagement	PA 3 – Diversity & Equity Coordination, PA 6 – Support for Underrepresented Groups	ISO 26000 (Social Responsibility)	SDG 5 (Gender Equality), SDG 10 (Reduced Inequalities), SDG 3 (Good Health)



ENVIRONMENTAL GOVERNANCE AND POLICY FRAMEWORK AT CSIR-NEERI

The institute develops eco-technologies, including waste valorization, bio-inspired solutions, waste-to-energy technologies, and sustainable water treatment methods.



A key focus is transforming waste into resources and promoting cleaner technologies in industry and urban environments.



Research focused on sustainable energy, including biomass-based fuels and reducing emissions to ensure an equitable transition to renewable energy sources.



NEERI is developing its Nagpur campus as a living lab, serving as a testbed for low-impact resource management, carbon neutrality, and nature-inspired restoration.



NEERI contributes to national policy-making for environmental management, such as the Swachh Bharat Mission and Clean Air initiatives etc, by providing scientific data & environmental compliance audits.



Green Skill Development Program, NEERI trains personnel to implement Environmental Management Plans (EMPs) and sustainable practices.



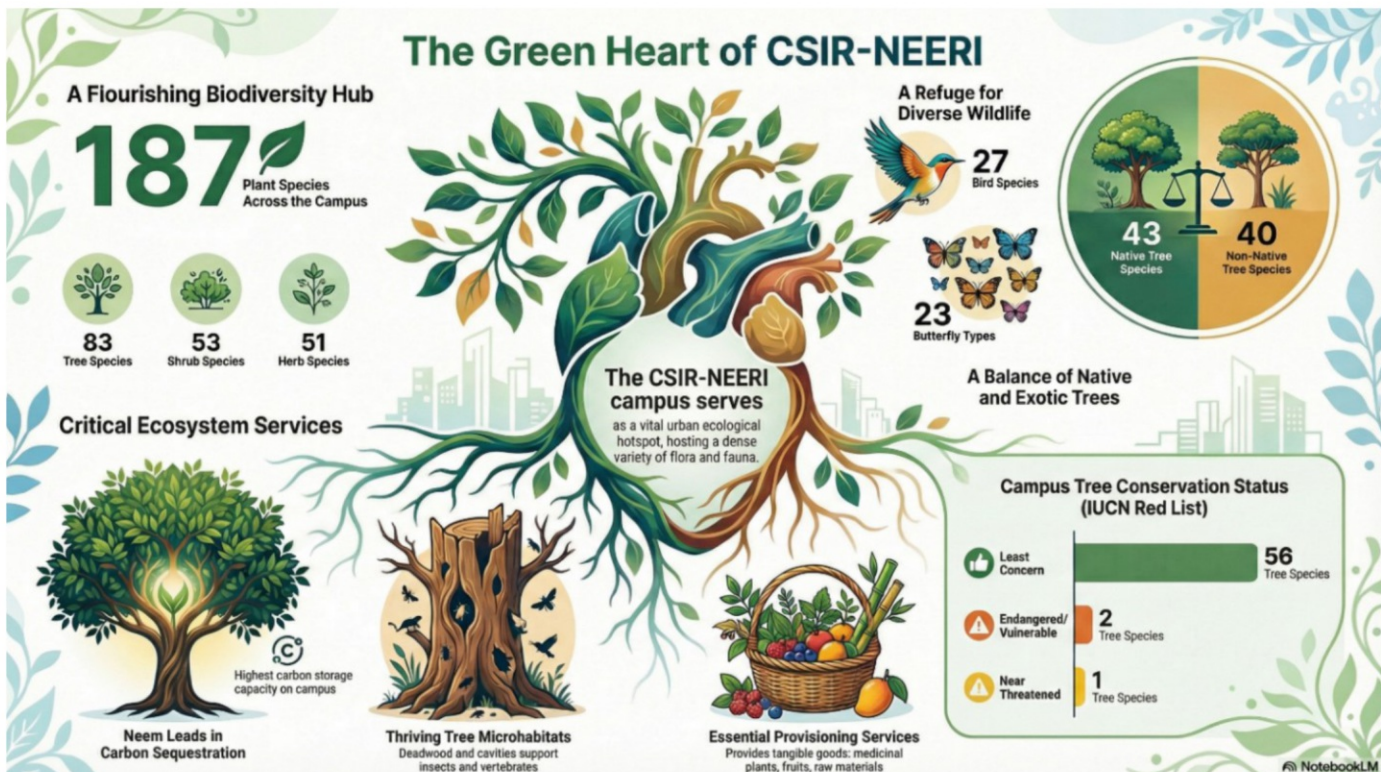
Regular monitoring, auditing, and benchmarking of sustainability performance.



CHAPTER

1

BIODIVERSITY AND ECOSYSTEM SERVICES



The CSIR–National Environmental Engineering Research Institute (CSIR-NEERI), Nagpur, plays a significant institutional role in showcasing how biodiversity supports ecological resilience and sustainable development in urbanised regions. NEERI's intact urban forest patches function as regional ecological hotspots that sustain complex trophic interactions. Vegetation supports diverse invertebrate communities, including predatory insects, arachnids, molluscs, and odonates, which contribute to pollination, biological pest regulation, and nutrient cycling. These habitats also support vertebrate fauna, including reptiles, amphibians, birds, and mammals, reflecting the ecological processes characteristic of larger forest ecosystems and emphasising the conservation significance of urban green spaces. These forest patches enhance key ecosystem services, including air purification, microclimate regulation, and landscape connectivity, and act as ecological “stepping stones” within fragmented urban matrices. Collectively, NEERI exemplifies a model for modern Urban Green Space by demonstrating the importance of conserving remnant forest patches and establishing green corridors to strengthen urban ecological resilience.

1.1 Biodiversity

1.1.1 Tree Diversity

The NEERI campus has a diverse range of trees, with 83 species from 36 families. The Fabaceae family exhibits the highest number of species diversity, with 15 species, followed by Moraceae (8 species) and Myrtaceae (5 species). Notable tree species in the campus include *Peltophorum pterocarpum* (Copperpod), *Delonix regia* (Gulmohar), *Azadirachta indica* (Neem), *Monoon longifolium* (False Ashoka), *Syzygium cumini* (Jamun) and *Mangifera indica* (Mango). Among the 83 tree species identified, 43 of the tree species are native to the Indian subcontinent, while 40 of the species are non-native or exotic species. The IUCN Status of the species studied showed that 56 species are of Least Concern, 19 species are not evaluated, 2 species are data deficient, 2 species are endangered and vulnerable, and 1 tree species is near threatened.

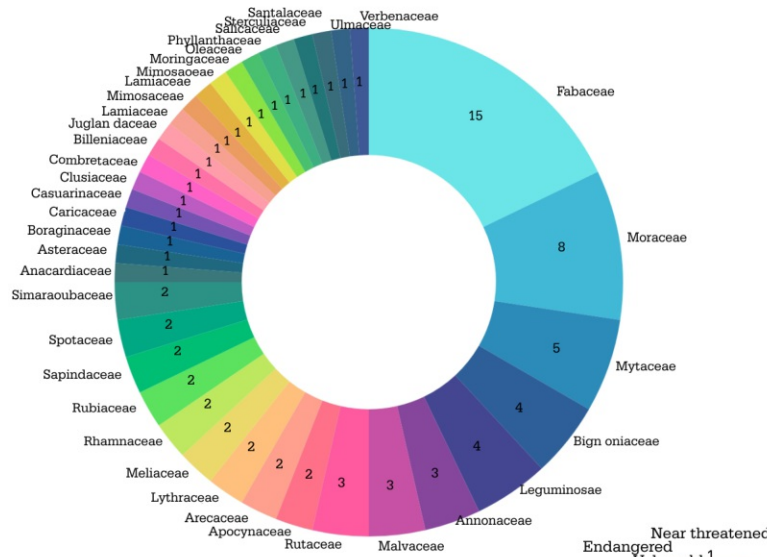


Figure 6: Family-wise distribution of tree species in CSIR-NEERI



Figure 8: IUCN status of tree species in NEERI

Figure 7: Origin of tree species in NEERI



Copperpod



Gulmohar



Karanj



Monkey pod tree



Saptaparni








Neem



Photoplate 2:
Common tree species present
in
NEERI campus

IUCN THREAT STATUS OF TREE SPECIES IN NEERI CAMPUS

Table 1:
IUCN
Threat Status
of Trees

<p>ENDANGERED</p>	 <p><i>Tectona grandis</i></p>	 <p><i>Pterocarpus erinaceus</i></p>
<p>VULNERABLE</p>	 <p><i>Eucalyptus cladocalyx</i></p>	 <p><i>Santalum album</i></p>
<p>NEAR THREATENED</p>	 <p><i>Aegle marmelos</i></p>	

*IUCN threat status (1) is a globally recognized indicator of a species risk of extinction. It categorizes biodiversity based on population size, decline rate, and distribution to guide conservation actions, highlighting species that need urgent protection

1.1.2 Shrub Diversity

The NEERI campus has a diverse range of shrub species, with 53 species from 24 families. The Apocynaceae family exhibited the highest species diversity, with eight species, followed by Euphorbiaceae (seven species) and Acanthaceae (six species). Notable shrub species in the campus include *Bougainvillea glabra* (Paperflower), *Nerium oleander* (Rosebay), and *Ixora chinensis* (Chinese Ixora).

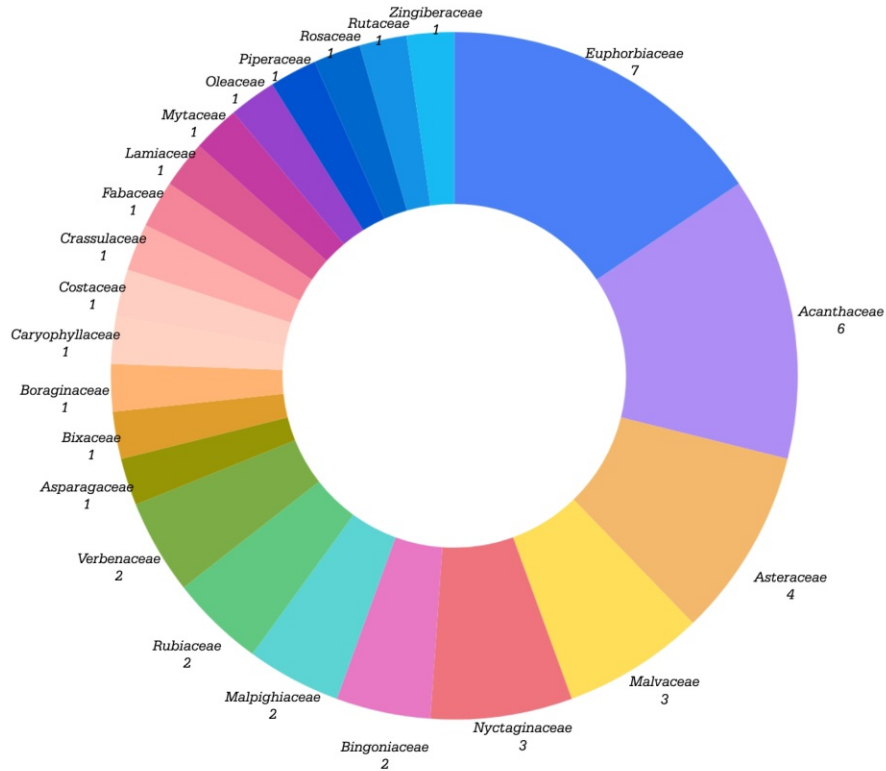


Figure 9: Family-wise distribution of shrub species in CSIR-NEERI



Life Plant



Yellow trumpet bush



Lipstick Tree



Paper-flower



Castor Oil Bean



Porcupine flower



Photoplate 3: Common shrub species present in NEERI campus

1.1.3 Herb Diversity

The NEERI campus has a diverse range of herb species, with 51 species from 24 families. The Asteraceae family exhibited the highest species diversity, with 14 species, followed by Fabaceae (5 species) and Acanthaceae (3 species). Notable shrub species on campus include *Alternanthera sessilis* (Sessile Joyweed), *Cyanthillium cinereum* (Little Ironweed), and *Euphorbia hirta* (Asthma Weed).

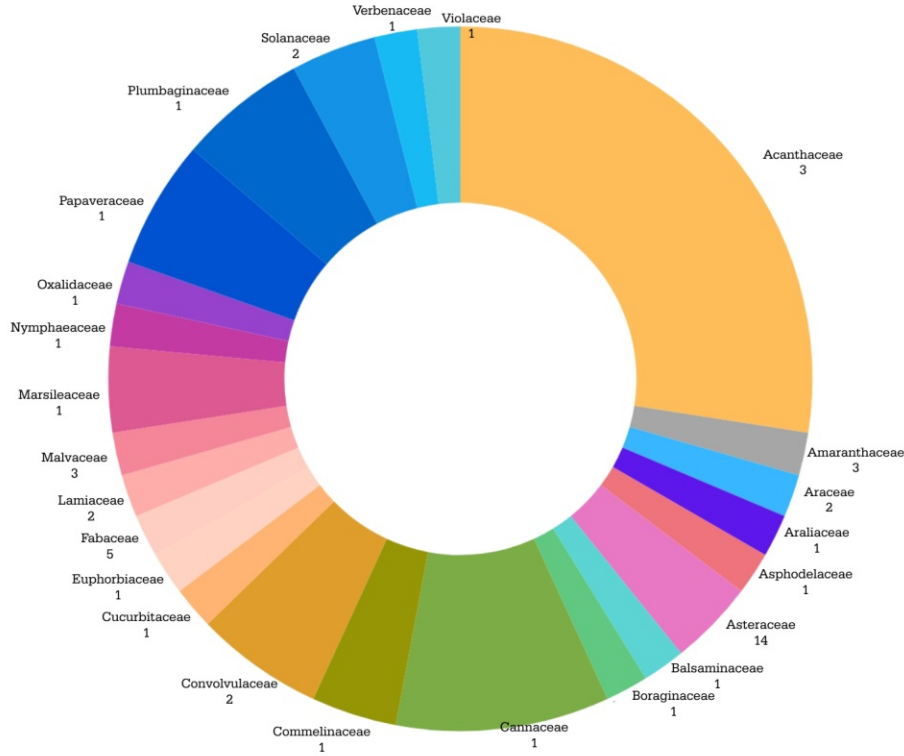


Figure 10: Family-wise distribution of herb species in CSIR-NEERI



Indian shot



Butterfly pea



Mexican mint



Obscure Morning



Glory Garden Petunia



Yellow Wood Sorrel



Photoplate 4: Common herb species present in NEERI campus

1.1.4 Butterfly Diversity

The campus features 22 butterfly species from 4 different families. The dominant family, Nymphalidae, contains 11 species, followed by Pieridae, which has 6, and so on.

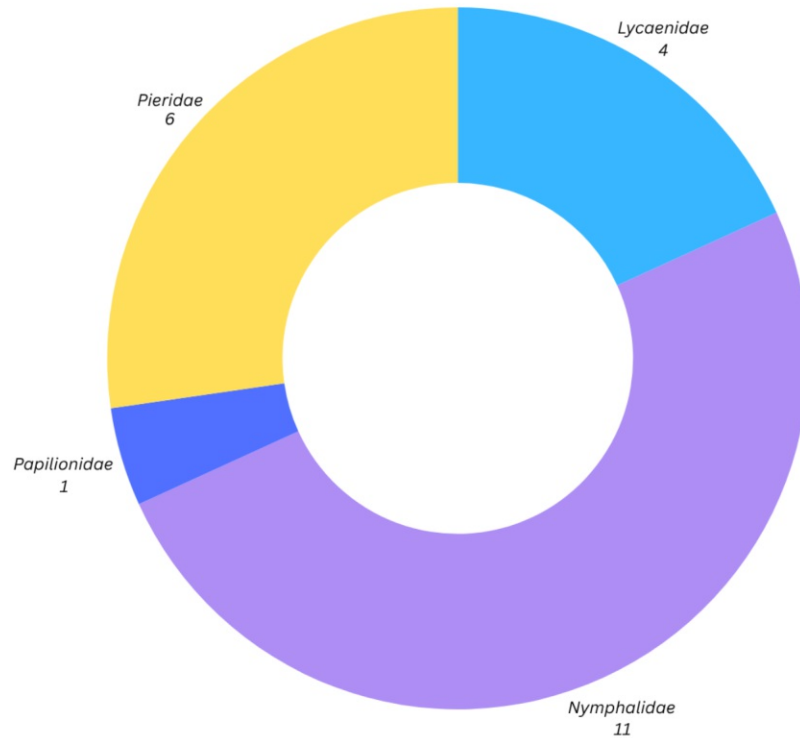
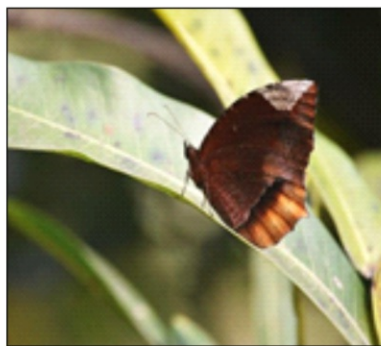
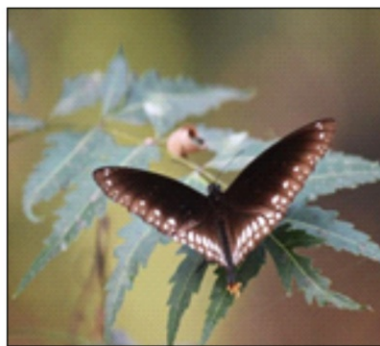


Figure 11: Family-wise distribution of butterfly species in CSIR-NEERI



Chestnut palmfly



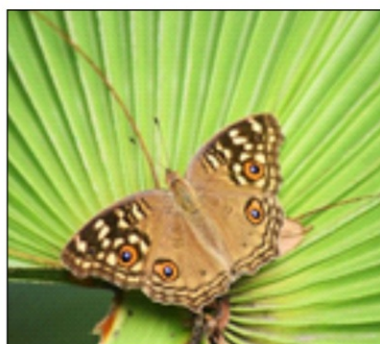
Common crow



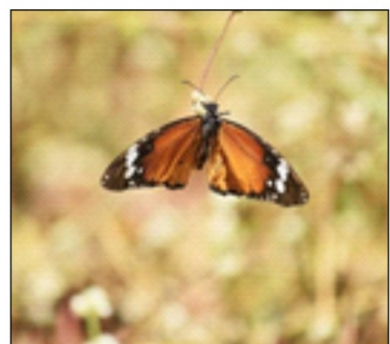
Commander



Common wanderer



Lemon pansy



Plain tiger



Photoplate 5: Common butterfly species present in NEERI campus

1.1.5 Bird Diversity

The campus is home to 27 bird species belonging to 21 families. Alcedinidae, Ardeidae, Columbidae, and Muscipidae were the dominant families on campus.

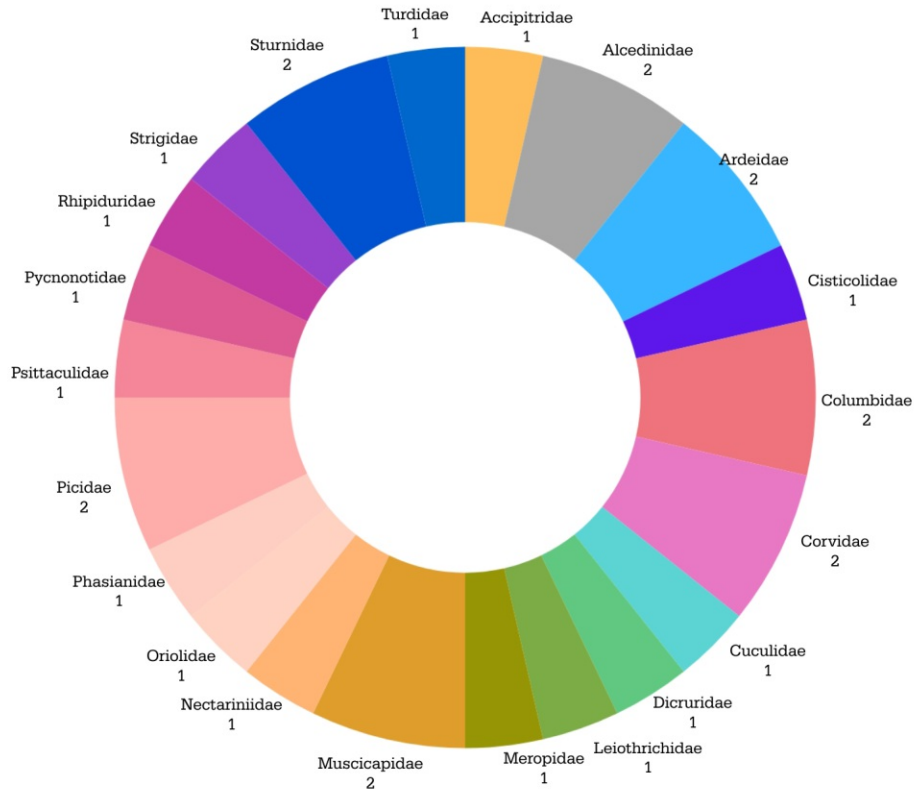


Figure 12: Family-wise distribution of bird species in CSIR-NEERI



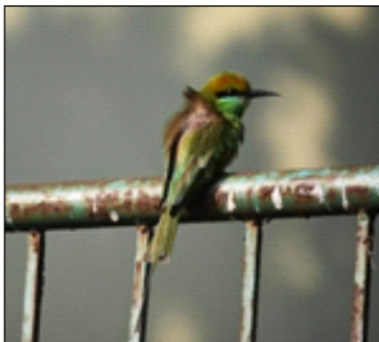
Shikra



Grey Hornbill



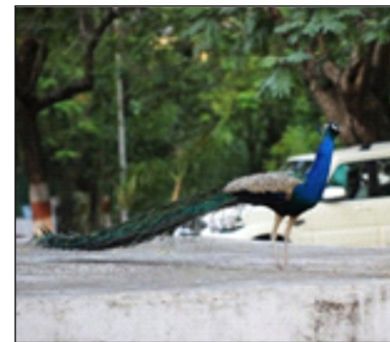
Orange-headed thrush



Asian green bee-eater



Rose-ringed parakeet



Indian peafowl



Photoplate 6: Common bird species present in NEERI campus

1.1.6 Fungal Diversity

The campus has 23 fungal genera from 15 botanical families. Among them, the Agaricaceae family is the most common, with 6 species.

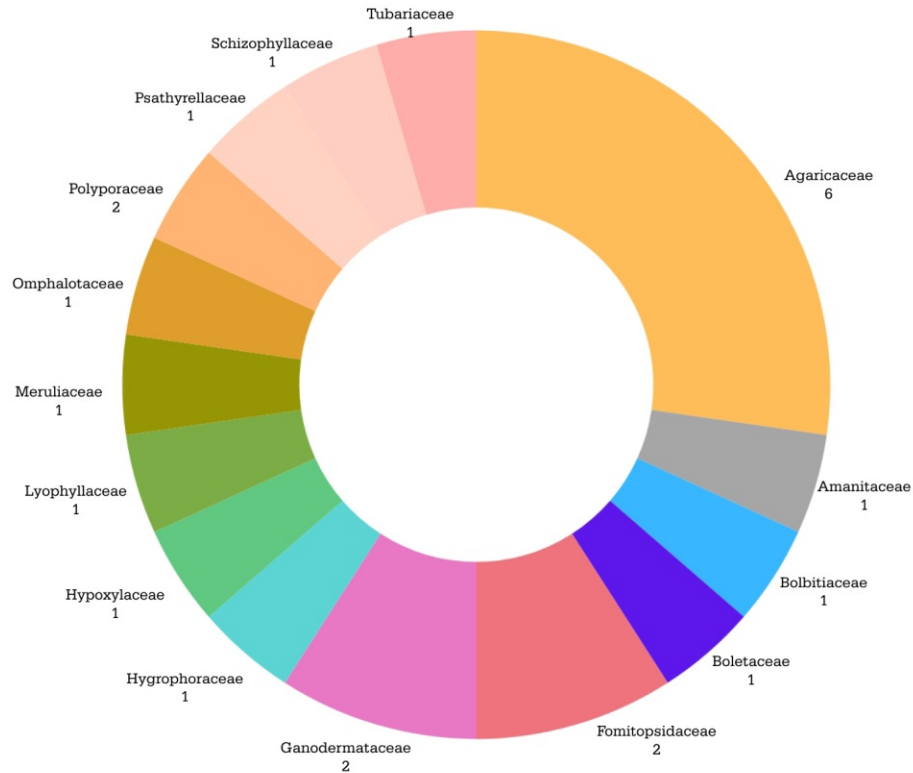
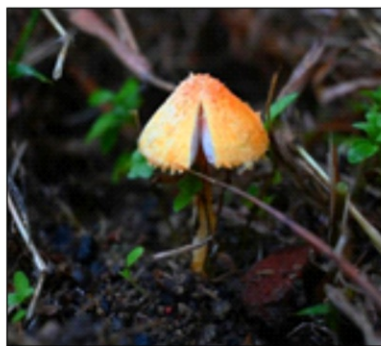


Figure 13: Family-wise distribution of Bird species in CSIR-NEERI



Inocybe



Macrolepiota



Leucocoprinus



Russula



Cotyldia



Phellodon



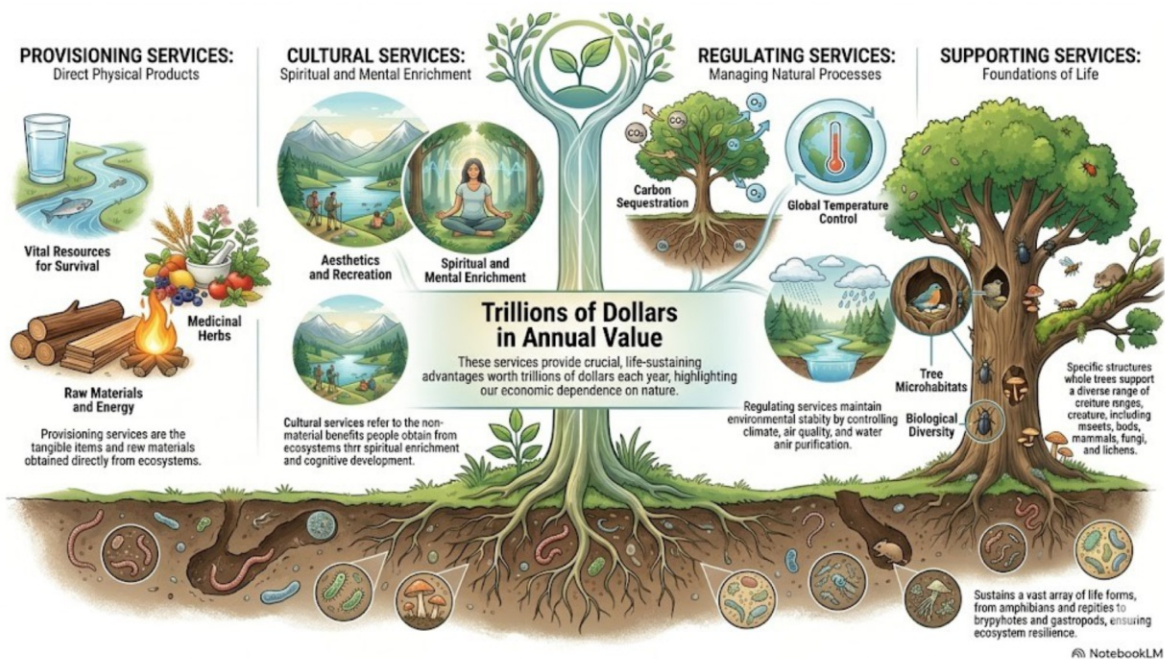
Photoplate 7: Common fungal species present in NEERI campus

1.2 Significance of Green Urban Campuses

Amidst the rapid urban expansion and biodiversity challenges in Nagpur, the NEERI's green campus stands as a vital ecological bastion, a 46-hectare campus that preserves nature within the growing city. This historically protected site mitigates habitat fragmentation by linking wildlife corridors and fostering diverse plant life that provides essential ecosystem services. These services highlight its immense value: moderating the local climate through tree and soil-based shading and carbon storage; purifying the air and controlling floods with its absorbent landscapes; and sustaining biodiversity for pollinators, birds, and microbes crucial for ecological health. For the community, it offers revitalizing green spaces that enhance well-being, education, and research motivation. Supported by secure institutional tenure, minimal disturbance, expert management, and continuous monitoring, NEERI's campus ensures the longevity of these services at a low cost. As a model Other Effective Area-Based Conservation Measure (OECM), it supports India's Kunming-Montreal 30x30 goals and SDGs 11 & 15, demonstrating that institutional green spaces can drive urban resilience and sustainable development.

1.3 Ecosystem Services

Ecosystem services are the direct and indirect contributions of ecosystems to human well-being, providing crucial life-sustaining benefits worth trillions of dollars each year. These advantages include clean air, water purification, food production, climate regulation, and cultural, spiritual and recreational values. These services are categorized into four types: provisioning, regulatory, cultural, and supporting.



Picture developed using Google Notebook LM

1.3.1 Carbon Sequestration by Trees

Carbon sequestration is a key regulating ecosystem service in which trees, soil, and vegetation capture and store atmospheric carbon dioxide. By lowering greenhouse gas emissions, slowing climate change, controlling global temperatures, and preserving atmospheric equilibrium, this approach promotes both environmental stability and human well-being. The dominant tree species on the CSIR-NEERI campus displayed variable carbon stock levels, with neem (*Azadirachta indica*) having the maximum sequestration capability, followed by copperpod (*Peltophorum pterocarpum*), mango (*Mangifera indica*), and jamun (*Syzygium cumini*). This ranking highlights neem's greater biomass accumulation and carbon storage capacity among other tree species, which contribute considerably to the campus's total biological carbon sink.

Carbon stock in dominant tree species in NEERI campus

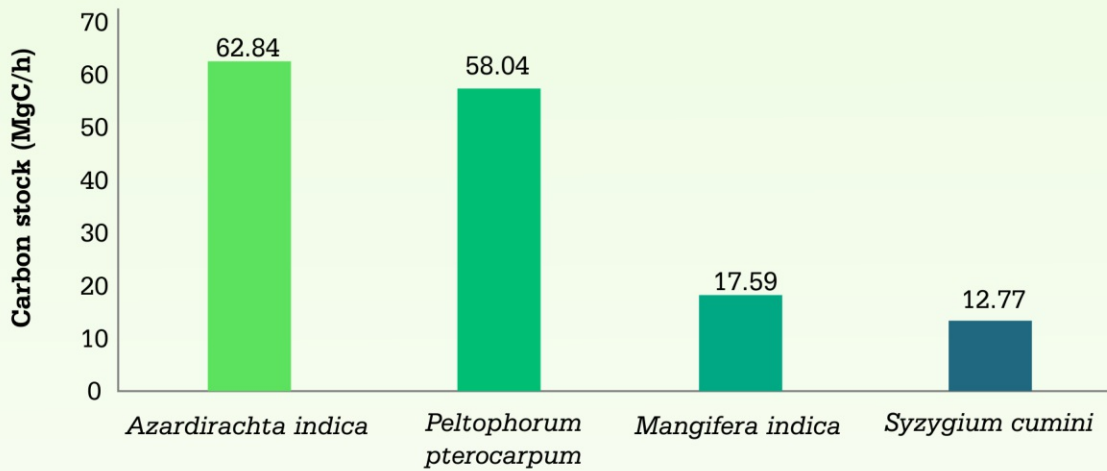


Figure 15: Carbon stock dominant tree species in NEERI campus

Carbon rich species in NEERI Campus

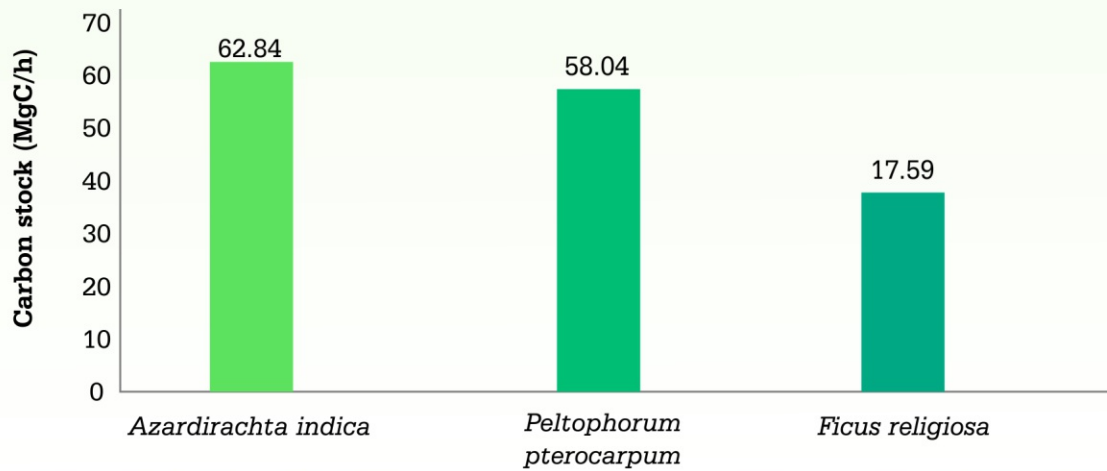


Figure 16: Carbon rich species in NEERI campus



1.3.2 Tree Microhabitat

"Tree microhabitats" refer to distinctive structures found within a tree that support a diverse range of creatures, including insects, arachnids, gastropods, birds, mammals, amphibians, reptiles, bryophytes, fungi, and lichens. Cavities, rot holes, crowns, deadwood, wounds, dead branches, insect galleries, epicormic shoots, and micro-soil, among other specialized micro-environments, sustain different stages of an organism's life cycle and serve as markers of adaptation and diversification (Thomas et al., 2025). Figure 17 shows the microhabitat distribution throughout the campus under various microhabitat categories. Among the given microhabitat categories, deadwood shows a high number, followed by cavities in trees on the campus.

Microhabitat distribution of trees

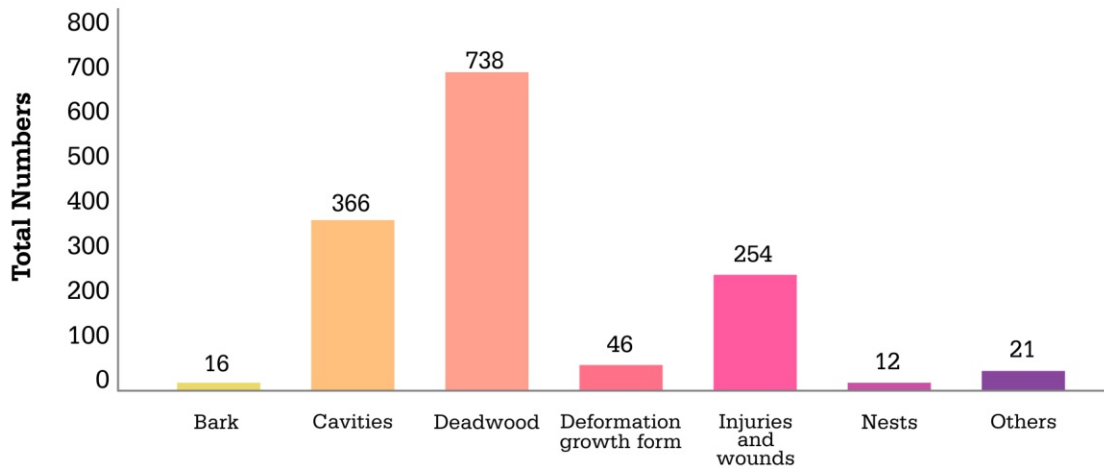
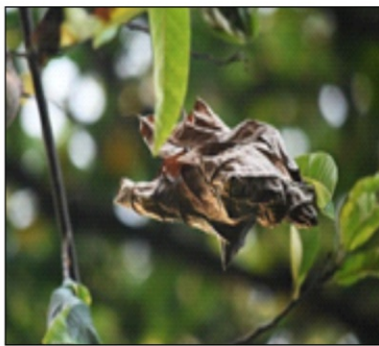


Figure 17: Tree microhabitat distribution in CSIR-NEERI



Invertebrate Nest



Insect Gallery



Fruiting Body

Photoplate 8: Common tree microhabitat present in NEERI campus



1.3.3 Provisioning Services

Provisioning services are tangible items obtained directly from the ecosystems. These include raw materials, food, fresh water, fuel wood, and medicinal plants. Some of the services provided by campus trees are shown in Figure 18.

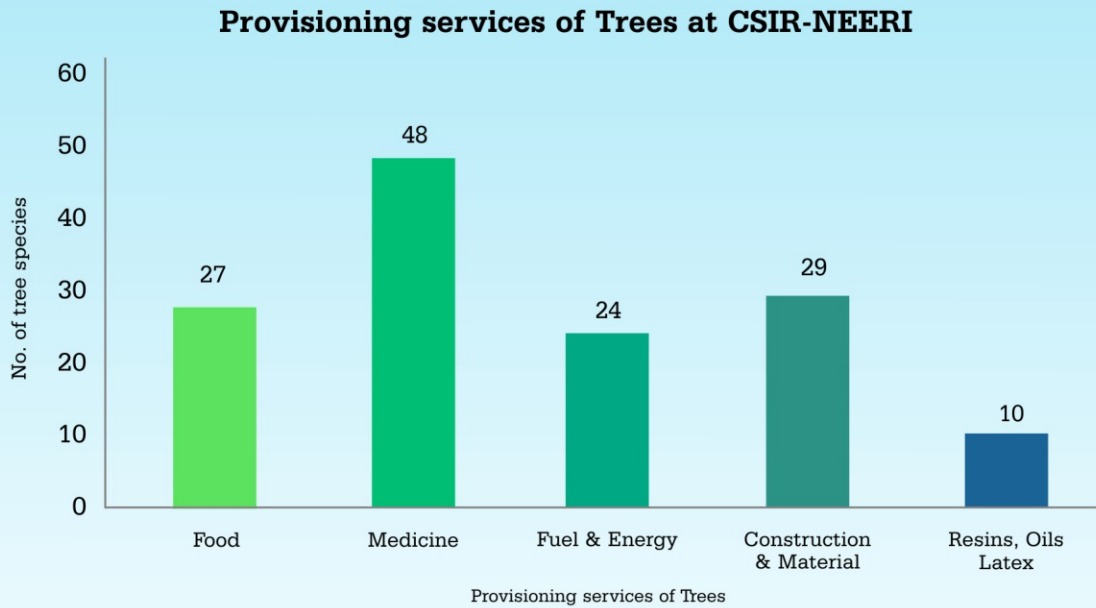


Figure 18: Provisioning services of Trees in CSIR-NEERI



CHAPTER

2

WATER MANAGEMENT

Optimising Water Resources: A Sustainability Roadmap for CSIR-NEERI

Analysis reveals significant discrepancy between current water consumption and recommended demand, with major opportunities for sustainable harvesting.

Consumption vs. Recommended Demand



Residential Usage Outpaces Recommendations



Harvesting & Infrastructure Potential

7.2 Million Litres of Rainwater Potential

Rooftop harvesting could provide 20 KLD, meeting 54% of daily institutional demand.

5 Abandoned Structures Ready for Reuse



3 Tanks

Storage & Recharge



2 Ponds

Underutilised Groundwater Assets



Utilised Occasionally

Only 3 of 10 Available Wells Utilised

India's modernisation may be heavily reliant on improving its water management. Despite accounting for 17% of the world's population, India has only 4% of the world's water resources (Amitabh Kant, 2018). Consequently, to meet the entire water demand, the efficiency of water consumption and reuse must be incorporated into institutional project design plans. CSIR-NEERI has one institutional and one residential campus. There are a total of eight dug wells spread across the institute's campus, and two dug wells in the residential colony. Of the 10 dug wells, only three are occasionally used for landscaping and other domestic purposes. Of these three dug wells, two are used on the institutional campus, and one is used in the residential colony. Wells located in the East campus are denoted as ES1, ES2, ES3, ES4, ES5, ES6, ES7 and ES8. Wells situated in the West colony of the campus are denoted as WS1 and WS2. There are two abandoned concrete tanks and four abandoned ponds on the institute's premises. These structures can be used for rainwater storage and groundwater recharge..

2.1 Existing water supply scheme

The present water requirement for the institute's buildings and quarters is supplied by the Nagpur Municipal Corporation. NMC water is supplied throughout the institute's office buildings using 150 mm diameter CI pipes. For quarters located in the east campus and west colony, 100 mm diameter CI pipe is being used. The following facilities are available for the supply of NMC water on campus.

2.2 NMC water consumption in CSIR-NEERI

Two separate NMC water meters were installed at CSIR-NEERI. One is on the east campus, and the other is in the institute's west colony. The following table shows the water consumption and NMC water bill details.



Photoplate 9:
Dug wells
in
CSIR-NEERI



Year	Month	West Colony Water Consumption (KL)	West Colony Water Bill (Rs.)	East Campus Water Consumption (KL)	East Campus Water Bill (Rs.)
2023	January	9312	136117.00	7789	282221.16
	February	8432	122703.91	5888	216704.17
	March	8215	118039.74	6490	238909.54
	April	8463	123370.55	7268	267606.85
	May	9240	145478.90	8723	335592.99
	June	9268	145559.94	11049	425213.77
	July	9303	146614.68	9119	350850.87
	August	8877	138953.49	9222	356755.39
	September	9281	148070.97	10290	398130.24
	October	10180	168362.96	10139	392280.66
	November	9245	145732.93	9544	367655.45
	December	8519	129466.64	11404	439405
Total:		108335	1668471.71	106925	4071326.09
Average daily water consumption		283 KLD		360 KLD	
2024	January	8630	13953.96	11621	447775.83
	February	8400	129615.60	10175	395405.05
	March	8737	137279.61	10610	412330.90
	April	9214	148126.53	11684	454119.83
	May	9593	157319.24	9972	388104.53
	June	9898	164274.76	11405	443948.65
	July	9416	153283.64	10782	419670.34
	August	10142	173183.07	9315	365574.94
	September	10188	174248.04	10186	399805.60
	October	10010	170130.14	9826	385657.60
	November	10774	183493.38	11735	455987.30
	December	10094	168035.46	9565	371574.3
Total:		115096	1890943.43	126876	4939954.87
Average daily water consumption		283 KLD		273 KLD	
2025	January	11248	195391.44	11827	459565.82
	February	-	-	-	-
	March	-	-	-	-
	April	10056	168178.08	13537	527438.52
	May	19063	311740.29	9994	389261.74
	June	-	-	17933	67750.95
	July	10211	171001.00	8911	342508.41
	August	9942	386537.85	15094	282139.04
	September	15329	290706.73	8644	337821.96
	October	21321	366942.57	14206	555014
	November	12051	213964.95	8164	318055.08
	December	16861	323873.45	6973	271581.79
Total:		126082	2428336.36	115283	4181137.31
Average monthly consumption of west colony.					8867 KL
Average monthly consumption of east campus.					10330KL

Table 2:
West and East campus water consumption and water bills data



2.3 Ponds and tanks

There are 3 concrete tanks and 2 pond across the institute premise. These structures are to be utilized for rainwater storage and groundwater recharge

Table 3:
List of tanks and ponds in NEERI

SI. No	Structure details	Coordinates	Location	Length	Breadth	Height	Volume
1	Concrete tank	LAT: 21°07'15.3" N LONG: 79°04'21.0"	Near dug well ES2	3.37m (Effective length, excluding partition walls)	1	1.1	3.7 m ³
2	Concrete tank	Lat: 21° 7'17.41"N Long:79°4'11.9 4"E	Behind EMD	12	3.37	2.5	101.1 m ³
3	Concrete tank	Lat: 21° 7'17.41"N Long:79°4'11.9 4"E	Behind EMD	6.8	2.2	1.8	27 m ³
4	Pond	LAT: 21° 7'23.88"N LONG:79° 4'9.50"E	Behind Technology Park	Area = 1500 m ²		2	3310 m ³
5	Pond	LAT: 21° 7'17.52"N LONG:79°4'12. 68"E	Behind EMD	13.40	12.9	3	518.58 m ³



Photoplate 10:
Pond in NEERI campus



2.4 Water consumption and water bills

Data regarding water consumption and water bills of CSIR-NEERI from 2023 to 2025 were compiled to find out the total water consumption, average daily consumption, and yearly water bills.

Year	Total Consumption (KL)		Average Daily Consumption (KLD)		Total Water Bill In Particular Year (Rs.)	
	West Colony	East Campus	West Colony	East Campus	West Colony	East Campus
2023	108335	106925	283	360	1668471.71	4071326.09
2024	115096	126876	283	273	1890943.43	4939954.87
2025	126082	115283	300	339	2428336.36	4181137.3

Table 4:
Water consumption
in
CSIR-NEERI

On an average, water consumption in east campus is more in comparison to west colony. From all the available data from 2023 to 2025, it can be inferred that average monthly consumption of west colony is 8867 KL whereas for east campus, it is 10330 KL. Average daily consumption for West colony from 2018 to 2022 is 292 KLD and for east campus, it is 340 KLD. Similarly average monthly bill from 2018 to 2022 for west colony is Rs. 120919 and for east campus, it is Rs. 336425.



2.5 Recommended water consumption

An estimate was prepared to find out ideal water demand for both the premises of CSIR-NEERI, considering recommended water use as per NBC 2016 and BIS (Central Ground Water Authority, Government of India, 2016)

Area	Zone	Description	Population	
East campus	Institute	Current Population	950	
	10% staff on Saturday and Sunday	Assumed data	95	
	Visitors	Peak Visitors recorded in a single day	100	
	Quarters	12 Quarters (Including Director Bungalow) and assuming 5 person per Quarters	60	
	Guest House	25 rooms and assuming 2 persons per room.	50	
Total water demand in a month	1723.5 KL			
Average daily water demand of the East campus.	58 KLD			
West Campus	Quarters	214 (Out of total 225 quarters, 11 quarters are in east campus) and assuming 5 persons per quarter	1070	
	RSH	22 Rooms and assuming 2 persons per room.	44	
	Dispensary	Assumed maximum population	20	
Total water demand in a month				
Average daily water demand of the West campus.				

Water Use	Description	Season	Tap use per day	NMC Tap efficiency	
Gardens	Garden in front of Main building	Summer(5 months)	8 hours	9 sec/litre	
		Winter (4 Months)	6 hours	9 sec/litre	
		Rainy	1 hours	9 sec/litre	



	Considered days in a month.	Assumed recommended daily water consumption	Total water consumption in a month	Average daily water demand
	22	50 LPCD	1045 KL	37.2 KLD
	8	50 LPCD	38 KL	
	22	15 LPCD	33 KL	
	30	200 LPCD	360 KL	21 KLD
	30	165 LPCD	2 47.5 KL	
	30	165	5297 KL	184 KLD
	30	165	218 KL	
	30	20	12 KL	0.4 KLD
				5527 KL
				185 KLD

Table 5: Water demand estimation for both of the premises



	Consumption in a day	Considered days in a month	Total Consumption in a month	Multiplying Factor: 2 (Considering other small gardens across the institute.)	Total consumption in a year
	3.2 KLD	26	83.2 KL	166.4 KL	832 KL
	2.4 KLD	26	62.4 KL	124.8 KL	500 KL
	0.4 KLD	26	10.4KL	20.8 KL	63 KL
				Total	1395 KL
				Average daily water use for landscaping across the east campus	3.8 KLD

Table 6: Water demand estimation for landscaping in the institute

Total water demand estimated in a month for east campus is 1728 KL, and the average monthly water demand for landscaping is 114 KL. So it sums up the average monthly demand for east campus up to 1838 KL. Similarly, the average monthly water demand estimated for west colony is 5527 KL. Dug well ES5's water is being utilized for landscaping in the garden near gate No.1 of the institute's premises. From the survey with the concerned person responsible for landscaping in this garden, it has been estimated dug well water use is 2715 KL in a year and the average monthly consumption of 227 KL.

Water Use	Description	Season	Tap use per day	Pipe efficiency	Consumption in a day	Considered days in a month	Total Consump. in a month	Total consump. in a year
Land-scaping	Smritivan	Summer (5 months)	6 hours /day	2 sec /litre	10.8 KL	26	280.8 KL	1404 KL
		Winter (4 Months)	7 hours /day	2 sec /litre	12.6 KL	26	327.6 KL	1310.4 KL
		Rainy	-	-	-	-	-	-
Total consumption in a year								2715

Table 7:
Dug well
ES5 Water
utilization
estimation

2.6 Rooftop rainwater harvesting

At present, Institute premise is having 35 small and big structures with concrete and shed roofs, which can be utilized for rainwater harvesting. Total rooftop catchment area as per the survey is about 10,014 m². Average yearly monsoon rainfall in Nagpur as per official government website is 1064 mm (District Nagpur, Government of Maharashtra), Coefficient of roof surface finish and coefficient of evaporation is taken 0.85 and 0.80 respectively as per rainwater harvesting and conservation manual, CPWD (Central Public Works Department, 2023). Taking all these data into account, so total rooftop rainwater harvesting potential for the institute's premise estimated is 72,45,394 L. It means around 20 KLD of rooftop harvested water will be available to meet the institute's daily demand of 37 KLD.



CHAPTER 3

WASTE WATER MANAGEMENT

UCCW: A Sustainable Revolution in Decentralised Wastewater Treatment

INNOVATION AND SUSTAINABLE ADVANTAGES



Integrated and Compact Design

Combines preliminary to tertiary treatment in one unit, significantly reducing land and infrastructure needs.



Minimal Energy and Maintenance

Relies on gravity-driven hydraulics and natural processes, requiring very low power and no skilled manpower.



Nature-Based Solution

Utilises plant-microbe interactions to enhance site aesthetics, create micro-habitats, and ensure silent operation.



PERFORMANCE AND SCALABILITY

95%

High Treatment Efficiency

Achieves over 95% reduction in Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS).



Modular and Scalable Deployment

Successfully demonstrated across multiple scales, from 1.5 KLD units to 300 KLD upcoming installations.

Pollutant Reduction Performance (Raw vs. Treated Effluent)

Parameters	Raw Sewage	Treated Effluent
TSS (mg/L)	120-210	< 5
BOD (mg/L)	200-250	< 10
COD (mg/L)	350-450	< 50

Rapid urbanization and population growth in India have led to a significant increase in municipal wastewater generation, posing serious challenges to public health, environmental sustainability, and water resource management. Nature-based solutions, particularly constructed wetland-based systems, offer a promising alternative by integrating ecological processes with engineered designs to achieve effective wastewater treatment.

3.1 UCCW-Based Sewage Treatment Plant

The Up-flow Compact Constructed Wetland (UCCW) based Sewage Treatment Plant (STP) is a CSIR-NEERI patented, decentralized wastewater treatment technology developed to address the limitations of conventional sewage treatment systems in Indian conditions. The UCCW system is designed as a compact, modular, and scalable treatment solution, enabling its deployment in space-constrained urban and peri-urban areas, institutional campuses, residential complexes, small towns, and community-level applications. A key distinguishing feature of the UCCW technology is the integration of all treatment stages within a single, compact system. The treatment stages comprising preliminary, primary, secondary, tertiary treatment, and disinfection are incorporated into a unified structure, eliminating the need for multiple independent units and extensive interconnecting infrastructure. This integrated configuration significantly reduces land requirement, construction complexity, and hydraulic losses.

UCCW-based STP is characterized by minimal dependence on electrical energy, as the treatment process primarily relies on gravity-driven up-flow hydraulics, natural bio-physico-chemical processes, and plant-microbe interactions. Electricity, where required, is limited to auxiliary components such as pumping or disinfection units, resulting in very low energy consumption compared to conventional and packaged STPs. Consequently, the system offers the least operation and maintenance (O&M) requirements, without mechanical components, reduced sludge generation, and no need for continuous skilled manpower. Another significant advantage of the UCCW-based STP is its silent operation, as it does not rely on blowers, diffusers, or high-speed mechanical equipment typically associated with noise generation in conventional treatment systems. The modular design allows for flexible capacity augmentation and easy replication across diverse geographic and climatic regions. In addition to efficient wastewater treatment, the UCCW-based STP contributes to ecological enhancement and environmental aesthetics by integrating vegetated wetland components. The system promotes green cover, supports micro-habitat creation, improves site aesthetics, and aligns with the principles of nature-based solutions and climate-resilient infrastructure. The scalability and field applicability of the UCCW-based STP technology have been successfully demonstrated through multiple full-scale installations under real operating conditions. In 2021, UCCW units with a combined treatment capacity of 1,500 L/day were installed at CSIR-NEERI, Nagpur, demonstrating the system's adaptability across different wastewater streams. Recently, a 15,000 L/day modular and packaged UCCW-based STP, fabricated as a single FRP tank, has been installed and commissioned at CSIR-NEERI, Nagpur, highlighting the system's compactness, modularity, and readiness for large-scale deployment (Photoplate 11). Collectively, these demonstrations validate the technical robustness, scalability, and suitability of the UCCW technology for decentralised wastewater treatment applications.



1.5 KLD UCCW based STP at CSIR – NEERI Nagpur



15 KLD UCCW based STP at CSIR – NEERI Nagpur

Parameters	Raw sewage	Treated Effluent
pH	6.5 – 7.5	6.5-8.5
TSS (mg/L)	120-210	< 5
BOD (mg/L)	200-250	<10
COD (mg/L)	350-450	< 50
Total Nitrogen (mg/L)	20-35	< 10
Total Phosphorus (mg/L)	5-10	< 1
Faecal Coliform (MPN/100mL)	106 – 107	< 230

Table 8:
Performance
of
UCCW
based STP

TREATED WATER QUALITY IN STAGES



INLET

UFSCW

USSCW

UDMF



CHAPTER

4

ENERGY MANAGEMENT

Greening the Campus: CSIR-NEERI's Energy Transformation

Strategic Efficiency Initiatives

Solar Transition via RESCO Model

Installed a 175.5 kWp rooftop solar plant across four major campus blocks.



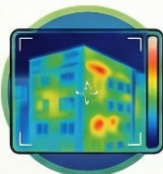
High-Efficiency Hardware Upgrades

Replaced 1,400 tube lights and 220 streetlights with energy-efficient LED systems.



Precision Thermal Monitoring

Used thermal scanning to identify micro-leakages in walls, optimising cooling energy retention.



Environmental & Financial Impact

₹23-24 Lakhs Annual Savings

Achieved significant financial reductions through a thermal-to-solar shift starting from year one.



1.48 Million kg CO2 Avoided

Cumulative carbon savings reached since the 2018 solar installation.



56% Lighting Energy Reduction

Predicted annual electricity savings specifically from the transition to LED lighting systems.



Cumulative Environmental Resource Savings (2019-2025)

Solar Units Generated

1,566,097.5
kWh



Coal Utilization Savings

1,252,878.0
kg



Fly Ash Content Savings

501,151.2
kg



A detailed Energy Audit was conducted at the CSIR-NEERI Campus in 2016, 2020 by VNIT-Nagpur and in 2023 by m/s Namdhari Eco Energy India. In this report, major power consuming sectors were cooling and lighting sector. The recommendations were focused on reduction of cooling and lighting sector power consumption. The average annual electricity bill of CSIR-NEERI was touching near Rs. 1 Crore (including colony campus).

We examined the patterns of energy use, increase overall energy efficiency, and implement energy-saving solutions, particularly in lighting and air conditioning, and lower carbon footprints through effective energy management. Encouraging the use of renewable energy and cost-management techniques among CSIR-NEERI employees was another goal. This in house MLP project was completed with annual financial savings of Rs. 23-24 Lakhs per year through thermal to solar shift and 1,161.57 tons of CO₂ savings per annum. This was the only project that gives financial savings from first year only.

We frequently work with energy supply and utilization. The energy resource group is involved in monitoring of benefits due to thermal to solar shift and environmental saving and technical solution to convert campus into Living Lab@ CSIR-NEERI Nagpur.

4.1 Energy Conservation and Management Initiatives

4.1.1 Energy Scenario at CSIR-NEERI

CSIR-NEERI has an all-encompassing contract requirement of 800 kVA each for its institute and residential colony. The electricity billing system uses residential rates for the colony and commercial rates for the institute.

To advance energy-saving measures using the RESCO model, the study's goals are to define baseline energy consumption, identify the potential for energy savings, and evaluate the techno-financial viability of those prospects. The CSIR NEERI has already Roof-Top Grid Interactive Connected Solar PV Power Plant of capacity 175.5kWp, these PV modules is connected to buildings roofs with its different capacity:

ACBD No.	Block	Nos. of PV Modules	Capacity (kWp)
1.	Main building	180	58.5
	Library building	80	26
2.	SJ building	160	52
3.	Modern School	120	39
	Total	540	175.5

Table 9:
Blocks with
respective
Solar Installation
Capacity

Initiatives

The CSIR-NEERI Energy Conservation and Management team has made remarkable strides in reducing building energy consumption, operating at an advanced level of integrated energy management for past 7 years and their ongoing efforts in energy conservation are exemplified by key initiatives:

- Rooftop solar plant (175.5 kWp).
- Replaced inefficient AC's, lights, fans, streetlight with energy-efficient models.
- Installed automatic power factor controller (0.997 PF).
- Thermal scanning of walls to identify heat loss and detect leaks.
- CSIR NEERI campus features a certified green building.
- Promoted energy conservation awareness city/state-wide.

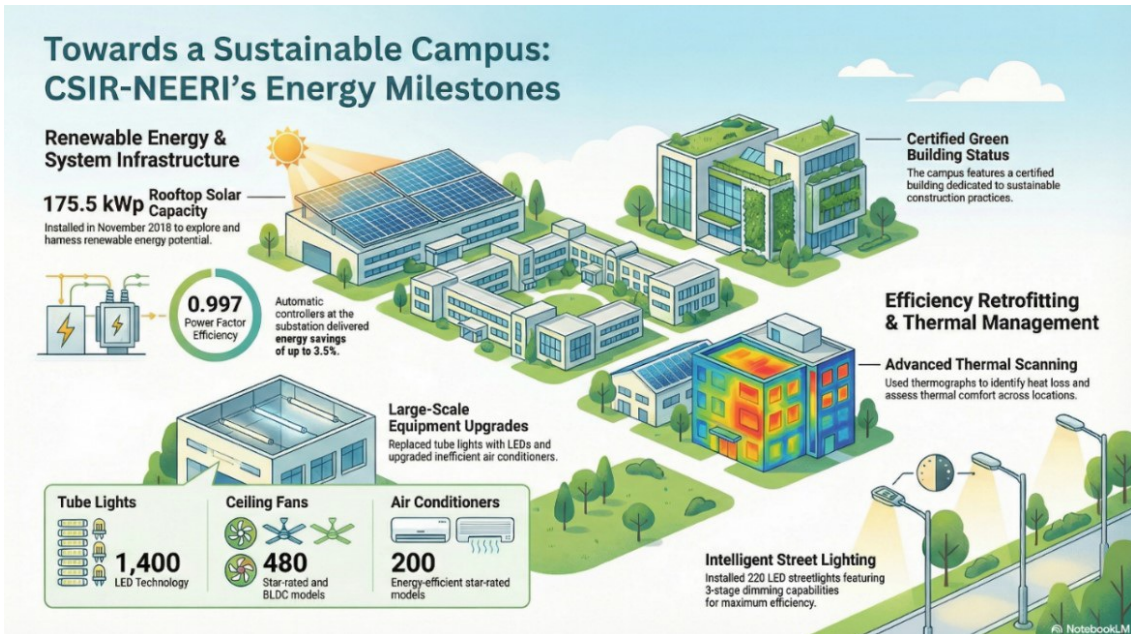


Figure 19: Energy Conservation initiatives CSIR-NEERI



Photoplate 12: RESCO Model Solar PV Plant at CSIR-NEERI Campus

4.1.2 Installation of 3 step dimming streetlights

Specifically designed three steps dimming 45 W LED streetlights have been installed in the NEERI campus since 2018. The three-step dimming LED technology offers customizable lighting options, allowing users to adjust brightness levels by controlling voltage, enhancing energy efficiency and providing simple control for versatile applications in various settings. They work on an output sequence of 100%, 50% and 10% depending on the time of day as illustrated in Figure 20.

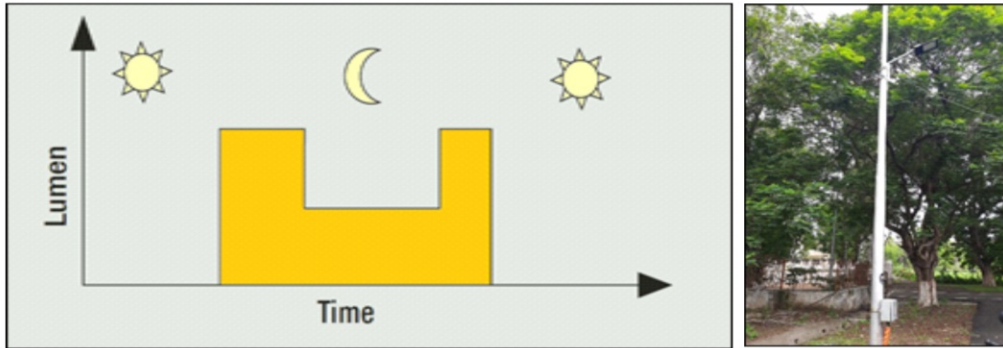


Figure 20:
Light output
over time

The present energy consumption in the lighting system at NEERI campus is 167.6 MWh/Year, which translates to Rs. 18.32/- Lakhs per annum. The anticipated energy saving due to the recommended measures is 94.28 MWh/year (replacing existing tube lights with LED lightings), translating to a saving of Rs 10.31/- Lakhs per annum. About 56 % of electricity saving can be envisaged in the annual cost of the energy used for lighting systems. Therefore, till date 1400 tube lights have been replaced with energy-efficient options. 220 streetlights were replaced with 45 watts LED lamps with 3-Stage dimming facility.

4.1.3 Measurements of illumination levels with a lux meter

The lux levels at all the departments were monitored, the lux level at all the major buildings is complying as per the NLC (National lighting code, 2010). The lux level in the campus is from 100-500 lumen. CSIR-NEERI is also performing experiments to identify fibre optic-based LED options to minimize the thermal effects. However, the experiments are in the nascent stage.

4.1.4 Thermal Analysis of Building Walls

As per the guidelines of green building, the constructed buildings should have sufficient available space for ventilation. Thermal leakages are also tried to be avoided for cooling systems to conserve the cooling energy. The leakages were identified using thermal analysis to understand the micro leakages, then sealed to protect them from cooling loss during summer. In parallel to the discussion, internal and external wall temperature was also monitored to understand the seasonal effects of the temperature on the wall surface. Figure 21. depicts two different walls and their change in surface temperature in the summer season.

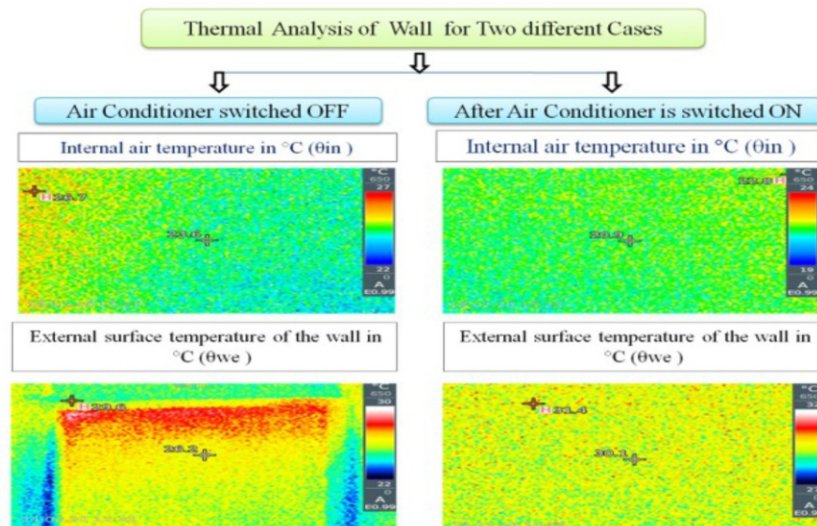


Figure 21:
Thermal
analysis of
a wall for
two different
cases: AC on
and AC OFF



4.2 Environmental Saving from solar

To get the real time CO₂ and Environmental Savings, CSIR-NEERI has designed a web page where users just need to update their solar plant capacity and monthly energy bills (both Solar and State Discoms). As per the Indian contexts of Thermal/ Coal based plants, factors for various parameters like SO₂, NO, PM_{2.5}, PM₁₀, VOC, Coal Utilization and Fly-Ash Content have been pre-inserted in the webpage so that the update can be rapid. For CSIR-NEERI's campus, real time web page link is as follows:

Year	Units Generated	CO ₂ Savings (kg)	SO ₂ Savings (kg)	NO Savings (kg)	PM _{2.5} Savings (kg)	PM10 Savings (kg)	VOC Savings (kg)	Coal Utilization Savings (kg)	Fly Ash Content Savings (kg)
2023	228499.6	217074.6	1615.5	982.5	48.1	93.8	7.4	182799.7	73119.9
2024	223855.53	212662.8	1582.7	962.6	47.1	91.9	7.3	179084.4	71633.8
2025	221932.35	210835.7	1553.5	887.7	46.7	91.1	7.2	177545.9	71018.4
2026 (till February)	18662.08	1531355.2	130.6	80.2	3.9	7.7	0.6	14929.7	5971.9
Total	1630614.93	3062710.4	11511.6	6945.1	343.4	669.2	52.8	1304491.9	521796.8

Table 10: Environmental Savings from Solar

4.3 Expanding the Current Solar PV Power Generation Capacity with 200 kW:

NEERI currently operates a 175.5 kWp Roof-Top Grid Interactive Solar PV Power Plant, established through the ESCO model project. These PV modules are connected to various campus buildings. It has come to our attention that NEERI's campus possesses additional rooftop space that could be utilized for the installation of PV modules of 200 kW. This expansion would enable the institute to augment its Solar PV Power generation capacity, with potential locations including the Technology Park, Environmental Materials Division, and Wastewater Technology Division. The expansion work of existing solar panel is under progress. Team is now discussing with various RESCO model solar plat developers for expansion of existing solar power plant of CSIR-NEERI.

Compared to electricity generated through thermal power, CSIR-NEERI currently derives approximately 22–25% of its energy from renewable sources such as solar power. Efforts are underway to increase this renewable energy share to 50% over the next five years.

4.4 Demonstration of one building under solar (with Electrical Section)

The location of one building suitable for solar installation has been identified. The institute plans to implement a rooftop solar project for this building under the RESCO model. In view of this, the work is currently in progress to implement the proposed concept.

5.5 Application of drone aided system for gaseous sensing, photogrammetry

Various images, 3D models, and 2D maps have been developed at the CSIR-NEERI campus to support green zone calculations, water slope analysis, tree height identification, and the assessment of various ecological parameters.





Figure 22:
2D Map
in the
CSIR-NEERI



Photoplate 13:
Tree height
measurement
using drone



CHAPTER

5

CARBON FOOTPRINTING

CSIR-NEERI: Mapping and Mitigating the Campus Carbon Footprint

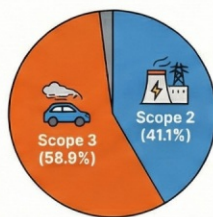


THE EMISSION PROFILE (2019-2020 BASELINE)

3,174.18
Total Tonnes of CO₂e

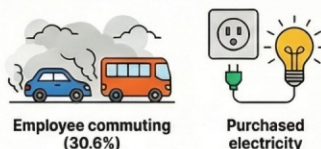
The total annual footprint translates to an intensity of 3.52 tons CO₂e per capita.

INDIRECT EMISSIONS DOMINATE THE FOOTPRINT



Scope 3 (58.8%) and Scope 2 (41.1%) constitute nearly the entire campus carbon output.

COMMUTING AND ELECTRICITY ARE THE MAIN HOTSPOTS



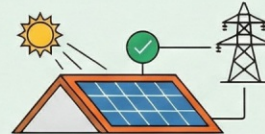
Employee commuting (30.6%)

Purchased electricity

Employee commuting and purchased electricity are the primary drivers of institutional emissions.

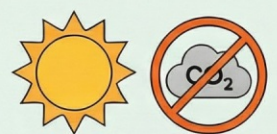
MITIGATION & IMPACT OF SOLAR INTERVENTIONS

SOLAR RESCO MODEL IMPLEMENTATION



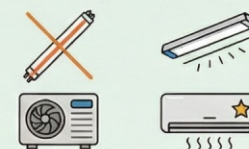
A zero-upfront-cost model where a third party manages the campus rooftop solar infrastructure.

~220 Tonnes of CO₂ AVOIDED ANNUALLY



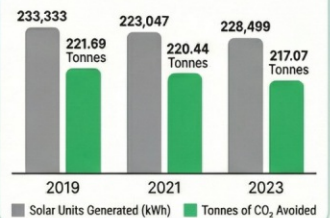
Consistent solar generation of over 200,000 units per year has significantly reduced grid dependency.

HOLISTIC ENERGY EFFICIENCY UPGRADES



Replacement of 1,400 tubes and 127 air conditioners with high-efficiency, star-rated alternatives.

CONSISTENT ENVIRONMENTAL BENEFITS OF SOLAR INSTALLATION



Carbon footprint assessment at the organizational level provides a quantitative basis for understanding emission sources, establishing baselines, and enabling systematic tracking of emissions over time. In this context, the present study undertakes a screening-level carbon footprint assessment of the CSIR–National Environmental Engineering Research Institute (CSIR-NEERI) campus for the baseline year 2019–2020. This study is explicitly designed as a simple baseline assessment due to the data constraints for 2019–2020. More granular data collection and expanded scope coverage are deferred to a future phase dependent on data availability.

5.1 Baseline Carbon Footprint Assessment

5.1.1 System Boundary and Scope

The organizational boundary follows the operational control approach, wherein all activities occurring within the physical campus boundary and under the direct operational control of CSIR-NEERI are included in the inventory, in accordance with the GHG Protocol Corporate Accounting and Reporting Standard.

The operational boundary includes the following emission scopes:

Scope 1 (Direct Emissions):

- o LPG consumption for cooking within the campus.

Scope 2 (Indirect Energy Emissions):

- o Purchased electricity consumed by laboratories, offices, residential quarters, and common facilities.

Scope 3 (Limited – Other Indirect Emissions):

- o Solid waste generation,
- o Wastewater generation and treatment,
- o Employee commuting (transportation).

5.1.2 Methodology

A bottom-up accounting approach was adopted, where emissions were calculated by multiplying activity data with appropriate emission factors. The overall framework aligns with the GHG Protocol Corporate Standard and IPCC-consistent methodologies as applied in earlier NEERI campus assessments as per Eqn. (1)

$$\text{GHG Emissions (tCO}_2\text{e)} = \sum_{i=0}^n \text{Activity Data} \times \text{Emission Factor} \quad \dots(\text{Eq.1})$$

Activity data were obtained from institutional records and structured surveys, while emission factors were sourced from peer-reviewed literature, IPCC guidelines, and national databases, consistent with earlier NEERI studies

5.1.3 Activity Data and Emission Factors

Figure 23 presents the various process/sources considered in this study for baseline year 2019–2020.



Understanding the Campus Carbon Footprint: A Three-Scope Breakdown



Picture developed using Google Notebook LM

Figure 23: Sources of Carbon emissions considered in the study

For Employee Commuting emissions were conducted through a vehicle country survey based on type (two and four wheelers). Three scenarios were assumed based on the distance travelled – 5, 10 and 15 kms travelled for office commute. Further, the number of working days were assumed to ~ 250 days per year. For the year 2019-20, the total CO₂ emission (CO₂e) of the studied organization was 3174.18 tons of CO₂e/yr. Under the IPCC protocol classification, it could be seen that SCOPE-3 (1860.75) emissions made 58.62% of the carbon emissions of the institute, and SCOPE-2 (1304.37) emissions also made 41.09% of the total emissions. Of the SCOPE-3 emissions, Employee commute made the highest contribution (30.66%) with considerable impact from the treatment of wastewater generated (23.275) in the premises. The per capita emission of the institute was 3.52 tons CO₂e/yr and 0.05 tons of CO₂e per square meter built-up area for 2019-20.

Table 11: Type, Scope and source wise carbon emissions for 2019-20

Type	Scope	Sources	Emissions tCO ₂ /yr)
Direct	Scope 1	LPG	9.06
Indirect	Scope 2	Grid Electricity	1304.37
	Scope 3	Solid Waste Disposal	148.93
		Wastewater Treatment	738.67
		Employee Commuting	973.15
		Total	3174.18

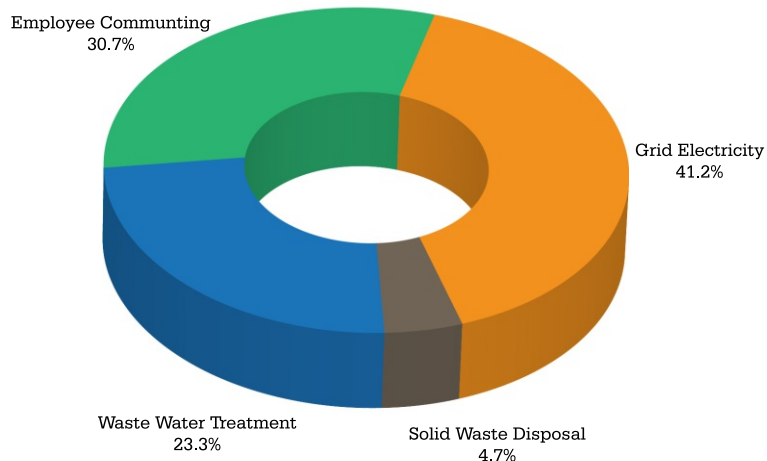


Figure 24: Source-wise distribution of carbon emission for the NEERI campus for 2019-20



5.1.4 Limitations

The assessment is subject to the following limitations:

- Use of aggregated campus-level activity data,
- Screening-level assumptions for commuting distances and mode share,
- Exclusion of several Scope-3 categories,
- Absence of uncertainty and sensitivity analysis.

These limitations are acceptable given the baseline nature of the study and are explicitly addressed in the proposed future work.

5.2 Carbon footprint estimation & Renewable Energy Interventions of campus

CSIR-NEERI has installed the roof-top solar-powered plant as per the RESCO model. This plan comes with a 25-year solar power guarantee and estimates a 6-year return time for establishment costs. In this approach, the RESCO bears all the capital costs associated with the installation of the plant. When compared to the CAPEX model, where the roof owner claims the venture/capital, the RESCO model is a less expensive option from the customer's point of view. The consumer receives appropriate recompense for the power generated at a discounted rate of Rs. 3.62 per unit but does not pay any upfront costs.

According to the RESCO concept, the RESCO will be solely responsible for managing, upkeep, and repairs of the solar plant for the duration of the PPA-funded project. In addition, RESCOs collect data related to energy production and other weather parameters every 15 minutes on an online dashboard. Furthermore, subject to state rules, the RESCO may choose to sell any extra electricity produced by the plant to the grid at competitive feed-in tariff rates. As a result, when demand exceeds supply, the RESCO gets paid by the utility for injecting excess electricity into the grid and by the consumer for their electricity use.

After the installation of solar plant at the end of year 2018, the MSEDCL bill has plummeted from 2019 onwards, as an annual solar generation were hitting to as high as 2 Lakhs units and above. As a result, from the below graphs, it has been depicted that dependency on MSEDCL units is reduced and expenses because of the solar plant have also decreased.

SOLAR PLANT INSTALLED (in Dec 2018)	2019	2020	2021	2022	2023	2024	2025
Solar units generated (Consumed) (kWh)	2,33,353	2,41,111	232047	231154	228499	223856	221932
Savings due to Solar Power Plant (Lakhs Rs.)	23.34	24.76	24.75	23.49	23.33	22.86	22.55
Tons CO ₂ avoided (1 unit=0.95 kg CO ₂)	221.69	229.06	220.44	219.60	217.07	212.66	210.83

Table 12:
CO₂ savings due to solar installation at CSIR-NEERI campus

*Inclusive of PV carbon footprint

- CO₂eq. emissions from Coal = 1 kg CO₂eq/kWh
- CO₂ eq. emission from PV = 0.05 kg CO₂eq/kWh
- Net CO₂ eq. = 0.95 kg CO₂ eq/kWh

Financial savings due to other energy interventions:

So far, inefficient ACs have been replaced with 87 ACs (5 star) and 40 AC (4 star); 1400 Tube lights and 480 Fans got replaced with energy efficient options; 220 Streetlights have been replaced with 45 watts LED lamps with 3-stage dimming facility and fixed an automatic power factor controller at electrical substation (0.997) (2.5-3.5%) for power factor regulation. But these are not considered as the initial cost of solar installation marked zero.

Estimate overall carbon & environmental footprints of identified labs and plan to minimize pollution:

CO₂, NO_x, SO_x, and airborne inorganic particles such fly ash, carbonaceous material (soot), suspended particulate matter (SPM), and other trace gas species are the main emissions from thermal power plants primarily burn coal and lignite.

Year	2019	2020	2021	2022	2023	2024	2025
Tons of CO ₂ avoided	221.69	229.06	220.44	219.61	217.07	212.66	210.83

Table 13:
Carbon-Dioxide Avoided due to Rooftop Solar Installation

5.3 Carbon Emissions Profile and Reduction Outcomes of CSIR-NEERI Campus

The carbon footprint assessment of the CSIR-NEERI campus provides a detailed understanding of both emission sources and mitigation strategies through an integrated analysis of baseline emissions and renewable energy interventions. The 2019–2020 baseline assessment estimated total greenhouse gas emissions at 3174.18 tons CO₂e/yr, with Scope 3 emissions accounting for the largest share (58.62%), followed by Scope 2 emissions (41.09%), while direct Scope 1 emissions remained minimal. Key emission hotspots included purchased electricity, employee commuting, and wastewater treatment, showing that indirect emissions are the main component of the campus's carbon footprint. The per capita emission was estimated at 3.52 tons CO₂e/yr, indicating the carbon intensity of campus activities primarily driven by energy use and mobility.

Complementing this baseline, the implementation of rooftop solar infrastructure under the RESCO model since 2018 has significantly reduced dependence on grid electricity and contributed to measurable emission reductions. The campus has consistently generated over 2 lakh kWh of solar energy annually, along with substantial financial savings. Energy efficiency measures, including replacement of conventional appliances with star-rated systems and LED infrastructure, further support emission reduction efforts.

Taken together, the combined analysis highlights a transition from a carbon-intensive baseline dominated by indirect emissions to a progressively optimized energy system supported by renewable energy adoption and efficiency improvements. While the baseline assessment identifies key emission hotspots requiring targeted interventions, the renewable energy and efficiency initiatives demonstrate the campus's capacity to reduce its carbon footprint and environmental impact. This integrated approach provides a strong foundation for future, more detailed carbon accounting and supports strategic planning toward a low-carbon and sustainable campus.

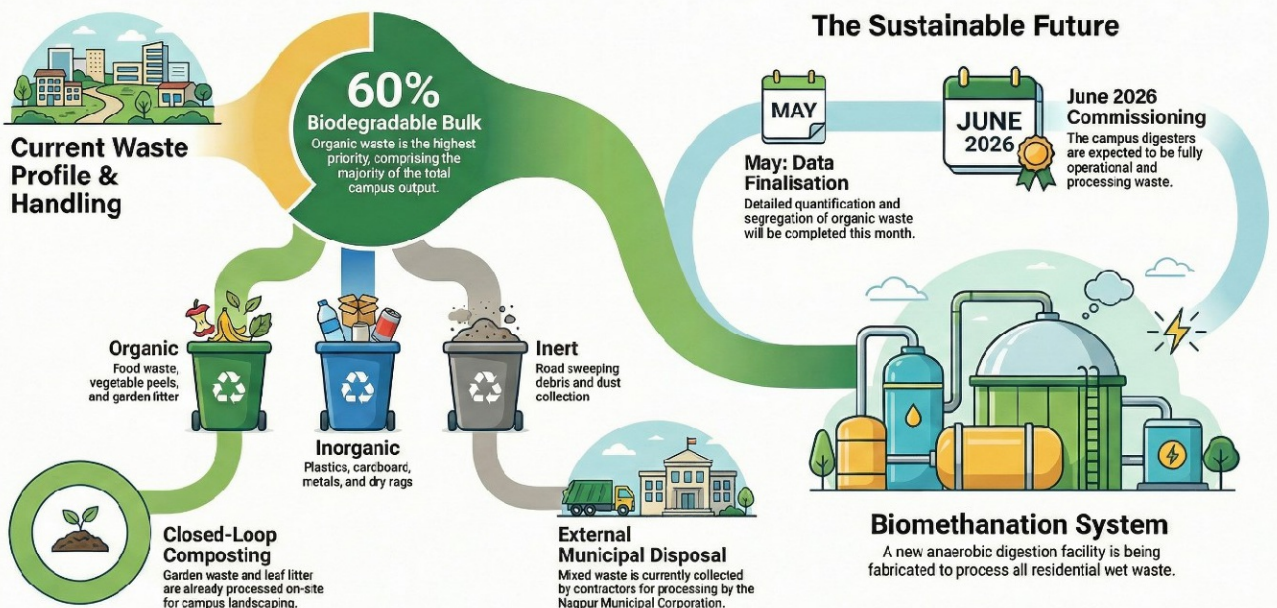


CHAPTER

6

SOLID WASTE MANAGEMENT

From Waste to Wealth: The NEERI Campus Sustainability Roadmap



Based on a preliminary assessment, the following categories of solid waste have been identified within the campus:

- **Organic (Biodegradable) Waste:** This includes food waste from households, hostels, canteen, and guesthouse; vegetable peels; leaf litter; and other garden waste generated across the campus.
- **Inorganic Waste:** This comprises recyclable materials such as plastics, cardboard, metals, rags, and similar dry waste fractions.
- **Inert Waste:** This mainly consists of waste generated from road sweeping and dust collection activities.

6.1 Present Waste Management Practices

In line with the objectives of developing a sustainable and resource-efficient campus, organic waste management has been identified as the high priority, as biodegradable waste constitutes approximately 60% of the total waste generated on the campus.

- At present, the mixed solid waste generated on the campus is collected by an authorized contractor and subsequently handed over to the Nagpur Municipal Corporation (NMC) for final processing and disposal.
- Garden waste and litter waste generated within the campus are currently managed through on-site composting pits, and the compost produced is reused for landscaping and gardening activities within the premises.
- Recyclable waste fractions with high calorific value will be tested at designated facilities, while the remaining recyclable materials will be handed over to authorized recyclers for further processing.

6.2 Anaerobic Digestion Facility

The following are the glimpses of the anaerobic digesters currently under fabrication and procurement, which are being developed to process wet waste generated from residential areas, hostels, the canteen, and the guesthouse within the NEERI campus.



Photoplate 14:
Anaerobic digester under procurement





**CONCLUSION
&
WAY FORWARD**

CONCLUSION

The campus' sustainability assessment demonstrates a thorough and integrated approach to environmental stewardship, illustrating how institutional settings may serve as living examples of sustainable development. Biodiversity conservation is one of the campus's most important foundations, with a wide range of native and planted species contributing to ecological stability, carbon sequestration, and habitat provision for birds and small animals. In addition to improving aesthetic and recreational value, these green areas also control microclimate, boost air quality, and fortify resistance to urban environmental stress. The campus landscape thus serves as both a conservation zone and a learning laboratory, reinforcing the importance of protecting natural ecosystems within built environments. Water management practices further reflect a strong commitment to resource efficiency and circular use. Rooftop rainwater harvesting systems, groundwater recharge measures etc. helps for a sustainable use of water management. Sewage treatment plants (STPs) based on up-flow compact constructed wetlands (UCCW) are a novel, redesigned wetland technology that may solve problems with water quality and budgetary limits, which makes them particularly appropriate for Indian circumstances ensure that wastewater is scientifically processed before reuse for landscaping and non-potable applications In parallel, solid waste management systems based on segregation at source, based on anaerobic digestion facility promote responsible consumption patterns and minimize landfill burden.

Energy management initiatives complement these efforts through the adoption of renewable energy sources, energy-efficient infrastructure, and conservation practices aimed at reducing carbon emissions. Solar installations, efficient lighting systems etc. contribute to climate change mitigation and operational sustainability. When combined, biodiversity protection, water stewardship, waste reduction, wastewater treatment, energy management and carbon foot printing adoption form a comprehensive sustainability framework. The campus becomes a self-regulating ecosystem that incorporates environmental responsibility into its operations and design, rather than just an educational or research institution. The campus will be positioned as a replicable example for organizations looking to strike a balance between development, ecological integrity, and long-term resilience through ongoing monitoring, community involvement, and innovation.

WAY FORWARD: ADVANCING CAMPUS SUSTAINABILITY

CSIR-NEERI is stepping up its sustainability efforts via integrated programs in water, waste, energy, and landscape management.

- To improve decentralized wastewater treatment and encourage water reuse on campus, a 75 KLD UCCW-based Sewage Treatment Plant (STP) is now under construction.
- Comprehensive quantification and segregation of organic waste in the campus and quarters is underway and is scheduled to be finished by May. To ensure long-term sustainable waste management, an anaerobic digestion (biomethanation) system has been proposed, with installation in progress and commissioning anticipated by June 2026, enabling efficient resource recovery.
- Future carbon footprint assessments (2024–2025) will transition from a screening-level approach to a comprehensive, activity-based inventory, incorporating expanded Scope 1 sources, disaggregated Scope 2 energy use, and broader Scope 3 categories. This will enhance emission tracking, support hotspot identification, and guide evidence-based mitigation strategies.
- Additionally, climate-sensitive landscaping interventions will be implemented to improve pollinator diversity, enhance campus aesthetics, and reduce urban heat island effects, further strengthening ecological resilience.



ROADMAP

LONG-TERM VISION (Net-Zero Pathway)

- Reduce dependence on grid electricity through renewable energy
- Address major emissions from commuting and wastewater
- Enhance carbon sinks through biodiversity and green infrastructure
- Transition toward a low-carbon and climate-resilient campus

MEDIUM-TERM (3–5 Years)

- Achieve 50% renewable energy share
- Develop comprehensive carbon inventory (Scope 1, 2, and 3)
- Strengthen water reuse and circular resource systems

SHORT-TERM (By 2026)

- Installation of 75 KLD Sewage Treatment Plant (STP) for wastewater recycling
- Commissioning of biomethanation unit (anaerobic digestion)
- Expansion of solar capacity by 200 kW
- Initiation of climate sensitive landscaping project.



CSIR-NEERI LIVING LAB

Building upon these initiatives, the CSIR-NEERI has begun to develop a test bed, Living Lab serves as a platform to integrate sustainability into real-world practice. Defined as a *user-centred, open innovation ecosystem*, the Living Lab fosters collaboration among researchers, stakeholders, and end-users to co-create practical and scalable solutions. It emphasizes active participation and bridges the gap between research and implementation by testing innovations within the campus itself.

VISION

"Integrating environmental stewardship with nature-inspired technologies creates an ecosystem for learning, experimentation, and sustainable implementation"

CSIR-NEERI, Nagpur Living Lab integrates traditional wisdom with modern scientific innovation to restore and safeguard the five fundamental *Panch Bhoota* elements of nature: Prithvi (Earth), Jal (Water), Agni (Energy), Vayu (Air), and Akash (Space).



Living Lab at CSIR-NEERI is a dynamic and creative test bed where research, innovation, and real-world application come together to build sustainability. By co-creating, testing, and improving technologies in practical settings, the Lab promotes dynamic collaboration between users, stakeholders, and researchers. By encouraging nature-based solutions that restore balance throughout the Panch Bhoota (Prithvi, Jal, Agni, Vayu, and Akash), for improved climate resilience solutions, Living Lab offers an effective answer to complex socio-ecological concerns.

Figure 25
Panch Bhoota
concept of
CSIR-NEERI
Living lab

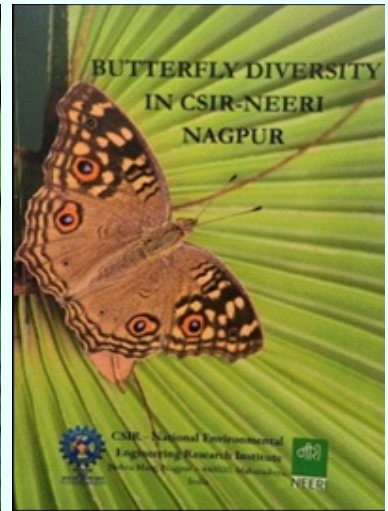
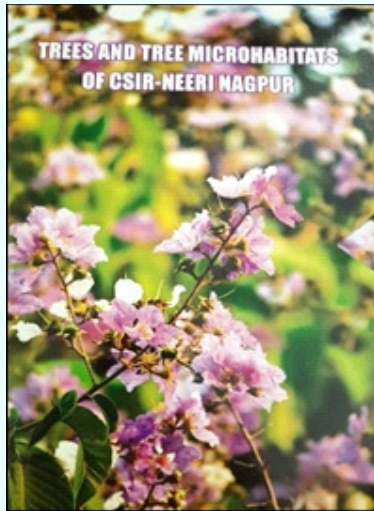


Campus Initiatives towards Sustainability Development Goals

The campus sustainability framework is directly compatible with the United Nations' Sustainable Development Goals (SDGs). The campus serves as a micro-model of sustainable development; combining social, economic, and environmental aspects. Campus biodiversity conservation promotes SDG 15 (Life on Land) by preserving local species and increasing green space. SDG 6 (Clean Water and Sanitation) is aided by water conservation measures including rainwater collection and wastewater reuse. Adoption of renewable energy and energy-efficient systems reduces carbon emissions, and waste management, which is in line with SDGs 7 (Affordable and Clean Energy) and 13 (Climate Action). The concepts of SDG 12 (Responsible Consumption and Production) are reflected in solid waste segregation, composting, and recycling. Additionally, sustainable campus planning promotes health and well-being, which contributes to SDG 3 (Good Health and Well-Being), while research, innovation, and environmental education help to achieve SDG 4 (Quality Education) and SDG 9 (Industry, Innovation and Infrastructure). As a result, the campus functions as a living laboratory where local action is converted into global sustainability objectives, showing how institutions may effectively contribute to the SDGs through responsible governance and integrated environmental management.



KNOWLEDGE PRODUCTS AND OUTREACH PROGRAMS



Participated in the Bioconserve 2026 event at Infosys, Bangalore, where our kiosk titled “Urban Living Lab: Green Solutions to Urban Challenges” showcased our key knowledge products and highlighted the concept and applications of the Living Lab approach. The platform provided an opportunity to engage with diverse stakeholders and disseminate our work on sustainable urban solutions. The platform enabled us to interact with a wide range of stakeholders while also promoting our research on sustainable urban solutions.



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