

Smart landscaping – Way forward for sustainable cities and communities

Utilizing vertical landscaping, rooftop landscaping, xeriscaping and diverse planting materials including native flora and fauna along with use of smart solar panels, sensor based application of water and nutrients to plants can mitigate the urban heat island effect, improve air quality, and reduce noise pollution. Urban green spaces are the basis of ecosystem and social well being. City parks, green barriers, rooftop garden and vertical gardens in residential yards contribute in climate change mitigation. These landscapes are also responsible for maintaining biodiversity, reducing the gap between natural and man-made environment. However, challenges in implementing green infrastructure include high costs, limited resources, and urban sprawl. Overcoming these barriers requires strategic planning, government incentives, and innovative design solutions.

SMART landscaping offers a sustainable solution for urban challenges by integrating horticultural innovations into city infrastructure, contributing to the UN Sustainable Development Goals (SDGs). The Comptroller and Auditor General of India (CAG) prepared a list of 17 sustainable development goals (SDGs) on July 8, 2019 to achieve the United Nations-mandated SDGs for holistic progress of the countries. One of the SDG ‘sustainable cities and communities’ calls for restructuring and implementation of sustainable city infrastructure following state of the art design innovations to reduce the environmental impact and improve the quality of living. Several of the concepts in the domain of Horticulture (vertical landscaping, rooftop landscaping and xeriscaping etc.) along with landscape designing (strategic use of trees, shrubs, climbers/herbs, and planting noise barriers) aims to progress towards achieving the above SDGs. These smart landscapes, for instance, maximize space efficiency in densely populated cities, providing benefits such as aesthetic beauty, thermal insulation, pollutant absorption, purification of air, noise reduction by optimal usage of natural resources like water, light, nutrients, with the help of new innovations such as various types of sensors and artificial intelligence (AI) and remote sensing along with GPS based mapping of our resources. This article sheds light on the smart landscaping with potential solutions and challenges thereof to address the issue of achieving the above SDGs, keeping in view the increasing population, rapid urbanization and shrinking horizontal space especially in cities and their outskirts.

Vertical landscaping

Incorporating landscaping in urban high-rise environments is essential for enhancing the microclimate

and promoting the psychological well-being of city residents and minimizing sick building syndrome. The limited availability of space in urban areas has prompted the use of vertical space over horizontal expansion. Vertical farming offers a range of advantages, particularly in regions like India with distinct seasonal variations. A well established vertical garden improves the microclimate, reduces noise, provides thermal insulation, offers natural shade and reduces energy consumption. A vertical garden involves cultivating vegetation on vertical surfaces supported by a modular framework containing a light weight growing medium, suitable plant species, sensor based fertigation and artificial intelligence (AI) based identification of symptoms of nutrient deficiencies and its control. The use of sensor based irrigation systems combined with rooftop underground rainwater harvesting can help to minimize water consumption for future generations. Opting for native, drought-tolerant plant species well adapted to local climatic conditions can further reduce maintenance cost. Vertical green walls enhance the wall’s thermal insulation by up to 30%, reducing the amount of heat absorbed or lost through walls and building facades. A layer of insulation stabilizes indoor temperatures, which results in lower energy usage for both heating and cooling systems. Additionally, the dense foliage allows only 5% to 30% of light to transmit, providing a natural shading effect and cooling the ambient air temperature up to 8°C in densely built urban areas. These vertical gardens also play a key role in absorbing harmful aerosols, including volatile organic compounds (VOCs), effectively aiding in the selective removal of pollutants from the environment, besides minimizing the urban heat island effect and sick building syndrome.



Vertical garden showcasing variation in foliage colour and texture

Rooftop landscaping

In recent years, the concept of rooftop gardening is getting popular among the residents of cosmopolitan cities like Bengaluru, Delhi, Hyderabad, Pune and Mumbai. The scarcity of space for raising a vegetable garden and for recreation purpose has led to the need for development of rooftop gardens for creating a sustainable green space within the comfort of their house. The rooftop gardens provide several benefits ranging from the amelioration of micro-environment besides production of fresh edibles for daily home consumption. Additionally, a well-designed rooftop garden adds aesthetic value to the property. Green roofs with diverse forms of plant material reduce the runoff volumes of the rainwater thereby reducing the burden on drainage systems and minimizing the risk of flooding. Leaves of varied texture over rooftop tend to adsorb suspended particulate matter and improve the air quality index of the surroundings. Vegetation over the terrace act as natural insulation, reducing heat absorption, and cool the microclimate and lower the energy consumption, especially during the summer months. Studies indicate a significant reduction in room temperature with rooftop covering. A reduction in temperature ranging from 4 to 11°C, during different seasons has been recorded, compared to the room temperature with bare rooftops. A careful planning of the rooftop garden design taking into consideration the orientation and proportion of the planting beds could yield an additional temperature reduction of 3–4°C. Studies have highlighted the efficacy of rooftop gardens in mitigating the urban heat island effect and minimizing diurnal temperature fluctuations.

Before establishing rooftop garden on any building, some important points shall be taken into account like weight bearing capacity of buildings, strength of the structure, water proofing, proper drainage along with selection of light weight growing media and locally adapted native plant materials.

Xeriscaping

The word 'Xeros' is a Greek word that means 'dry'. Xeriscape refers to a landscape that utilizes little or marginal quantity of water to ensure the survival of different plant species. It is misconception to denote a xeriscape as a dry, barren landscape, or a 'no maintenance' landscape. Xeriscaping involves careful designing and selection of plant species to minimize periodic care and maintenance besides limiting the frequent application of

water. This includes careful selection of certain indigenous plant species that are well adapted to dry or arid climate as well as following certain cultural practices such as use of mulches that suppress weed growth and help conserve soil moisture, besides installation of sensor based drip irrigation system to make the judicious and need based application of water and nutrients. The drought prone landscapes can effectively lend a colour and fragrance like other garden landscapes where water and other management practices are not the limiting factors.

Xeriscape does not mean to specifically design a single landscape or garden design. It is a concept of water conservation that can be applied to landscape design of any style – Traditional, English, Japanese, Persian, Hindu, Buddhist gardens and others. The design may be formal or informal (natural-looking). The principles that govern the xeriscape are fundamental that involves Good Horticultural Practices (GHP) taking into consideration seven water-conserving principles viz. planning and design (based on traditional and AI), efficient irrigation systems (sensor based), use of biodegradable mulches (eco-friendly), soil preparation (laser based), appropriate turf (native and locally adapted), water-efficient plant material (native and locally adapted) and appropriate maintenance (with minimal use of resources).

Integrating diverse planting materials for effective environmental amelioration

Vegetation has a capacity to alter the microclimate of any area and improve its Air Quality Index (AQI). The diversity of plant species in urban areas plays a crucial role in urban ecology, contributing to social functions and enhancing the well-being of residents. It forms the backbone of green infrastructure, acting as a life support system for urban eco-systems. Urban green spaces typically consist of a blend of both natural and cultivated plants, offering a vital balance between nature and human-designed landscapes. A greater variety of species especially native plants are believed to offer better resilience against environmental changes and unpredictable climatic changes.

Diverse forms of ornamental plant species especially in urban/peri urban areas positively impact the microclimate by absorbing or filtering radiant heat and reducing glare from buildings and human activities. However, this impact varies with plant size and species due to differences in their morphological structure and location of placement. Based on Air Pollution Tolerance Index (APTI), and other parameters, many ornamental plants species are better for amelioration of environment (Table 1).

Carbon sequestration and climate change mitigation

Cities are among the largest contributors to carbon emissions, significantly influencing climate change. In 2015, urban areas accounted for 61.8% of global greenhouse gas emissions, and it is projected that by 2100, this figure will surpass 80%. Carbon sequestration, as defined by the United Nations Framework on Climate Change (UNFCCC), is the process of capturing CO₂ from the atmosphere and storing it in reservoirs. Trees and other ornamental plants play a crucial role in this process by absorbing CO₂ and

Table 1. Ornamental plants used for effective environmental amelioration in urban system

Action	Ornamental plants
Reduce air and noise pollution (Outdoor)	<i>Ficus, Alstonia, Putranjiva, Pongamia, Anthocephalus and Terminalia, Nyctanthes, Hamelia, Jatropha, Cestru, Murraya, Euonymous, Bouganivillea, Vernonia, Ipomoea, Thunbergia, Clerodendrum, Aristolochia, Petrea</i>
Reduce air pollution and adsorb particulate matter (Indoor)	<i>Areca palm, Song of India, Peace lily, Spider plant, Money plant, Snake plant, Dracena, Dieffenbachia, Syngonium, Chlorophytum and English Ivy (Hedera helix)</i>
Phyto-remediation	<i>Canna, Iris, Heliconia, Zantedeschia, Zinnia</i> Turf grasses: <i>Agrostis capillaris</i> and <i>Festuca rubra</i>

other pollutants like CO, ozone, and NO₂ through their stomata and reduce carbon footprint. Particulate matter (PM₁₀ and PM_{2.5}) also adheres to leaf surfaces, assisted by wind currents, before being absorbed. Plants with thick leaf hair or a waxy surface excel in capturing PM. Urban landscapes, particularly urban forests, green roofs, gardens, and green corridors, have a significant potential to reduce carbon emissions, accounting for approximately 10% of global terrestrial carbon pools.

Ornamental trees and shrubs are recognized for their superior carbon sequestration capacity compared to other plant species. Besides trees and shrubs, the turf grasses also play a vital role in carbon storage. For instance, residential turf grass areas store twice as much Organic Carbon (OC) as agricultural land. Studies suggest that over three decades, turf can sequester between 0.34 and 1.4 Mg/ha/year of carbon from atmosphere. They also play role in reduction of soil erosion and retain soil carbon undisturbed. A 10% increase in green cover reduces runoff of the residential yard by 4.9% as suggested based on modeling. Additionally, optimizing vertical space by creating a layered plant community of herbs, shrubs, and trees maximizes land-use efficiency and enhances carbon sequestration potential.

Noise pollution reduction with green barriers

Traffic noise is a nuisance and contributes to stress leaving a negative impact on the health and well-being of people residing adjoining roads with a higher vehicular traffic. Exposure to higher levels of traffic noise (> 60 dB) can cause multiple hearing and health problems, including cardiovascular disease and sleep disturbance (Insomnia). It is therefore important to take appropriate and eco-friendly measures to reduce the impact of traffic noise on the living beings. Noise barriers are a potential solution to reduce the intensity of sound transmitted from the noise source to the receiver. However, their effectiveness depends on factors, such as the height and length of the barrier, the texture of material used and the distance between the noise source and the barrier. Green noise barriers have been proven effective in reducing noise intensity in urban areas while providing additional environmental benefits (improvement in AQI, create habitats for wildlife, carbon sequestration). A study reports that green noise barriers of native plant species have a potential to reduce noise levels by 2-8 dB, much efficient than concrete walls. Using native ornamental plant species of trees and shrubs like *Ficus*, *Askoka*, *Amaltas*, *Dhak*, *Pride of India*, *Sukhchain*, *Rhododendron*, *Mahagony*, *Maulsri*, *Kachnar*, *Neem*, *Hamelia*, *White Chadani*, *Ixora* etc. planted in double/

triple row system according to their height and spread at optimum spacing alongside the national/state highways for creating a dense screen wall/bio-fencing between highways and residential areas is a cost-effective solution in mitigating the traffic noise.

Employment opportunities in smart landscaping

There is a great demand of smart landscaping to achieve SDGs not only in urban and peri-urban but also in rural areas due to eco-tourism becoming very popular in villages. A good landscape professional can earn money by designing of landscape plan/design, visiting the sites, providing the landscape consultancy, handling turnkey projects of landscaping of different themes/styles. There is a lot of scope for ornamental/landscape nursery business as landscape mall/hub dealing with all aspect of landscaping like ornamental plants/seeds, trees, shrubs, climbers, indoor plants, seasonal flowers as gift, turf grasses, cacti and succulents, bonsai, topiaries and all other accessories like garden tools/equipments, decorative pots, growing media mixture, materials to make landscape project smart like sensors, GPS and Artificial Intelligence (AI) based site analysis/surveys of landscape site, polyhouse/net house construction, solar pumps/lights, fertigation and above all sourcing of skilled/trained manpower to handle smart landscape projects etc.

Challenges and solutions in implementing green infrastructure

The United Nations has projected that over two-thirds of the world's population will be inhabiting in cities by 2050. With an aim to achieve SDGs for holistic growth of country, Indian cities are facing rapid urbanization with a significant reduction in agricultural land over the years. The high density living and rapid reduction of green spaces has contributed to severe physical and mental health issues of people, in addition to the inflation. The scarcity of the available natural resources such as water, fresh air and green spaces are being rapidly consumed without recharging, recycling and reusing leading to the deterioration in their quality. Rapid depleting of resources jeopardizes the journey to sustainable development. Erratic weather and seasonal climatic variation across the Indian sub-continent also hinder in the growth, development and maintenance of urban green infrastructure. Above all, there is scarcity of trained/skilled landscape professionals for smart landscape designing as well as trained manpower for the maintenance of smart landscape projects.

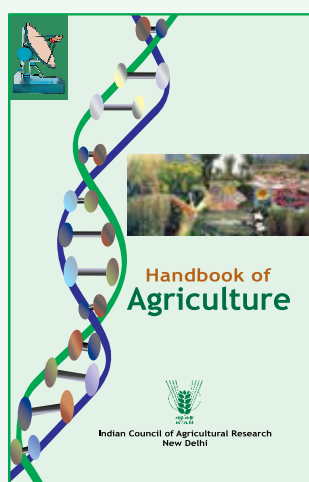
A way forward in achieving the above Sustainable Development Goals (SDGs) with the limited resources can be done through strict government legislations that aim to protect the land and water resources. Urban horticulture needs to be promoted in cities through land zoning in city master plans. There should be design plan for introducing community gardens for the city residents to collectively grow their fresh organic veggies and fruits. The municipal corporation should heavily tax vacant plots and cease to construct on land adjoining residential colonies. A dedicated space adjoining residential colonies must be ensured by the city corporations for growing dense canopy of trees (high density planting of native plants in different layers) as buffer zones following NGT guidelines. Urban horticulture policies should be framed and implemented considering social, economic and environmental aspects. Due to the multi-dimensional nature of urban horticulture, policy development and planning should involve multiple stakeholders comprising horticulture scientists, physicians, waste management stakeholders and town planners. Higher cost of vertical garden infrastructure reduces its

coverage to larger population in urban areas. Reducing the cost by financial incentive is one way to implement it. Also, innovative solutions such as lightweight growing media, modular systems can be used to incorporate vertical gardens into both new and existing structures. An inventory of the available vacant open land within the city by GIS-based data should be made and assessed for its suitability to promote urban farming. Government incentives can be provided to organized groups of urban producers and private stakeholders to promote urban farming and creating a sustainable infrastructure like rooftop water harvesting and sensor based application of water to plants, use of solar pumps and lights, *in-situ* preparation of compost from kitchen wastes, incentives for community level plantation and their maintenance.

For further interaction, please write to:

Dr R K Dubey (Professor & Head), Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, Punjab 141 027. *Corresponding author email: rkubey.flori@pau.edu

Handbook of Agriculture



The Handbook of Agriculture is one of the most popular publication of the ICAR with a wider readership. The present edition presents science-led developments in Indian agriculture, the ongoing research efforts at the national level and with some ideas on the shape of future agriculture. While information in some chapters such as Soil and water, Land utilization, field and forage crops has been updated with latest developments, many new topics such as the Environment, agrobiodiversity, Resource conservation technologies, IPM, Pesticides residues, Seed production technologies, Energy in agriculture, informatics, Biotechnology, Intellectual Property Rights, Agricultural marketing and trading and Indigenous Technical Knowledge have been included in the present edition. For those who take intelligent interest in agriculture – and their number is increasing fast – the present edition would serve as a useful book.

TECHNICAL SPECIFICATIONS

Size	:	Royal Octavo (16 cm x 24 cm)
No. of pages	:	i-xii + 1620
Price	:	₹ 2000
Postage	:	₹ 200
ISBN No.	:	978-81-7164-096-6

For obtaining copies:

Business Manager

Directorate of Knowledge Management in Agriculture
Krishi Anusandhan Bhavan-I, Pusa, New Delhi 110 012
Tel: 011-25843657, Fax: 09-11-25841282; E-mail: bmicar@gmail.com

SCAN QR Code to
Purchase Online

