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Future of Indoor Plants: Smart Floriculture for Healthier and Greener Living Spaces

Kushal S. G. Naik[1*], Manjunath D. R.[2] and Subhrajyoti Mohanty[3]

[1]Department of Floriculture and Landscape Architecture, KRCCH, Arabhavi, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India

[2, 3]Department of Floriculture and Landscape Architecture, College of Horticulture, Bagalkot, University of Horticultural Sciences, Bagalkot-587104, Karnataka, India

*Email: kushalnaik652@gmail.com

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Abstract

Indoor plants have become an integral part of modern lifestyles due to increasing urbanization, shrinking green spaces and growing awareness of health and environmental sustainability. Beyond their ornamental appeal, indoor plants contribute significantly to improving indoor air quality, enhancing psychological well-being, reducing stress and creating healthier living and working environments. The advancement of smart floriculture has transformed indoor plant cultivation through the integration of digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), automated irrigation systems, environmental sensors and smart lighting. These innovations enable precise monitoring of plant health, optimize resource use, minimize maintenance efforts and improve the quality of ornamental plants. Smart floriculture is increasingly being adopted in homes, offices, hospitals, educational institutions, hotels and commercial buildings to promote sustainable urban living. The future of indoor plants lies in combining advanced technologies with environmentally friendly production systems, ensuring efficient water management, energy conservation and reduced carbon footprints.

Keywords: Indoor plants, Smart floriculture, Internet of Things (IoT), Artificial Intelligence, Indoor air quality, Sustainable landscaping, Urban horticulture, Smart gardening.

Introduction

Indoor ornamental plants are cultivated primarily for their attractive foliage, flowers and aesthetic appeal. They are capable of adapting to relatively low light intensity, controlled temperatures and limited growing spaces. Popular indoor plants such as *Spathiphyllum*, *Aglaonema*, *Philodendron*, *Syngonium*, *Monstera*, *Dracaena*, *Ficus elastica*, *Anthurium*, ZZ plant (*Zamioculcas zamiifolia*), Snake Plant (*Sansevieria trifasciata*) and Pothos (*Epipremnum aureum*) have gained worldwide popularity because of their ease of maintenance and decorative value (Aydogan and Cerone, 2021). Indoor vegetation contributes to improved indoor environmental quality by reducing certain airborne pollutants, moderating humidity and creating a more pleasant living environment (Han and Ruan, 2020). Furthermore, the presence of indoor plants has been associated with reduced stress, improved cognitive performance, enhanced concentration, increased workplace productivity and better psychological well-being (Bringslimark *et al.*, 2009). These benefits became especially evident during the COVID-19 pandemic, when indoor gardening emerged as a valuable activity for relaxation, emotional support and mental health improvement (Chamola *et al.*, 2022). Traditional maintenance of indoor plants often relies on manual watering, fertilization and environmental monitoring, which may result in inconsistent growth and inefficient resource utilization. Recent advances in smart floriculture have introduced sensor-based and automated management systems integrating Internet of Things (IoT), cloud computing, mobile applications and artificial intelligence to optimize plant care through real-time monitoring of soil moisture, light intensity, temperature, humidity and nutrient status, thereby improving plant health while conserving water and energy (Nabaei *et al.*, 2025).

Importance of Indoor Plants

Indoor plants have become increasingly important because they contribute to both environmental quality and human well-being. Green interiors create attractive spaces that improve the aesthetic value of homes, offices, hotels, hospitals, shopping malls and educational institutions. The presence of indoor plants reduces stress, improves mood, enhances concentration and increases workplace productivity (Bringslimark *et al*., 2009).

Plants also help maintain comfortable indoor humidity through transpiration and contribute to better indoor environmental quality. Although they are not a substitute for proper ventilation, certain plant species can assist in reducing some indoor air pollutants under controlled conditions (Aydogan and Cerone, 2021). Gardening activities further promote relaxation, reduce anxiety and encourage a closer connection with nature (Hall and Knuth, 2019).

The COVID-19 pandemic highlighted the value of indoor gardening, as many people turned to houseplants to improve their living environments and support their mental well-being during extended periods indoors (Chamola *et al*., 2022).

Smart Floriculture: The Future of Indoor Gardening

- Smart floriculture is transforming the cultivation and maintenance of indoor plants through the use of advanced digital technologies (Nabaei *et al*., 2025).
- Traditional plant care often depends on manual watering and observation, which can result in inconsistent growth and inefficient use of resources (Nabaei *et al*., 2025).
- Smart systems provide continuous monitoring and automatic control of environmental conditions, allowing plants to receive the right amount of water, light and nutrients at the right time (Nabaei *et al*., 2025).

Internet of Things (IoT)

- IoT-based sensors continuously monitor soil moisture, temperature, humidity, light intensity and nutrient status.
- These sensors send real-time information to mobile applications or cloud platforms, enabling users to monitor plant health remotely.
- Automatic irrigation systems are activated only when required, reducing water wastage and improving plant growth.

Artificial Intelligence (AI)

Artificial Intelligence analyses plant growth data and identifies problems such as nutrient deficiencies, water stress and diseases before visible symptoms appear. AI-powered mobile applications can identify plant species, recommend management practices and assist users in maintaining healthy indoor plants. In commercial nurseries, AI improves production planning, disease detection and quality management (Liakos *et al*., 2018).

Smart Lighting and Automated Irrigation

Smart LED grow lights provide the light spectrum required for efficient photosynthesis while consuming less electricity than conventional lighting systems.

Smart LED systems allow growers to adjust:

- Light intensity
- Photoperiod (day length)
- Light spectrum
- Light duration
- Energy consumption

Blue wavelengths promote vegetative growth, while red wavelengths stimulate flowering and biomass accumulation. Some advanced systems automatically modify light intensity according to natural daylight availability, reducing electricity consumption while maintaining optimum plant performance (Mitchell and Sheibani, 2020).

Automated Irrigation

Automated irrigation systems equipped with moisture sensors ensure precise watering, prevent over-irrigation, improve root development and conserve water. Together, these technologies reduce maintenance efforts and improve ornamental plant quality.

Advantages of automated irrigation:

- Water savings of up to 30–50%
- Reduced labour requirements
- Uniform moisture distribution
- Prevention of overwatering
- Improved root development
- Enhanced nutrient uptake
- Better plant growth consistency

Smart Floriculture for Sustainable Urban Living

Sustainability has become one of the major driving forces behind modern horticultural research. Smart floriculture contributes significantly to sustainable development by improving resource-use efficiency while minimizing environmental impacts (Nabaei *et al*., 2025).

As urban populations continue to increase and green spaces become limited, indoor plants will play an increasingly important role in creating healthier, greener and more sustainable cities. The integration of horticulture with digital technologies represents a major step toward the future of urban living (Runkle *et al*., 2019).

Sustainability benefits

Water Conservation

Water conservation is one of the major sustainability benefits of smart floriculture. Precision irrigation systems use soil-moisture sensors, environmental sensors and automated controllers to supply water according to the actual requirements of plants. Instead of following fixed irrigation schedules, these systems monitor the moisture level of the growing medium and provide water only when necessary. This reduces over-irrigation, evaporation losses and water wastage. In addition, automated irrigation systems can improve water-use efficiency by delivering water directly to the root zone. The conservation of freshwater resources is particularly important in urban areas where water demand is increasing and availability may be limited. Thus, smart irrigation technologies support the sustainable production of indoor plants while reducing unnecessary consumption of water (Kumar *et al*., 2024).

Energy Efficiency

Energy efficiency is another important advantage of smart floriculture systems. Indoor plant production often requires artificial lighting, ventilation, heating, cooling and environmental control systems. Smart LED lighting consumes considerably less electricity than conventional lighting systems and can provide specific light wavelengths required for plant growth. Automated lighting systems can also adjust the intensity and duration of light according to plant requirements and the availability of natural daylight. Similarly, smart climate-control systems can regulate temperature and humidity more efficiently by operating only when necessary. These technologies help reduce energy consumption and operational costs while maintaining suitable conditions for plant growth. The use of energy-efficient systems can also reduce greenhouse gas emissions associated with electricity consumption, thereby contributing to more environmentally sustainable indoor horticulture (Runkle *et al*., 2019).

Reduced Chemical Inputs

It can help reduce the unnecessary use of pesticides, fungicides and other chemical inputs. Advanced monitoring systems, cameras and artificial intelligence-based image analysis can detect early symptoms of pest infestation and diseases before they become widespread. Early detection allows growers to take timely and targeted management measures instead of applying chemicals routinely or over large areas. This precision-based approach reduces pesticide consumption and minimizes the risk of chemical residues and environmental contamination. Accurate monitoring of plant health can help identify nutritional deficiencies and other stress conditions at an early stage, allowing corrective measures to be applied more efficiently. Consequently, smart plant management promotes safer and more environmentally friendly production practices (Banerjee *et al*., 2025).

Waste Reduction

Smart floriculture contributes to waste reduction by improving the accuracy and efficiency of resource application. Precision fertigation and nutrient management systems provide plants with the required quantity of nutrients according to their growth stage and environmental conditions. This reduces excessive fertilizer application, nutrient losses and runoff. Smart monitoring can also help identify plant stress, poor growth and disease at an early stage, reducing the loss of plants and production resources. Automated systems can improve the use of water, fertilizers, growing media and other inputs, thereby minimizing wastage. In addition, efficient production planning and data-based management can reduce unnecessary plant losses and improve the overall productivity of indoor plant production systems (Kumar *et al*., 2024).

Carbon Sequestration

Indoor plants contribute to improved environmental quality through photosynthesis, during which carbon dioxide is absorbed and oxygen is released. Although the carbon sequestration capacity of individual indoor plants is relatively modest compared with forests and large-scale vegetation, the collective presence of plants in homes, offices, institutions and commercial buildings can contribute to greener and healthier indoor environments. Plants also support the visual and psychological quality of indoor spaces and may help improve the overall perception of environmental comfort. When smart technologies are used to maintain healthy plant growth with efficient resource use, indoor greenery can be managed more sustainably. The combination of indoor plants and energy-efficient production technologies therefore supports the development of greener urban living spaces (Sena *et al*., 2024).

Climate Resilience

Smart floriculture technologies can improve the resilience of plants to changing environmental conditions. Indoor plants may be exposed to fluctuations in temperature, humidity, light intensity and water availability. Smart sensors continuously monitor these conditions and allow automated systems to respond quickly to environmental changes. For example, irrigation, lighting, ventilation and temperature-control systems can be adjusted according to real-time plant requirements. This helps maintain a more stable growing environment and improves plant survival under stressful conditions. Climate-resilient plant management is particularly important as urban environments experience increasing temperature fluctuations and other effects associated with climate change. By improving resource efficiency and plant adaptability, smart floriculture can support sustainable urban ecosystems (Kumar *et al*., 2024).These technologies directly support several United Nations Sustainable Development Goals (SDGs), particularly those related to sustainable cities, responsible consumption, climate action and good health and well-being.

Challenges and Future Prospects

Despite its advantages, smart floriculture faces several challenges, including high installation costs, technical complexity, maintenance of sensors and energy requirements. Small-scale growers may find advanced technologies expensive and successful operation requires basic digital skills (Kumar *et al*., 2024). Future developments are expected to make smart gardening systems more affordable and user-friendly. Emerging technologies such as robotics, computer vision, digital twins, nanotechnology, renewable energy integration and blockchain-based traceability will further improve indoor plant production. Research is also focusing on developing intelligent systems capable of automatically diagnosing plant disorders and providing real-time management recommendations (Banerjee *et al*., 2025). As urban populations continue to increase and green spaces become limited, indoor plants will play an increasingly important role in creating healthier, greener and more sustainable cities. The integration of horticulture with digital technologies represents a major step toward the future of urban living (Sena *et al*., 2024).

Conclusion

Indoor plants have evolved from simple decorative elements into valuable components of healthy and sustainable living environments. They improve interior aesthetics, enhance psychological well-being, support indoor environmental quality and encourage a stronger connection between people and nature. The emergence of smart floriculture has further transformed indoor gardening by integrating IoT, Artificial Intelligence, smart sensors, automated irrigation, and energy-efficient lighting into plant management systems. These technologies enable precise monitoring of plant growth, improve resource-use efficiency, reduce maintenance efforts, and promote environmentally sustainable practices. Although challenges such as cost and technical expertise remain, continuous technological advancements are expected to make smart indoor gardening more accessible in the coming years. Smart floriculture will play a vital role in supporting greener homes, healthier lifestyles, and sustainable urban development, making indoor plants an essential part of future living spaces.

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