

SMART GARDENING IN THE UNITED STATES AND GLOBAL MARKETS: ADOPTION DRIVERS, TECHNOLOGY TRENDS, AND FUTURE GROWTH

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Abstract

Smart gardening is an emerging sector that combines hydroponics, Internet-of-Things (IoT) sensors, automation and artificial intelligence to enable consumers to grow herbs and vegetables indoors or manage outdoor plants with minimal effort. This paper uses secondary research to compare the United States (U.S.) market with the global smart gardening landscape. Market reports and academic studies published between 2023 and 2025 provide the evidence base. The U.S. is treated as the base market due to its early adoption of smart home technologies and large consumer base, while regional differences and growth drivers across Europe, Asia-Pacific and other regions are assessed. The study identifies market size trends, key technologies, sustainability benefits, consumer adoption patterns, and major challenges. It integrates theoretical perspectives from technology adoption models and draws on case studies such as the rise and temporary closure of AeroGarden and IoT-based models for high-rise buildings. The paper concludes with recommendations for businesses and policymakers to foster sustainable growth and user-centric innovation in smart gardening.

Introduction

Background and context

Urbanization, climate change and the pursuit of healthier lifestyles are fundamentally transforming how people produce and consume food. More than four billion people now live in cities, over half of the global population and this urban share continues to rise (Ritchie et al., 2025). Smart gardening emerges as a response to limited arable land in urban areas by combining compact hydroponic or soil-based systems with environmental sensors, automated lighting and nutrient dosing to create controlled micro-ecosystems. These solutions range from plug-and-play countertop herb gardens to wall-mounted planters and modular vertical gardens, while institutions experiment with IoT-enabled models for high-rise buildings (Zailan & Hamid, 2023). Evidence indicates that indoor smart

gardens enhance food production, support environmental sustainability and improve dietary health (Mihailović et al., 2023); precision irrigation technologies reduce water use and environmental footprints (Lakhia et al., 2024). Moreover, exposure to plants and gardening confers mental and physical health benefits, reinforcing the appeal of these systems (Thompson, 2018). Adoption has been strongest in North America due to early smart-home uptake and higher disposable incomes, but demand is accelerating globally as consumers seek resilient local food sources and policymakers promote sustainable urban agriculture. As a result, analysts anticipate the smart indoor gardening market to expand rapidly over the coming decade.

Problem statement

Despite the growth projections, the smart gardening market remains fragmented and has experienced notable setbacks. Some early entrants have struggled to build sustainable business models or maintain reliable customer support. Consumers often find the devices expensive, complex to operate or reliant on proprietary consumables. There is also limited research on how smart gardening contributes to sustainability goals such as water conservation and food security at household and city scales. Consequently, adoption varies widely across regions and demographics.

Objectives

This research aims to:

1. **Assess market size and growth** of smart gardening in the U.S. and globally, distinguishing between indoor garden devices, indoor gardening systems and smart gardening sensors.
2. **Identify key technologies and innovation trends** shaping smart gardening, including sensors, automation, artificial intelligence, and eco-friendly materials.
3. **Evaluate sustainability and health impacts** of smart gardens compared with traditional gardening.
4. **Analyse consumer adoption drivers and barriers**, drawing on models of technology acceptance and diffusion of innovation.
5. **Compare regional differences** in adoption, regulation and growth prospects.
6. **Examine case studies** that illustrate business challenges and novel applications.
7. **Provide strategic recommendations** for businesses and policymakers to foster sustainable growth.

Research questions

1. What are the current and projected market sizes for smart indoor gardens, smart indoor gardening systems and smart gardening sensors?
2. Which technologies are becoming standard versus premium features in smart gardening devices?
3. How do smart gardens contribute to sustainability goals such as water efficiency and reduced food miles?
4. What motivates consumers to adopt smart gardening, and what factors cause them to abandon these devices?
5. How do regional markets differ in terms of growth drivers, regulatory contexts and consumer behavior?

Scope and limitations

The scope of this study is deliberately confined to consumer-oriented smart gardening technologies, such as indoor hydroponic gardens, countertop herb planters, app-controlled irrigation systems, and IoT-enabled sensors, because these innovations bring agricultural techniques into homes and small institutions. While commercial vertical farms and industrial controlled-environment agriculture are occasionally referenced to provide context, they fall outside the core investigation. This narrow focus allows for a detailed examination of user-level adoption, system design, and market dynamics without conflating these themes with large-scale commercial farming practices. Additionally, the analysis is based solely on secondary sources (market reports, academic literature, and industry analyses). As such, the findings are constrained by the availability, quality, and timeliness of existing data; primary data on adoption and user experience are not collected, and recent innovations that have emerged after the study's literature window may not be reflected.

Literature Review

Smart gardening versus smart agriculture

Smart agriculture refers to large-scale farming systems that integrate automation, robotics and data analytics to optimize crop yields. These operations may deploy autonomous machinery, drones and extensive sensor networks across large fields to maximize productivity. By contrast, smart gardening targets households and small institutions, focusing on compact systems that can be deployed in kitchens, balconies or classrooms. A 2023 study on indoor smart gardens notes that these systems can significantly increase food production, improve environmental sustainability and enhance human health in urban areas (Mihailović et al., 2023). Indoor smart gardens rely on IoT sensors, automated lighting and nutrient dosing to maintain optimal conditions, whereas smart

agriculture typically involves tractors, drones and large data infrastructures. The distinction lies not only in scale but also in purpose: smart gardening empowers individuals and communities to grow food locally, while smart agriculture modernizes conventional farming practices across thousands of acres.

Key technologies in smart gardening

Sensors and IoT. Smart garden devices use soil-moisture, temperature, pH, nutrient and light sensors to monitor plant conditions in real time. These sensors generate continuous data streams that inform adaptive watering, nutrient delivery and lighting schedules. Wireless connectivity through Bluetooth or Wi-Fi enables remote monitoring and integration with smart-home assistants, and data analytics can interpret these inputs to provide predictive plant care and personalized recommendations.

Hydroponics and automation. Hydroponic systems grow plants without soil, using nutrient solutions and controlled lighting; this method enables high yields in confined spaces and reduces pest risks. Automated watering and feeding reduce labor and ensure consistent growth conditions. Compact, modular systems have become popular among urban consumers, and innovative devices such as vertical towers, wall-mounted gardens and self-watering planters allow users to expand their gardens as needed.

Artificial intelligence and machine vision. Advanced platforms incorporate AI to analyze environmental data and plant growth patterns. Machine-vision applications can diagnose plant health through smartphone cameras, while AI algorithms adjust lighting and irrigation schedules, adapting cultivation cycles to users' consumption habits. These features simplify maintenance and make horticultural expertise more accessible.

Eco-friendly materials and energy efficiency. Sustainability-conscious consumers drive demand for biodegradable seed pods, recyclable hydroponic components and energy-efficient LED lighting. Solar-powered sensors and biodegradable growing media are gaining traction, reflecting broader environmental awareness. Research into precision irrigation technologies emphasizes that reducing water consumption and nutrient runoff is critical for sustainable smart gardening (Lakhiar et al., 2024).

Sustainability and environmental impact

Smart gardens promise resource efficiency by controlling water and nutrient inputs. Sensors and artificial-intelligence algorithms calibrate irrigation and nutrient dosing to plants' needs, reducing waste and improving yields. A recent study on sustainable indoor gardening emphasises that such systems enable water conservation and energy efficiency while improving plant health and increasing production rates (Wadud et al., 2025). Indoor smart gardens can also increase food

production, reduce food miles and enhance environmental sustainability compared with traditional outdoor farming. Urban indoor systems support year-round production, which reduces reliance on seasonal and long-distance supply chains and helps lower the carbon footprint of food.

Consumer adoption models

Technology adoption theories such as the Technology Acceptance Model and Rogers' Diffusion of Innovation highlight perceived usefulness, ease of use, trialability and observability as critical factors. Smart-garden adoption is driven by convenience, the desire for fresh, pesticide-free produce and the appeal of integrating greenery into modern lifestyles. Proprietary consumables and subscription-based seed pods can encourage recurring use, and integration with voice assistants or smart-home ecosystems may boost long-term engagement. However, high upfront costs, technical complexity, dependence on proprietary consumables and trust issues following company failures remain significant barriers. Many devices require reliable internet connectivity and smartphone apps; poor app functionality is a major source of negative user feedback. Adoption also depends on cultural and economic contexts: recent research on urban gardening in Peru notes that models like TAM, the Diffusion of Innovation and the Theory of Planned Behavior show how end-users' characteristics and needs influence uptake, and that systems must be user-friendly and adaptable to local contexts (Ibarra-Cabrera et al., 2024).

Research gaps

Most research on smart agriculture focuses on large-scale farming, leaving a gap in knowledge about household-level and compact urban systems. IoT-based gardening models for small spaces, such as high-rise academic buildings, remain underexplored. Longitudinal data on retention rates and the long-term behavior of smart-garden users are limited, so little is known about how engagement evolves after the novelty wears off. Few studies examine cultural differences and policy influences on adoption, despite evidence that socioeconomic and cultural factors shape user acceptance of urban-gardening technologies (Ibarra-Cabrera et al., 2024). Additional research is needed to understand how design can accommodate diverse user needs, to assess the environmental benefits of sustained use, and to evaluate how policy frameworks might foster or hinder adoption.

Methodology

This research employs a qualitative synthesis of secondary sources, including market reports, academic articles, press releases and case studies published between 2023 and 2025. The U.S. market is treated as the base for comparisons across Europe, Asia-Pacific, Latin America and the Middle East. Information is

triangulated across sources to identify consistent trends and to mitigate potential biases; data are categorized by themes such as technology trends, adoption drivers, sustainability impacts and market segmentation. Because our analysis relies on existing literature rather than primary data, findings are constrained by the availability, quality and timeliness of those sources. Market size figures are reported in current U.S. dollars, and any gaps in the literature are noted as areas for further investigation.

Market Overview: Smart Gardening in the U.S.

Market size and segmentation

The U.S. smart indoor garden market has grown rapidly since the COVID-19 pandemic spurred interest in home gardening. Industry estimates suggest that the global market reached about USD 3.5 billion in 2025 and is projected to exceed USD 4 billion in 2026 and USD 12 billion by 2035. North America is expected to capture a significant share of the global market by 2035 due to strong consumer purchasing power and the early adoption of smart-home technologies. The residential consumer segment accounts for the majority of sales, and online and e-commerce channels dominate distribution. Popular product categories in the U.S. include countertop herb gardens, modular vertical systems and smart irrigation devices for outdoor yards.

Demand drivers

Several factors fuel U.S. demand for smart gardening:

1. **Urban lifestyles and wellness trends.** Consumers living in small apartments seek convenient ways to grow fresh produce and herbs indoors. Health-conscious individuals value pesticide-free food and the mental benefits of connecting with plants.

2. **Technological integration.** High adoption of smart home assistants in the U.S. encourages integration with gardening systems. Voice commands and app-based control simplify maintenance.

3. **Subscription models.** Companies like Click & Grow and Rise Gardens offer seed pod subscription services that ensure ongoing revenue and user engagement (BusinessWire, 2025).

4. **Government investment.** The U.S. Department of Agriculture funds-controlled environment agriculture and smart farming projects, which accelerates innovation and validates the technology (Research Nester, 2025).

Consumer profiles

Smart-garden users in the U.S. fall into several segments. Young professionals are attracted to tech-enabled lifestyles and appreciate the convenience of automated plant care. Families view smart gardens as educational tools for children to learn

about science and nutrition. Health enthusiasts are interested in fresh herbs and microgreens to support healthy diets. Seniors and individuals with limited mobility benefit from systems that reduce the physical effort of gardening. Hobby gardeners use smart devices to explore hydroponics and experiment with new crops. The price of high-end systems can range from USD 200 to over USD 1 000, positioning many products as premium appliances.

Competitive landscape

The U.S. market features a mix of domestic and international players. Established brands offer countertop herb gardens, modular vertical systems and app-controlled irrigation, while newer entrants emphasize advanced automation features, artificial-intelligence-driven care and sleek designs. Product differentiation focuses on aesthetics, modularity and the level of automation. Subscription pods create recurring revenue but may lock consumers into proprietary ecosystems. Competition among manufacturers drives innovation but can also create fragmentation in connectivity standards and consumable formats.

Pricing and revenue models

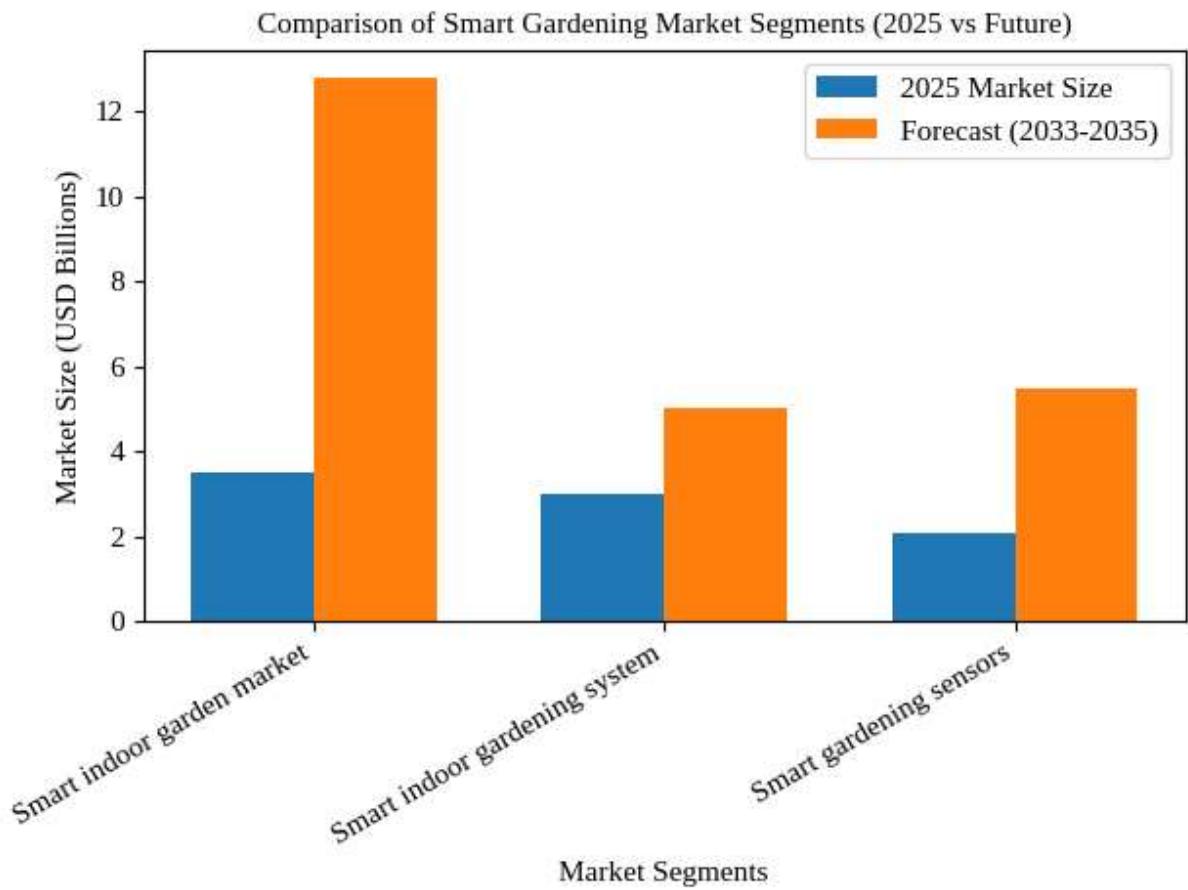
Most smart-garden companies follow a razor-and-blade model: they sell hardware at competitive prices and generate profits from consumables such as seed pods and nutrient solutions. Premium app subscriptions offer advanced guidance, plant recognition and personalized growing recommendations. Some brands partner with restaurants, schools and wellness spaces to supply live herbs on site, diversifying revenue streams and building awareness.

Regulatory and environmental context

Water conservation regulations in drought-prone states such as California encourage adoption of smart irrigation systems. Indoor hydroponic devices must comply with electrical safety standards, and marketing claims must adhere to environmental advertising guidelines. The U.S. Environmental Protection Agency's food recovery hierarchy prioritizes source reduction, and local production of fresh produce through smart gardens can reduce food waste and transportation emissions. Federal initiatives support research and commercialization of controlled environment agriculture; recent USDA funding has provided more than \$50 million since 2022 to advance these technologies, signaling continued public support for sustainable indoor farming.

Chart: Market Size Comparison

Below is a bar chart comparing the market size of three major segments - smart indoor gardens, smart indoor gardening systems and smart gardening sensors - in 2025 and their projected values for 2033 -2035. The data show that while indoor garden devices generate the largest revenue, sensors are the fastest-growing segment.

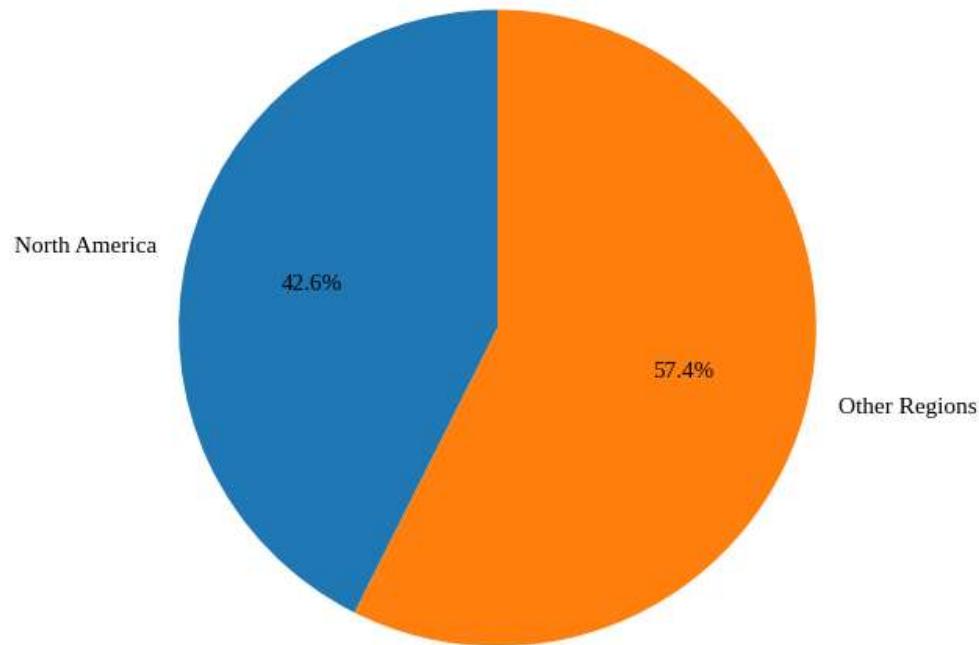


Market Size Comparison

Chart: U.S. and Global Market Segmentation

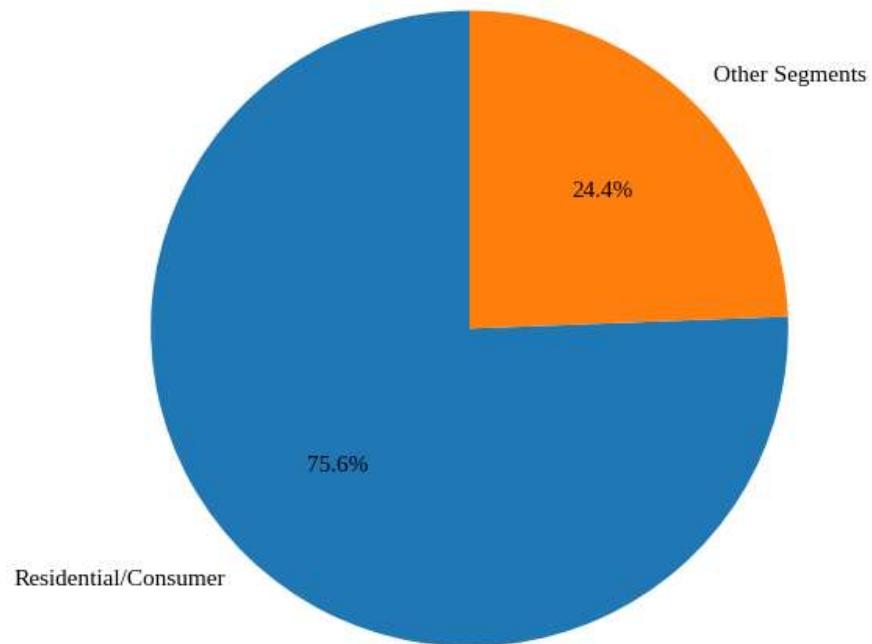
Two pie charts illustrate the projected share of North America versus other regions and the dominance of the residential/consumer segment in 2035.

Regional Market Share in Smart Indoor Gardening (2035 Projected)



Regional Market Share

Market Segmentation Share (2035 Projected)



Segment

Share

Global Smart Gardening Market: Comparative Lens

Regional overview

North America is expected to remain the largest regional market for smart indoor gardens through the next decade, with some analysts projecting that the region could account for more than two-fifths of global sales by 2035. Asia-Pacific is forecast to grow rapidly, driven by high population density, food-security concerns and interest in compact solutions that can operate in small living spaces. Europe's adoption reflects strong sustainability policies and a culture of eco-consumerism, while the Middle East shows enthusiasm for water-saving technologies that address chronic aridity. Major adopting countries include the United States, China, Japan, Germany and the United Kingdom. Emerging markets such as India, South Korea, Singapore and Australia are poised for rapid growth as urbanization and disposable income rise.

Drivers and challenges

Urbanization and land scarcity push consumers toward indoor gardens that maximize yield per square foot. Advances in controlled-environment agriculture supported by public funding encourage innovation and legitimacy; the U.S. Department of Agriculture has awarded contracts and grants exceeding fifty million dollars since 2022 to support research and commercialization of controlled-environment systems. Corporations and institutions are integrating indoor gardens into supply chains and campuses to demonstrate commitment to sustainability and food transparency.

Nonetheless, regulatory hurdles complicate cross-border sales. Seed and plant-health regulations vary by country, requiring companies to maintain separate inventories and navigate complex phytosanitary rules. Technological integration and software development remain ongoing challenges; unreliable apps or hardware can erode customer satisfaction and increase product returns. Adoption is also limited by price sensitivity and space constraints in densely populated regions, where consumers may prefer lower-cost DIY kits or shared community gardens over premium smart devices.

Market segments and business models

Globally, the residential and consumer segment accounts for well over three-quarters of smart-garden sales, reflecting the appeal of compact systems for home use. E-commerce and direct-to-consumer distribution dominate because online channels support customization and subscription replenishment services. Commercial applications such as hotels, offices, restaurants and schools, form a

smaller but growing niche by offering decorative edible gardens and educational features. Business models vary by region: companies in East Asia often position smart gardens as premium home appliances, while European brands emphasize sustainability and circular design. In emerging markets, affordability drives demand for modular kits and open-source systems that allow users to source their own seeds and nutrients rather than rely on proprietary consumables.

Technology Trends and Innovation Roadmap (2025–2035)

IoT evolution and sensor integration

Rapid advances in Internet-of-Things (IoT) technology are making precision monitoring accessible even to home gardeners. Systems now routinely employ soil-moisture, temperature and pH sensors connected to microcontrollers and Wi-Fi modules; real-time data is transmitted to mobile applications so users can remotely monitor plant conditions and trigger irrigation only when needed (Othman et al., 2025). Researchers emphasise that integrating accurate sensor arrays with smart-home platforms improves ease of use and ensures compatibility (Othman et al., 2025). Looking ahead, developers are experimenting with solar-powered sensors and biodegradable materials to reduce energy consumption and electronic waste (Rollo et al., 2025). Voice assistants and home automation hubs are becoming standard interfaces, allowing users to check moisture levels or adjust lighting through simple voice commands.

Artificial intelligence and personalization

Artificial intelligence (AI) enhances smart-garden functionality by analyzing environmental data and user habits to deliver predictive plant care. Algorithms can anticipate when water or nutrients are needed and adjust schedules based on how quickly plants are harvested. Machine-vision technology is also being incorporated; one recent study describes a smartphone application that diagnoses plant diseases by analyzing leaf images and provides specific prevention and treatment recommendations. Subscription services are evolving to include smart seed refills and nutrient packs, delivered automatically when sensors detect that supplies are running low. Educational features, particularly those aimed at children and schools, blend gardening activities with science, technology, engineering and mathematics (STEM) lessons, making indoor gardening both an instructive and practical activity.

Modularity and ecosystem design

Next-generation smart gardens emphasize modularity. Many systems let users start with a basic countertop unit and then expand by adding vertical towers, wall-mounted planters or additional trays as they gain confidence. Interoperability

with broader smart-home ecosystems is critical so that devices can share data and respond collaboratively to changes in light, humidity or temperature. Companies are also promoting community-driven platforms where users exchange growing tips, share recipes and showcase creative system configurations, encouraging social engagement around home food production.

Sustainability innovations

Sustainability is a core driver of innovation. Designers are increasingly using biodegradable seed pods, recyclable plastics and energy-efficient LEDs to minimize waste. Combining reusable wireless sensor networks with detachable, degradable sensors can monitor parameters like pH while keeping the environmental footprint low (Rollo et al., 2025). Solar-powered sensors and renewable energy integration further reduce reliance on the electrical grid, aligning smart gardens with circular-economy goals.

Supply chain and subscription models

The razor-and-blade business model (hardware plus consumables) continues to dominate. However, high initial costs and subscription fatigue prompt some consumers to seek DIY or open-source alternatives. Companies are exploring partnerships with seed companies and sustainable packaging providers to create circular refill systems.

Business Strategy Analysis

Value chain

Smart gardening companies operate along a value chain that spans hardware manufacturing, software development, consumables production and customer support. Hardware manufacturers design hydroponic units, lighting systems and sensor arrays; software developers build mobile apps and cloud platforms to manage irrigation and lighting schedules; consumable producers supply seed pods, nutrient solutions and replacement parts; and customer-support teams help users navigate installation, maintenance and troubleshooting. Vertical integration across these stages can enhance the user experience by ensuring that hardware, software and consumables work seamlessly together, but it demands substantial capital and technical expertise. Controlled-environment agriculture (CEA) systems require high initial investments: the start-up cost for a vertical farm can range from approximately USD 150 to USD 400 per square foot, compared with USD 50 to USD 150 for a traditional greenhouse, and advanced systems must address challenges such as even distribution of water and light across stacked tiers (Stein, 2021). Operating costs are also elevated because CEA farms need highly skilled scientists, engineers and horticulturists; however, proponents argue that these facilities can create high-tech jobs in urban areas (van Delden et al., 2021; Shamshiri et al., 2018).

Energy consumption is another major expense, artificial lighting can make up the largest share of operating costs and research suggests that producing staple crops indoors will remain economically challenging unless energy efficiency improves or renewable sources are widely adopted (Mills & Dunn, 2017). Despite these hurdles, advocates note that CEA farms located near consumers can diversify food supply chains, reduce transportation emissions, and ensure access to fresh produce during disruptions such as extreme weather or logistics bottlenecks (Pinstrup-Anderson, 2018; Beachum et al., 2019).

Competitive strategies

Competitive strategies in the smart-gardening industry vary widely. Some firms pursue cost leadership by offering basic devices with minimal automation, targeting budget-conscious consumers. Others differentiate through advanced artificial-intelligence features, elegant industrial design and modularity; these premium systems often promise higher yields and more sustainable operation. Research on vertical farming shows that yields can be 70-80 times greater than conventional farmland, and consumers perceive larger, technology-driven systems as more sustainable (Maurya et al., 2023; Jürkenbeck et al., 2019). However, these benefits come with trade-offs: climate control and artificial lighting create substantial energy costs (Debdas et al., 2023; Ullah et al., 2023). To broaden appeal, some companies market open systems that allow users to source seeds and nutrients from multiple providers, catering to do-it-yourself enthusiasts. Niche strategies focus on specific user groups, families, schools or chefs, offering educational content, child-safe designs or chef-grade herb cultivators. Premium brands emphasize aesthetics and seamless integration with voice assistants and smart-home ecosystems, turning indoor gardens into lifestyle products rather than utilitarian appliances.

Partnerships and ecosystems

Partnerships and ecosystems play an important role in expanding the reach of smart-gardening technologies. Collaborations with schools and wellness programs introduce children and patients to hands-on plant science and nutrition, supporting science, technology, engineering and mathematics (STEM) curricula and therapeutic activities. Restaurants and cafés incorporate countertop herb gardens and vertical planters to demonstrate freshness and sustainability to patrons. Real-estate developers integrate smart gardens and living walls into apartment complexes and corporate campuses, promoting biophilic design and employee well-being. Research on vertical greening systems notes that indoor and outdoor green walls can improve air quality, enhance building thermal comfort and attenuate noise in dense cities (Fonseca et al., 2023), suggesting that such

installations offer both environmental and psychological benefits. Agricultural universities and extension services provide credible plant-care content and training, accelerating innovation and helping companies refine technologies. These partnerships create an ecosystem where smart-garden companies, educational institutions, and public and private organizations collaborate to promote resilient local food systems, sustainable building design and community engagement.

Consumer Behavior and Adoption Barriers

Motivations for adoption

Consumers adopt smart gardens for multiple reasons. Compact systems offer year-round access to fresh herbs and vegetables even in small apartments, and the presence of greenery has been shown to enhance physical and mental health. App-connected devices provide real-time reminders and plant-care advice, and integration with voice assistants allows hands-free control. Subscriptions for seed pods and nutrient refills simplify the growing process, lower the learning curve for beginners and reinforce long-term use. Industry studies of smart-home adoption note that relative advantage, enjoyment, image enhancement and modern multifunctional design are key drivers of technology uptake (Basarir-Ozel et al., 2022); these factors apply equally to smart gardens, which combine practical benefits with lifestyle appeal.

Reasons for discontinuation

Despite these motivations, a range of barriers can lead to discontinuation. High upfront costs and recurring subscription fees deter price-sensitive users, while technical complexity and maintenance requirements discourage those without gardening or technology experience. Qualitative research with industry experts identifies high cost, complexity, lack of compatibility and the absence of trusted brands as principal barriers to smart-home adoption (Basarir-Ozel et al., 2022); similar obstacles exist for smart gardens. Proprietary consumables and closed ecosystems can make users feel locked into a single supplier and limit experimentation. Hardware or software glitches erode confidence, and when prominent manufacturers reduce support or exit the market, consumers may migrate to open-source or do-it-yourself solutions rather than risk being stranded without replacement parts or seed pods.

Trust, privacy and data concerns

Smart-gardening devices also raise privacy and data-security concerns. Like other IoT products, they collect environmental and usage data, which can be exploited if not properly safeguarded. A recent study of IoT users found that privacy and security concerns increase with job level and frequency of IoT use, and that large volumes of data transmitted by connected devices can heighten the risk

of breaches and unauthorized data monetization (Koohang et al., 2023). These concerns may discourage adoption unless manufacturers provide transparent data policies, robust encryption and clear explanations of how collected data are stored and used. To build and maintain trust, firms must prioritize cybersecurity, allow users to control data sharing and ensure that devices remain functional and supported for the duration of their expected life.

Case Studies

AeroGarden's closure and relaunch

AeroGarden, one of the pioneers of home hydroponic gardens, announced that it would close at the end of 2024. The brand cited business challenges and supply chain issues. In January 2025, however, AeroGarden announced a relaunch for spring 2025 with promises of revamped products and reinstated customer support(Vegbed, 2025)(Vegbed, 2025). The community's response was mixed: long-time fans welcomed the return of a familiar, plug-and-play system, while others expressed scepticism after being left without parts and pods during the closure(Vegbed, 2025). During AeroGarden's absence, many users explored alternatives such as Vegbed's biodegradable grow mats, DIY hydroponics and competitor systems like Click & Grow, Lettuce Grow and Rise Gardens(Vegbed, 2025). This case highlights the vulnerability of consumers to corporate decisions and the importance of reliable support and open ecosystems.

AgriSmart: IoT-based model for high-rise academic buildings

The AgriSmart project proposed an IoT-based smart gardening model designed for high-rise academic buildings. It integrates environmental sensors, precision irrigation and predictive analytics to manage compact green spaces in institutions. The system aims to reduce maintenance effort, optimize water usage and provide real-time monitoring (Zailan & Hamid, 2023). Researchers argue that most smart gardening solutions are built for rooftops or commercial farms and lack adaptability for confined spaces. By automating irrigation based on soil moisture and using real-time data analytics, AgriSmart addresses labour and resource constraints and demonstrates how smart gardening can contribute to urban sustainability and student engagement.

Discussion

Smart gardening sits at the intersection of technology, sustainability and lifestyle trends. In the United States adoption is strong because of higher incomes, early uptake of smart-home technology and robust consumer spending, while fast growth in Asia-Pacific indicates that the global landscape will evolve as urban populations pursue food security and personal wellness. Forecasts for the market vary widely because analysts use different definitions of what constitutes a "smart

garden" device or system; this divergence underscores the need for standardized market segmentation and more transparent reporting of assumptions.

Adoption drivers closely align with technology-acceptance theory. People perceive smart gardens as useful because they provide year-round access to fresh, pesticide-free produce and automate complex horticultural tasks; they are easy to use thanks to app-based control and voice-assistant integration; and they carry social appeal as part of broader wellness and environmental-consciousness trends. A systematic review of smart-home adoption notes that relative advantage, enjoyment, image enhancement and modern design are significant drivers, while high cost, complexity, lack of compatibility and the absence of trusted brands are major barriers (Basarir-Ozel et al., 2022). These findings translate directly to smart gardens: price-conscious users may be deterred by high up-front costs and recurring subscription fees, and technical glitches or business failures can quickly erode consumer trust and push users toward DIY or open solutions.

Sustainability benefits appear promising. Controlled-environment farming systems can reduce water usage by 80-99% through recycling and precision irrigation, decrease reliance on long-distance supply chains and deliver fresher, more nutritious produce by bringing cultivation closer to consumers (Dohlman et al., 2023). Indoor gardens also empower individuals to grow nutrient-dense microgreens and herbs in small spaces. Nonetheless, these gains must be weighed against the energy footprint of LED lighting and climate-control systems; life-cycle assessments are needed to compare environmental impacts across different technologies and operating conditions.

Finally, there are clear research gaps. Much of the existing literature focuses on household devices in developed markets, leaving questions about how smart-garden systems can be adapted for high-rise buildings, schools and hospitals. A systematic review of smart-home adoption emphasizes that most studies address developed countries and urban populations, neglecting the variables that affect adoption in emerging economies, rural communities and among low-income or disabled users (Valencia-Arias et al., 2023). Cultural differences may influence preferences. For example, collectivist societies might favor community gardens over individual devices and regions with limited internet connectivity may require offline functionality. Addressing these gaps will require interdisciplinary research that combines agronomy, engineering, behavioral science and cultural studies to design inclusive, resilient and sustainable smart-gardening ecosystems.

Recommendations

For startups and product developers

1. **Simplify onboarding and maintenance.** Reduce technical complexity through intuitive design and plug-and-play modules. Provide offline functionality and robust customer support.
2. **Adopt open ecosystems.** Allow users to choose seeds, nutrients and third-party accessories to avoid proprietary lock-in and increase trust.
3. **Design for sustainability.** Use recyclable materials, energy-efficient LEDs and biodegradable pods. Integrate sensors that optimize water and nutrient use.
4. **Leverage AI responsibly.** Implement AI features that enhance, rather than complicate, user experience. Offer personalized tips, diagnostic feedback and predictive scheduling.

5. **Build community features.** Incorporate social platforms or forums where users can share recipes, successes and tips, fostering retention and brand loyalty.

For policymakers and sustainability stakeholders

1. **Support research and development.** Fund innovation in urban agriculture, precision irrigation and sustainable materials. Provide grants for pilot projects in schools, hospitals and public housing.
2. **Establish standards and certifications.** Develop guidelines for smart garden safety, data privacy and environmental claims to protect consumers and encourage transparency.
3. **Promote education and equity.** Integrate smart gardening programs into school curricula and community initiatives to improve nutrition and environmental awareness. Provide subsidies or tax incentives for low-income households to access sustainable gardening technologies.
4. **Encourage data sharing and interoperability.** Facilitate collaboration between device manufacturers, researchers and regulators to set data standards that respect privacy and enable innovation.

Conclusion

Smart gardening is evolving from a niche hobby to a mainstream component of smart homes and sustainable urban living. Market forecasts indicate substantial growth, yet the trajectory depends on resolving barriers such as cost, complexity and trust. The U.S. market leads adoption today, but Asia-Pacific countries are poised for rapid expansion. Technological innovations in sensors, AI and eco-friendly materials will shape the next decade, while sustainability concerns and consumer preferences will influence design and business models. By addressing the

challenges identified and capitalising on emerging opportunities, smart gardening can contribute meaningfully to food security, wellness and environmental sustainability.

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