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Designing for ecological aesthetics in urban agriculture: Operationalising ecodesign principles across multilayer city landscapes

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Abstract. Ecologically designed urban agricultural landscapes present a critical, yet underutilised, strategy for mitigating biodiversity loss, enhancing climate resilience, and addressing social inequities within contemporary urban environments. The primary purpose of this study was to develop and operationalise a theoretical and practical framework that integrates ecological aesthetics into the design of urban agriculture, positioning aesthetic experience as a core component of multifunctional ecological performance. A mixed-methods approach was employed, combining a comprehensive literature review on ecological aesthetics with a detailed analysis of design examples from existing urban agricultural spaces. The investigation established a structured ecodesign framework with explicit criteria that synthesise aesthetics, ecological function, and resilience across diverse urban layers, including green roofs, greenways, and building facades. It was found that sensory qualities such as colour, texture, and rhythm, along with cultural meaning, can be deliberately orchestrated to amplify biodiversity support, enhance food production, and improve climate regulation without compromising ecological integrity. The framework further demonstrated how these aesthetic strategies can be systematically applied across vertical, horizontal, and transitional urban spaces to create coherent and engaging landscapes. The practical value of this research resides in its actionable design guidance and evaluation criteria, which can be utilised by urban planners, landscape architects, and policymakers to create adaptive, context-aware urban agricultural environments that harmonise beauty with robust ecological function and social relevance

Keywords: green infrastructure; ecological performance; landscape typology; microclimate mitigation; biodiversity strategies; vertical urbanism; ecosystem services

INTRODUCTION

Urban agricultural landscapes are rapidly emerging as a critical spatial typology within contemporary cities, offering a multifunctional approach to addressing interconnected challenges of food security, environmental degradation, and social well-being. E. Mino *et al*. (2021) noted that as urban populations continue to expand, the integration of food production into the urban fabric presents a strategic opportunity to transform underutilised spaces into productive and ecologically beneficial environments. These landscapes hold the potential to reconnect urban dwellers with food systems, mitigate the urban heat island effect, manage stormwater, and support biodiversity, thereby contributing to the overall resilience and sustainability of cities. Consequently, understanding how to effectively design and implement urban agricultural landscapes

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has become a pressing concern for researchers, planners, and policymakers seeking to create more liveable and sustainable urban futures.

The scholarship has made significant strides in advancing the ecological and functional dimensions of urban agricultural design. R. Hansen *et al*. (2023) explored the potential of urban agricultural landscapes to address food insecurity and environmental degradation, establishing a foundational understanding of their multifunctional role in urban settings. Expanding on this, K. Bohn & D. Chu (2021) developed the "food-productive greenway" concept, proposing an integrated approach that combines food production with urban food system activities to enhance both ecological capacity and socio-economic resilience. This work provided a significant framework for thinking about how productive landscapes could be woven into urban infrastructure. In a related vein, I. Quintero *et al*. (2022) introduced the Main Agro-ecological Structure (MAS) index, a comprehensive assessment tool comprising ten criteria and twenty-nine indicators designed to evaluate agro-biodiversity. Their research emphasised that the structural and spatial configuration of agricultural landscapes, particularly the extension and diversity of ecological connectors, can be strategically designed to enhance biodiversity connectivity. Furthermore, they argued that effective design must integrate physical landscape elements with cultural context, accounting for management practices and farmer perceptions to create resilient agro-ecosystems. However, their work, like much of the current research, focuses primarily on ecological function and connectivity without delving into the aesthetic dimensions of these designed landscapes.

Parallel developments in urban park design have yielded principles applicable to urban agriculture. F. Bolat & V. Deneri (2022) identified key agroecology principles such as habitat preservation and stormwater management that have been successfully implemented in urban agricultural projects, emphasising the importance of community involvement and resilience in creating successful public spaces. Similarly, J. Yuan & C.S. Kim (2024) advanced context-sensitive design approaches for coastal urban areas, focusing on the integration of salt-tolerant plant species and specialised soil and water management techniques. While these studies provide valuable insights into the ecological and functional aspects of designed landscapes, they similarly overlook the role of aesthetic experience in shaping user engagement and long-term stewardship.

The question of aesthetic experience in landscape architecture has itself undergone significant re-examination. K. Melcher (2022) traced the historical evolution of aesthetic preferences, noting that while aesthetic experience has varied across different periods and cultures, it has predominantly been centred on visual appeal, with people historically drawn to landscapes characterised by symmetry, colour, and formal beauty. However, R. Mundher *et al*. (2022) documented a growing recognition that contemporary design aesthetics must transcend mere visual attraction to incorporate principles of ecological sustainability. This shift has given rise to what S. Fu & F. Lv (2023) characterised as "ecological aesthetics", an emerging paradigm that integrates ecological principles directly into aesthetic theory and practice. Their work established that ecological aesthetics represents not merely an application of ecological knowledge to design, but a fundamental reconceptualisation of beauty itself as inherently connected to ecological health and function.

Urban agricultural landscapes present a uniquely promising opportunity for the application of ecological aesthetics. J. Zhang (2025) argued that by integrating ecological aesthetics into the design of these productive spaces, designers can create multifunctional environments that are simultaneously engaging, environmentally beneficial, and rich with social educational potential. Their research suggested that such integration could transform urban agriculture from primarily a food production strategy into a comprehensive approach to urban placemaking. Yet despite this potential, the systematic application of ecological aesthetics within urban agricultural contexts remains largely underexplored, representing a significant gap in current scholarship. Given these insights, this study was conducted to investigate the concept of ecological aesthetics and to develop a categorised typology of urban agriculture applications across multiple city layers. By incorporating ecological aesthetics into the design of these typologies, the research sought to establish a framework for enhancing the multifunctionality and resilience of urban agricultural landscapes, ensuring they not only contribute to food security and environmental sustainability but also meaningfully enrich the urban aesthetic experience.

This study employed a qualitative mixed-strategy design that integrated theoretical synthesis with comparative case study analysis. The methodology was constructed through an iterative process in which a literature review informed the selection and analysis of design exemplars, and insights from the cases subsequently refined the theoretical framework. The literature review established a robust theoretical scaffold for ecological aesthetics, drawing on interdisciplinary scholarship across landscape ecology, urban design, and sustainability studies. This review generated an analytical framework comprising three core categories – aesthetics, ecological function, and resilience – which structured the subsequent case analysis.

Case selection was guided by this theoretical foundation, with projects chosen to represent a spectrum of scales, contexts, and operational strategies within contemporary landscape and ecological design. The sample was purposively selected to ensure coverage of diverse urban strata, including the horizontal ground plane, the vertical building envelope, interior spaces, and coastal

edges. The set of exemplars comprised: Hauser & Wirth Somerset (Oudolf, n.d.), the Battersea Power Station Roof Garden (Crook, 2023), the Brick Swale at Balfour Street Pocket Park (MacGowan, 2012), the Oyster-tecture Project (SCAPE, 2025), and the Urban Farming Office in Ho Chi Minh City (Elangical, 2023).

Analysis procedures involved applying the three analytical categories to each case study. Data sources included project documentation, design drawings/models, and published critiques. Cross-case synthesis was employed to identify recurring operational strategies and context-specific adaptations for embedding ecological aesthetics within different urban layers. This integrated approach – moving iteratively between theoretical categories and empirical cases – supported the development of a structured multi-layer ecodesign framework that translates ecological aesthetics into explicit design criteria.

ECOLOGICAL AESTHETICS AND EDIBLE LANDSCAPES IN SUSTAINABLE URBAN DESIGN

Edible landscape has roots that trace back to the earliest practices of gardening. Since the early 2000s, this age-old practice has experienced a resurgence in urban areas, driven by concerns such as environmental degradation and food security issues linked to industrial food production systems. As Z.-W. Zheng & R.-J. Chou (2023) argued in their systematic review, these pressing challenges have positioned edible landscapes as a key strategy for sustainable urban development. Urban agricultural landscape should be understood not as mere spaces to be occupied, but as deliberate design elements that integrate edible functionality into the urban fabric. According to X. Shi (2023), who explored the creation of public edible landscapes, urban food forests and productive plantings can transform public spaces by encouraging community participation and multifunctional use. By incorporating productive plantings – such as fruiting trees, culinary herbs, edible perennials, and nourishing groundcovers – urban environments evolve from static backdrops to dynamic, functional ecosystems. This approach harmonises aesthetics with nourishment, yielding places that are visually compelling and ecologically and socially functional, promoting biodiversity, resilience, and community engagement. As R. Biasi & E. Brunori (2023) further emphasised, such integration of food systems into urban design fosters multifunctional landscapes that address both ecological and social dimensions of sustainability. In embracing edible landscape design, the authors acknowledge that urban spaces can be both aesthetically refined and materially productive, transforming each corner into a locus of nourishment, shelter, and sustainable practice.

In environmental design, designers seek a form of beauty capable of coexisting harmoniously with the natural world. As T. Beck (2013) observed, this pursuit emphasises how aesthetic elements – such as form, material, colour, light, and movement – play a crucial role in shaping landscapes that are both visually appealing and environmentally responsible. Emerging from these ideas, ecological aesthetics offers a perspective that foregrounds the relationship between people and ecosystems. By focusing on how landscapes look, feel, and function, ecological aesthetics fosters public understanding and acceptance of sustainable design, making beauty an accessible and meaningful dimension of everyday environments.

Ecological aesthetics redefine landscape appreciation by foregrounding cognitive processing, environmentalism, and a normative, style-independent approach to beauty. Rooted in the principle of "making nature visible", this conception, according to B.-W. Min (2012), emphasised multi-sensory experience, ecological functions, landscape temporality, and the historical dimension of place, while also addressing concerns of security and accessibility. Building on this foundation, A. Berleant (2025) concept of aesthetic engagement reconceptualises aesthetic experience as an immersive, temporal process rather than a moment of detached contemplation. It foregrounds the viewer's active participation within a holistic context, where meaning emerges through direct sensory interaction with the environment. Aesthetic value, in this view, is not inherent in an object alone but arises from the dynamic relationship between participant and setting, unfolding over time as perception deepens and conditions shift. By decoupling aesthetics from rigid stylistic norms, ecological aesthetics invites a broader, more inclusive understanding of beauty – one that highlights the integrative roles of ecosystems, human perception, and cultural memory. In translating these characteristics into practice, designers are urged to cultivate what J. Mikkonen (2022) described as creativity that effectively communicates ecological functions and the evolving narratives of landscapes to the public. Through such approaches, ostensibly unattractive or hidden ecological spaces can be transformed into legible, engaging, and artistic environments.

Urban agricultural spaces, as integral components of green infrastructure, offer substantial design opportunities to mitigate pollution and regulate urban microclimates. As D.L. Evans *et al*. (2022) demonstrated in their systematic review, thoughtful integration of spatial composition, materiality, and aesthetics can transform these spaces into multifunctional environmental assets. When edible vegetation is integrated into the built fabric through deliberate design, these spaces can simultaneously perform ecological functions – such as providing shade and cooling through evapotranspiration – and make those functions legible as part of the landscape's identity.

Central to this approach is the principle of revealing ecological functions – making the invisible work of

microclimate regulation visible and tangible to users. P. Pradhan *et al*. (2023) emphasised that performance outcomes such as cooling, shading, and airflow must be deliberately considered in design decisions, ensuring that aesthetic quality and ecological function reinforce one another. The resulting microclimatic benefits – captured particulates, CO_2 sequestration, moderated temperatures, directed breezes, and controlled humidity – should therefore inform both form and material choices, transforming abstract environmental services into sensory experiences.

Spatial layout plays a key role in this process. By prioritising the relationship between sun exposure and prevailing winds, designers can guide the orientation of planting beds, access routes, and built elements to maximise cooling, shading, and airflow. More importantly, these spatial decisions become perceptible to users: shaded walkways signal temperature modulation, breezeways channel moving air, and open planting arrangements invite awareness of sun and shade dynamics. The balance between enclosure and openness, achieved through plan geometry, sightlines, and perforated barriers, further communicates ecological function while protecting crops from proximal pollution sources.

Materiality reinforces this legibility. Materials with natural textures and colours can reflect moisture and light, while ventilated facades, green walls, and permeable pavements reveal how water, air, and heat move through the space. As D. Giaquinto *et al*. (2022) observed, green walls, vertical gardens, tree canopies, and green corridors should be integrated not only for their ecological value but also as expressive design elements that visually narrate pollution absorption, cooling, and habitat provision. In this way, material choices do not merely serve function – they articulate it, making the landscape a readable story of environmental performance. In sum, when spatial composition and materiality are intentionally designed to reveal microclimatic processes, urban agriculture transcends its productive role to become a model of ecological aesthetics. It makes visible the ways in which landscapes regulate, cool, and clean, inviting users to experience sustainability not as an abstract concept but as an everyday, embodied reality.

Beyond microclimatic regulation, urban agricultural spaces can function as engines of sustainability when design foregrounds closed-loop resource flows, biodiversity, and resilient water management. As O. Morrow & A. Davies (2022) argued, these productive landscapes offer a unique opportunity to demonstrate how urban systems can operate within ecological limits when their underlying processes are made visible through design – and in becoming visible, they invite users to participate in and care for the systems that sustain them. C.I. Nicholls *et al*. (2016) highlighted how thoughtfully configured productive landscapes can exemplify waste-to-resource cycles, energy synergy, and habitat creation. Drawing from the design strategies synthesised in Table 1, a design-centric perspective emphasises spatial composition, materiality, and aesthetic integration to translate these ecological principles into visible, legible, and usable landscapes. By shaping layouts that reveal these interconnected systems, designers can craft spaces where ecological performance is experienced as everyday beauty and practical function.

Spatial composition plays a foundational role in making closed-loop processes perceptible. H. Rashidi *et al*. (2015) demonstrated that layouts can organise composting zones, rainwater harvesting systems, and renewable-energy installations in deliberate sequence with planting beds, paths, and gathering spaces – allowing users to intuitively grasp the logic of material flows. The differentiation between perimeter and core spaces, achieved through thoughtful enclosure and openness, can communicate concepts of material reuse and energy cycling while maintaining accessibility and crop productivity. The arrangement of beds, terraces, containers, and vertical elements should dramatise the movement of resources: from organic waste transforming into compost, from solar energy captured to energy used on-site, from greywater collected to irrigation delivered. In this way, the landscape itself becomes a living demonstration of circular design, inviting users to witness and learn from its processes.

Materiality is equally central to rendering these ecological functions legible. H.A. Saleh & T.R. Alrobaee (2024) emphasised that durable, repurposed, and modular materials can embody circular economy principles while simultaneously conveying ecological function. Reclaimed timber signals resource efficiency; recycled metal exemplifies material reuse; porous pavers and permeable surfaces reveal the movement of water through the site. Surface textures and colours can further articulate ecological dynamics: rough, heat-absorbing textures in exposed zones contrast with cool, reflective finishes near rainwater catchment or composting areas, making thermal performance tangible. As D. Giaquinto *et al*. (2022) observed, vegetation and architectural elements should be coordinated to reveal closed-loop processes – for example, composting enclosures with vented sides can be designed as visible, accessible features, and rooftop solar arrays integrated with shade-providing canopies can simultaneously harvest energy and moderate microclimates, making energy synergy perceptible in daily experience.

Aesthetic integration, as H.A. Saleh & T.R. Alrobaee (2024) articulated, requires that ecological functions be made legible through a coherent design language. Green infrastructure components – bioswales, green walls, vertical gardens, and tree canopies – should serve as expressive accents that narrate ecological strategies rather than function as hidden

systems. Plant palettes can be selected to demonstrate ecosystem services and support biodiversity, with species chosen for growth patterns that visibly illustrate water filtration, soil stabilisation, habitat provision, and their attractiveness to pollinators and other wildlife. Path networks, seating, and educational signage should reveal cause-and-effect relationships: where rainfall is captured, how shade patterns form, where air quality improvements become perceptible. Lighting, colour, and proportion can be used to highlight functional zones and to unify utility with beauty, as synthesised from the design strategies in Table 1. Through these integrated design moves, the landscape communicates not only what it does, but how and why – inviting users into an ongoing relationship with the ecological systems that sustain them.

Table 1. Design strategies for achieving ecological aesthetics

Category of ecological functions	Ecological design principles	Examples of related design strategies
Microclimate regulation/Climate resiliency	Temperature and humidity moderation to make local temperatures milder	1. Carefully arrange the layout and orientation of planting beds, access routes, and built elements to maximise shading, cooling, and airflow. 2. Use large-canopy deciduous trees on south and west sides to block hot sun in summer while allowing winter solar gain. 3. Layer shrubs and groundcover to maximise interception, evaporation, and cooling.
	Providing shade to lower local temperatures	
	Directing breezes to improve air circulation	
	Cooling the air through evapotranspiration	1. Choose high-transpiration, climate-appropriate species (often natives) with a mix of evergreens and deciduous trees to sustain shade across seasons. 2. Favour light-coloured, porous surfaces and efficient irrigation with mulch to minimise soil heat and evaporation; use reflective ground covers where appropriate.
	Capturing particulates to reduce dust and pollutants in the air	1. Strategic windbreaks with dense evergreens. 2. Multi-layer tree canopies for interception. 3. Native, pollutant-tolerant shrub belts along roads. 4. Green walls and vertical gardens. 5. Pollutant-absorbing species selection. 6. Seasonal adjustments for maximum capture.
	CO_2 sequestration by absorbing carbon dioxide from the air	1. Maximise biomass carbon through shade trees and forest-like structure. 2. Prioritise native and climate-appropriate species. 3. Create multi-layer canopies for accelerated photosynthesis. 4. Lifecycle planning for longevity.
Resource cycling	Converting waste into resources	1. Make explicit turning organic waste into fertiliser. 2. Turning used recyclables and used item into the design of space.
	Energy synergy	1. Make explicit utilising renewable energy and using it on-site.
	Water management	1. Make explicit rainwater harvesting and greywater irrigation.
Biodiversity	Increasing biodiversity	1. Create a mosaic of habitat types. 2. Continuous flowering and nectar sources. 3. Habitat corridors and connected spaces. 4. Native plant species selection. 5. Deadwood and snag habitat.
Ecological education	Displaying ecological processes through landscape design	1. Educational signs and signages. 2. Utilising technologies like AR+VR.

Source: created by authors based on M.A. Altieri & C.I. Nicholls (2018)

In summary, a design strategy for urban agricultural spaces, when grounded in the principles of ecological aesthetics, must transcend the mere provision of functional benefits. Its core mission is to translate abstract ecological processes into tangible, visceral experiences for the user. This means designing spaces where the ecological processes and functions are not hidden utilities but are made legible and sensory. By doing so, the landscape becomes a lived-in narrative of sustainability, fostering a public understanding and emotional connection that transforms functional green infrastructure into a cherished and meaningful place.

Landscapes are inherently dynamic, evolving through seasonal cycles and ecological succession. Ecological aesthetics, as B.-W. Min (2012) articulates, celebrates the beauty of this temporality, positioning

change not as loss but as a generative design material. The central task of design, therefore, is to acknowledge and reveal these temporal processes so that people can directly experience the shifting character of the landscape. By making time an explicit dimension of the landscape's story – illuminating its past, present, and potential futures – sustainable design fosters a long-term emotional connection between people and place.

This temporal orientation operates across multiple scales. Landscapes carry layers of history, and preserving historical elements within landscapes is essential for sustaining both ecological integrity and cultural continuity. Landscape narratives convey historical and cultural meanings by weaving memory into spatial form, plant communities, and built features. M. Agnoletti & A. Santoro (2022) extended this view, emphasising that historical landscapes function as repositories of collective memory – encompassing natural history (ancient trees), cultural history (ruins), and ecological history (former wetlands). Design should integrate these elements so that history remains an active, living dimension rather than a static relic, enhancing people's sense of identity and belonging.

The Hauser & Wirth Somerset project illustrated in Figure 1, designed by P. Oudolf (n.d.), exemplifies landscape temporality as a core dimension of ecological aesthetics through its masterful planting design. Rather than conceiving the garden as a static composition of perpetual bloom, P. Oudolf (n.d.) celebrated the full lifecycle of perennial plants – from fresh spring emergence to summer flowering, autumn seed-head formation, and winter decay. This deliberate embrace of seasonal change reveals the temporal beauty inherent in living systems, where each phase, including dormancy and dieback, contributes to the landscape's evolving narrative. By allowing plants to stand through winter, their skeletal structures catch frost and low sunlight, transforming decay into its own form of visual poetry. In this way, the project makes visible the ecological processes of growth, senescence, and regeneration, inviting visitors to perceive time as an integral and beautiful dimension of the landscape – a central tenet of ecological aesthetics.

Figure 1. Seasonal change through planting design to show the lifecycle of perennial plants
Note: Hauser & Wirth Somerset designed by P. Oudolf
Source: P. Oudolf (n.d.)

Looking forward, design must also incorporate emerging technologies to enhance both the experience and resilience of ecological aesthetics. U.K. Ashinze *et al*. (2024) proposed integrating sensors and data-driven systems to monitor soil moisture, microclimate, biodiversity indicators, and pollution levels, with these metrics translated into real-time or seasonal visual cues within the landscape. Renewable energy installations – such as solar-canopy structures and small-scale microgrids – can power irrigation, lighting, and interactive interpretive displays without compromising aesthetics or habitat value.

Crucially, seasonal change, weather variability, and climate change must be incorporated as explicit temporal dimensions shaping design decisions. Seasonal shifts in plant phenology, colour, texture, and structure can be leveraged to craft evolving visual experiences throughout the year. Weather events – storms, droughts, wind patterns – inform the arrangement of spaces, drainage strategies, and material choices to maintain resilience and comfort. S. Štrbac *et al*. (2023) emphasised that climate change, understood as long-term shifts in temperature, precipitation, and extreme events, should be reflected in adaptive design strategies: modular, heat- and drought-tolerant planting palettes, scalable water harvesting and retention systems, and flexible infrastructure responsive to changing rainfall regimes and storm intensities. These temporal axes – seasonal, weather, and climate – become integral to the landscape's story, enabling visitors to perceive adaptability and foresight as part of ecological aesthetics.

In sum, the temporal beauty of landscapes is amplified by a design approach that fuses historical depth with forward-looking considerations of seasonality, weather, and climate change, while lightly integrating technology. By weaving temporal storytelling, heritage preservation, and adaptive systems into the fabric of ecological aesthetics, future landscapes can integrate historical narratives while demonstrating how people, ecosystems, and innovative design co-create resilient,

meaningful environments over time. Having established ecological aesthetics as a guiding framework, the next section translates these principles into concrete design applications across the urban area's layered landscape.

MULTILAYER IMPLEMENTATION: SPATIAL TYPOLOGIES

Urban agricultural landscapes manifest across multiple urban strata, from aerial habitats to street-scale interventions, with each layer presenting distinct opportunities for integrating productive landscapes into everyday life. Operationalising ecological aesthetics across these multilayer city landscapes requires treating urban agriculture not as a standalone program but as a design medium through which food production, ecological function, and sensory experience converge. As U.K. Ashinze *et al*. (2024) contended, this integrative approach enables landscape designers to fuse food production with ecological aesthetics, social engagement, and climate resilience across diverse urban strata – including Green Roofs, Greenways and Corridors, Community Farms and Parks, Coastal Green Spaces, Street-level Edges and Medians, and Building Facades. The challenge, as T. Thiesen *et al*. (2022) and J. Yuan & C.S. Kim (2024) respectively emphasised, lies in developing design strategies that honour context, function, and beauty within each layer's specific conditions. The following synthesis outlines how agricultural elements can be integrated into each urban layer through landscape design strategies that render ecological processes perceptible, temporally legible, and aesthetically coherent – making the layered city itself a canvas for ecological aesthetics in action.

Green roofs offer an elevated stage for design-led ecological expression and aesthetic enhancement within the urban canopy. As J. Zhang (2025) described, they function as aerial ecologies – vertical landscapes that influence skyline composition while integrating edible production and habitat value into a cohesive visual narrative. The design objective is to cultivate legible, poetically structured experiences that are perceptible from aerial vantage points and from street-level views through surrounding facades. Edible assemblages – comprising salad greens, herbs, compact fruiting species, and rooftop orchard configurations – are conceptualised as design modules selected not solely for productivity but for their contributions to colour, form, and texture across seasonal cycles. A modular, weight-conscious growing-media system is conceptualised as a sculptural substrate that supports diverse plant guilds while enabling precise tactile contrasts among succulent mats, herbaceous perennials, and flowering taxa, thereby generating perceptual depth within the constrained roofscape.

Aesthetics on the roof emerge as a choreography of colour, texture, and topography. Seasonal colour trajectories provide a discernible narrative of phenological change. Texture heterogeneity – dense, low-lying succulent mats juxtaposed with airy, flowering perennials – produces spatial depth and tactile richness that invite close observation from proximate terraces and elevated viewpoints. Micro-topographies – graded mounds, sunken pockets, and stepped beds – generate intimate moments for users, such as kneeling contours aligned with viewer eye-lines to the urban horizon or sheltered herbaceous terraces that function as micro-gardens within a dense city fabric. These design elements render ecological processes – growth, flowering, seasonal adaptation – perceptible and experientially vivid.

From a functional perspective, the roof can be designed as a constellation of productive parterres and pollinator strips that are legible as urban artworks. The spatial arrangement prioritises formal clarity: geometric beds delineate crops as a living mosaic, aisles serve as contemplative circulation routes, and strategically placed focal plantings anchor seasonal composition. Irrigation, drainage, and soil-health systems are integrated into the aesthetic discourse as visible design gestures: colour-coded irrigation conduits become intentional accents, moisture indicators translate into subtle shifts in plant presentation, and rainwater-harvesting features are embedded as sculptural elements that simultaneously educate and engage. T. Beck (2013) observed that this design language renders water stewardship readable and accessible, transforming the roof into a pedagogical and sensorial landscape where ecological function is not merely operative but perceptually present.

To maximise aesthetic resonance, roof landscapes should achieve consonance with prevailing architectural grammars and urban rhythms. Plant palettes may be selected to reflect adjacent materiality and tonalities or to articulate city-wide seasonal palettes, while the arrangement of beds and circulation paths can exhibit formal or contextual looseness yet maintain coherence with broader urban design intentions. The roofscape should be legible across scales: at a macro level, the overall composition should be discernible from higher vantage points; at meso and micro scales, careful attention to plant selections, texture differentials, edging materials, seating, and enclosure devices should reward close inspection. Seating arrangements, shade strategies, and microclimate interventions – such as wind buffering and sun-tracking planters – are embedded as aesthetic decisions that simultaneously enhance user comfort and social interaction, while foregrounding the roof's role as a modulated, responsive habitat.

The rooftop garden at Battersea Power Station, designed by James Corner Field Operations, exemplifies how ecological aesthetics can be rendered perceptible within a landscape of industrial heritage (Fig. 2). The vertical planting, which echoes the power station's iconic columns, creates a dynamic visual rhythm while simultaneously establishing vertical habitat corridors

and microclimatic gradients that support diverse insect communities. The violet blossoms, with their rich, deep hue, contrast beautifully with the white towers and the expansive blue sky – a chromatic dialogue between cultural memory and living systems that makes ecological processes legible through seasonal flowering rhythms. This design not only pays homage to the site's industrial past but also introduces a new layer of ecological and aesthetic richness wherein plant growth, pollination activity, and phenological change become experientially vivid. The garden's layout, with its carefully arranged planters and pathways, invites visitors to observe the interplay of texture, colour, and biotic activity at close range, transforming a once-industrial rooftop into a pedagogical and sensorial landscape of the kind T. Beck (2013) describes – where water stewardship, habitat provision, and living processes are not merely operative but perceptually present. The integration of modern planting techniques with the robust architecture of the power station results in a harmonious composition that renders ecological function visible and engaging, offering a serene retreat where industrial memory and ecological expression coalesce within the urban canopy.

Figure 2. Roof garden at Battersea Power Station
Note: James Corner Field Operations
Source: L. Crook (2023)

Green ways/corridors function as linear spatial structures that can be strategically designed to connect disparate urban areas while serving multiple purposes. As J. Melicher & J. Špulerová (2022) observed, their environmental and social value is substantially enhanced when design solutions and aesthetic approaches consciously integrate the potential of urban agriculture. Within this framework, green routes can be configured as continuous multifunctional spaces that incorporate edible plantings, thereby amplifying both productive capacity and recreational appeal while rendering ecological processes legible to users.

The spatial organisation of the corridor may adopt a gradient structure of plantings – a concept advanced by W.S. Alawsey *et al*. (2025) – that reflects a gradual transition from locally adapted, nature-oriented communities and pollinator-supportive zones toward more cultivated border plantings and public areas situated near sites of social activity. This sequential arrangement contributes to the formation of seasonally expressed landscape narratives, stimulates both passive perception and active participation, and ensures the visual coherence of green infrastructure across multiple scales. More importantly, it makes ecological gradients perceptible: users can literally walk from a wilder, insect-friendly margin into a more cultivated edible zone, experiencing first-hand the relationship between plant community structure and ecological function.

Path edges become sculptural frames for edible hedgerows – currants, raspberries, and edible flowers – that, according to C.I. Nicholls *et al*. (2016), function simultaneously as habitat corridors and deliberate design accents. Here, ecological aesthetics emerge through the dual legibility of these plantings: they are recognisable both as productive elements and as pollinator habitat, their flowering and fruiting cycles marking seasonal time while supporting urban biodiversity. Materials and surface treatments articulate a tactile hierarchy that reinforces this ecological narrative. H. Rashidi *et al*. (2015) demonstrated that permeable pavements, bioswales, and rain gardens are not merely functional components but essential contributors to texture and rhythm within the spatial procession. The sound of water moving through a bioswale, the contrasting textures of gravel and wood, and the aromatic release of crushed herbs underfoot collectively constitute a multisensory palette that heightens spatial identity and renders hydrological and ecological processes experientially accessible across seasons.

Wayfinding and interpretive signage are reframed as integral design devices rather than mere information kiosks. As noted by J. McCarthy & P. Wright (2024), this approach aligns with the principle of emotionally durable visual communication design, which enables these elements to communicate ecological functions effectively, thereby influencing visitors' aesthetic

sensibilities and guiding their behaviour toward greater environmental awareness. Within the greenway context, signage should articulate ecological processes and cultivation cycles through a cohesive visual grammar – colour coding that corresponds to plant guilds, typographic hierarchies that distinguish between immediate sensory observation and deeper ecological explanation, and pictorial language that complements the landscape's material palette. Such signage does not explain ecology from outside but rather makes visible the ecological relationships already present in the planted form.

The greenway, reimagined as a living classroom and market, invites immersive encounters that deepen ecological perception. As Y. Zhou *et al*. (2021) suggested, seed-sharing nodes, demonstration beds, and pop-up harvest areas can be integrated as architectural moments within the corridor, each exhibiting distinct yet harmonious expressions of form, colour, and texture. These elements function as pedagogical interventions that make visible the otherwise abstract cycles of cultivation, harvest, and regeneration. Through such design strategies, the greenway transcends its functional role as a connector to become a legible ecological aesthetic – a linear landscape where productivity, biodiversity, and sensory experience coalesce, and where users encounter not just greenery but the visible evidence of living systems at work (Fig. 3).

Figure 3. Ecological Education signage design of parcours du lac de l'Arret Darre
Source: Pic Bois (2022)

Community farms and parks function as central nodes in democratising urban food systems, yet their design demands a pronounced emphasis on ecological aesthetics – the deliberate making-visible of living processes through form, material, and spatial arrangement. Landscape configurations should foreground legibility, coherence, and plasticity, ensuring that productive functions remain inseparable from perceptual quality and social engagement. Within this framework, productive plots can be conceptualised as spatial modules organised into recognisable zones. These include demonstration gardens that articulate companion planting, soil regeneration, and ecological pedagogy, as O. Morrow & A. Davies (2022) described; community plots that provide affordable, legible access to fresh produce; and edible landscapes that integrate food crops with ornamental elements to cultivate a rich, contextual visual grammar. Visual unity across these zones arises through a deliberate material palette, curated plant guilds, and canopy configurations that harmonise disparate crops into a cohesive narrative – one in which composting cycles, pollinator activity, and soil health become perceptible rather than merely operational.

Ecological aesthetics in the community farm context emerge through the legible expression of systemic relationships. Sculptural plantings, pollinator habitats, and insect hotels are designed to read as architectural details within the landscape – not hidden functional inserts but deliberate compositional elements that reinforce ecological function while generating human-scale moments of discovery. A habitat stack, for instance, might be articulated through carefully arranged materials that reveal their purpose through form: drilled logs, bundled stems, and layered stone become textural accents that simultaneously support solitary bees and invite tactile inquiry. Water features, operating as irrigation reservoirs and microclimate modifiers, contribute to the aesthetic palette through materiality, form, and movement. As H. Yu (2025) observed, they transform waterflow into an educational element wherein children and adults alike can observe the relationship between storage, distribution, and plant health.

Shading structures offer thermal relief while hosting climbing edible species such as beans or grapes, thereby weaving vertical productivity into the human comfort zone. Here, ecological aesthetics operate through double-coding: a pergola is simultaneously a shade device, a support structure for food production, and a frame for viewing the farm's larger composition. M.R. Khalilnezhad *et al*. (2024) noted that the seasonal transformation of these living structures – from bare tendrils in early spring to dense foliar canopy in high summer – renders time perceptible and deepens attachment through repeated observation.

Planting strategies must balance productivity with spectacle, yet as A. Russo & L. McCarthy (2024) argued, spectacle itself is reimagined in ecological terms. The spatial choreography reveals seasonal progressions and maintains visual interest during non-harvest periods through architectural planting schemes, canopy rhythms, and ornamental understory layers. A bed of overwintering kale, its leaves frost-silvered, becomes as compositionally significant as a flowering perennial border; the skeletal structure of fruit trees in winter offers a lesson in branching architecture that is at once aesthetic and ecological. Soil, too, is not hidden but

celebrated: composting areas are sited as prominent landscape moments, their layered materials and thermophilic activity visible through thoughtful enclosure, transforming decomposition into a pedagogical and sensorial experience. Ultimately, the community farm or park achieves ecological aesthetics when its visitors can read the landscape as an integrated system – when the relationship between flower and pollinator, between compost bin and fertile soil, between rainwater catchment and thriving crop becomes intuitively graspable through designed experience. In such spaces, as N. Wijesooriya & A. Brambilla (2021) contended, ecological function is not merely operative but perceptually present, inviting sustained engagement and cultivating the environmental awareness that underlies truly democratic urban food systems.

MULTILAYER IMPLEMENTATION: URBAN INTERFACES AND VERTICAL SYSTEMS

Coastal green spaces must withstand salinity, surge, and sea-level change, yet their value is profoundly amplified when design and aesthetics foreground place-making and experiential richness. From a design perspective, agricultural elements should be integrated as legible, culturally resonant features that articulate both habitat value and edible production within a coherent coastal narrative. Another constituent of coastal urban agriculture extends beyond conventional design mediums. Oyster farming, for example, can be understood as an integral component of coastal food systems – one that blends ecological process with designed form. SCAPE Studio's Oyster-texture project in New York Harbour (SCAPE, 2025) offers a compelling case (Fig. 4). The proposal envisions a living reef constructed from "fuzzy rope" that boosts marine biodiversity and cleans harbour water through natural filtration by oysters and other species. What distinguishes this project as an exercise in ecological aesthetics is its deliberate making-visible of underwater processes: the fuzzy rope substrate is not merely functional but formally expressive, creating a three-dimensional landscape that registers visually at the water's surface while operating invisibly below. The design renders oyster filtration legible as a dynamic system – fluctuations in water clarity, the gradual accretion of reef structure, and the return of marine life become perceptible indicators of ecological function. This aesthetic operates across scales: from the sculptural quality of the rope fields viewed from the shoreline to the intimate encounter with thriving marine communities accessible by kayak. The project thus transforms ecological remediation into an immersive educational experience wherein visitors can observe, touch, and begin to understand the relationship between designed form and living system.

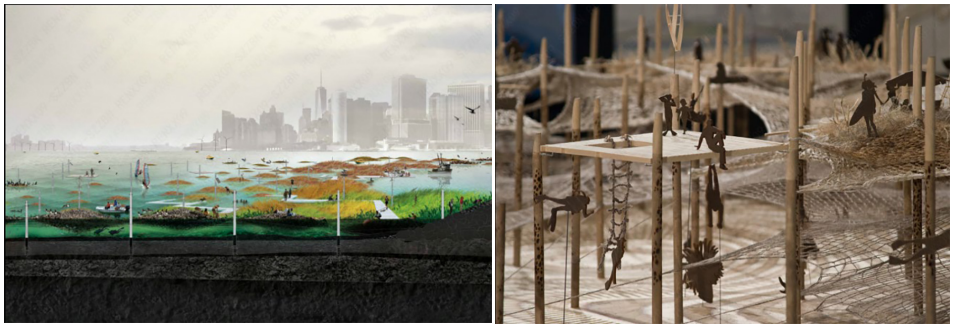

Figure 4. Oyster-tecture, diversifying marine life and recreational potential
Source: SCAPE (2025)

Vegetation communities are curated to balance ornamentality with practical resilience. The plant palette integrates hardy ornamentals alongside salt-tolerant edibles such as Salicornia and coastal herbs, creating a living narrative of place and adaptation. This approach foregrounds seasonal shifts in texture and colour, ensuring visual legibility from both sea-facing and inland viewpoints. Material choices – weathered timbers, salt-resistant concretes, and patinated metalwork – reinforce the coastline's tactile character while serving functional roles in drainage and microclimate modulation. As A. Ghirardelli *et al*. (2025) observed, edible crops arranged within raised beds in legible geometries evoke historic coastal patterns and rhythms of human cultivation, rendering visible the enduring relationship between coastal communities and cultivated margins. J. Yuan & C.S. Kim (2024) further noted that these material and planting expressions simultaneously address practical needs – drainage, microclimate control – while cultivating a distinctive coastal aesthetic. Together, vegetation and materiality cohere into a designed expression where ecological function and cultural resonance become perceptibly intertwined.

Water-management features are conceived as sculptural elements that communicate ecological processes. Dune-like topographies serve as sculptural windbreaks and flood-storage devices; their forms reveal protective function while shaping spatial experience. Tidal indicators and rain-harvesting systems are embedded as formal accents that articulate coastal hydrology. These

components become design protagonists, contributing to an educational narrative about adaptation and food security. A tidal indicator might mark daily fluctuations through changes in water colour or textured surfaces, rendering tidal range perceptible and engaging.

Together, these strategies craft a multi-sensory landscape where form, materiality, and planting express coastal identity and ecological resilience. In such designs, ecological function is not merely operative but perceptually present – visitors encounter not just protection from surge but the sculptural expression of dune morphology, not just water filtration but the visible life of the oyster reef, not just salt-tolerant crops but a living palette that narrates adaptation at the edge of land and sea. Through these integrated strategies, coastal landscapes become pedagogical fields wherein the dynamics of salinity, tide, and resilience are rendered intuitively graspable through designed experience.

Street-level Edges and Medians offer highly accessible opportunities to democratise urban edible landscape, but their value is amplified when design and aesthetics foreground experiential quality and visual legibility. From a design standpoint, these strips should read as cohesive, human-scaled narratives that frame the street, provide shade, and deliver fresh produce in a manner that enhances daily traversals (Ogwu & Kosoe, 2025). Street-level edges and medians represent critical opportunities to democratise the urban edible landscape, yet their full potential emerges only when design and aesthetics foreground experiential quality and visual legibility. As M.C. Ogwu & E.A. Kosoe (2025) argued, from a design standpoint these strips should read as cohesive, human-scaled narratives that frame the street, provide shade, and deliver fresh produce in ways that enrich everyday movement. By embedding ecological aesthetics into these narrow corridors, designers can transform functional infrastructure into legible, living systems where ecological processes become sensory experiences.

Edges and avenues become living corridors whose plant language is carefully choreographed. Edible street trees and low-lying fruiting shrubs are integrated with maintenance-friendly groundcovers to create a continuous, tactile edge encountered during routine passages. J. Peng *et al*. (2021) emphasised that the plant palette must balance fruitfulness with street-scale readability: tree canopies that cast shade without blocking sightlines, mid-layer shrubs offering seasonal fruit, and unifying groundcovers that provide consistent texture. This composition yields a rhythmic, legible edge where ecological function – food production, habitat support, microclimate regulation – is made perceptible through deliberate form and material continuity. The threshold between public realm and private frontage thus becomes a smooth, meaningful transition rather than an abrupt boundary.

Medians, meanwhile, function as micro-landscapes capable of transforming the daily commute into an immersive edible experience. Small-scale vegetable beds, herb cushions, and pollinator-friendly groundcovers are arranged in clear geometries responsive to pedestrian flow and curb contours. Z. Iqbal *et al*. (2025) highlighted the importance of seasonal choreography – edible blooms, shifting foliage colors, and crop succession – which generates a dynamic visual sequence rewarding repeated encounters. Modular planting beds, defined edges, and transparent planting hierarchies ensure that ecological complexity remains visually legible from a distance while inviting close inspection. Here, ecological aesthetics operates through designed readability: biodiversity, pollination cycles, and soil health become tangible, observable phenomena woven into the urban fabric.

Across both edges and medians, the visual language must prioritise legibility and safety without compromising beauty. D. Adams *et al*. (2023) underscored the need for clear sightlines, durable materials, and concise, design-conscious signage communicating crop cycles and harvest timing. Material choices – paving textures, edging, seating, and plant-support structures – should reinforce a coherent street aesthetic that resonates with surrounding built forms while enabling low-maintenance operation. Rain gardens and permeable pavements aligned with curbs contribute to stormwater management while conveying a sense of urban care, textural richness, and place identity. These infrastructural elements, when aesthetically integrated, render invisible ecological services visibly and experientially present.

As shown in Figure 5, designed by J. Irwin Landscape Architecture and completed in Sydney in 2010 (MacGowan, 2012), the Balfour Street Pocket Park transforms stormwater management into a visible and engaging urban feature. Its curved brick swale channels runoff from surrounding streets, with protruding bricks that slow water flow and capture debris, making the process of water filtration perceptible to users. The swale transitions into a mini-wetland where specially designed paving creates ripples, visually narrating water movement through the landscape. This project exemplifies ecological aesthetics by rendering a hidden utility – stormwater drainage – into a tangible sensory experience, allowing visitors to see and hear water being cleansed. It transforms functional infrastructure into what J. Irwin called a "demonstration piece", educating the public about hydrological processes while enriching everyday experience.

From a design-analytic perspective, integrating edible landscapes into street-scale edges and medians demands a cohesive design vocabulary uniting form, function, and experience. This requires specifying planting grammars attuned to local climate and urban character, establishing predictable maintenance regimes, and

articulating seasonal transitions as perceptible design moves. By foregrounding aesthetic coherence – through plant form, colour relationships, materiality, and spatial sequencing – the street becomes a democratic, sensorially rich corridor supporting nourishment, biodiversity, and civic identity. Ecological aesthetics thus operates not as an abstract principle but as a tangible framework through which urban dwellers daily encounter and understand the living systems sustaining their city.

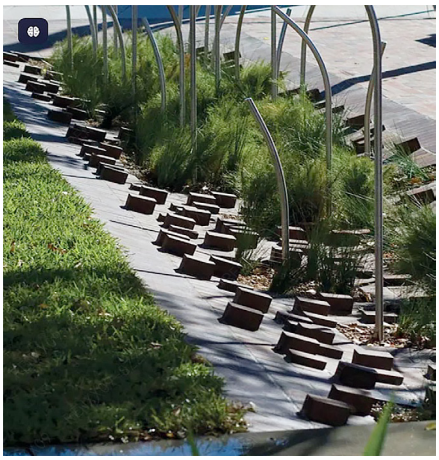

Figure 5. Brick Swale as a drainage system
Note: Balfore Street Pocket Park created by Jane Irwin Landscape Architecture
Source: T. MacGowan (2012)

Building facades present a vertical canvas for edible architecture, where green facades, living walls, and espaliered fruiting trees transform cultivation into overt architectural expression. As K. Al-Kodmany (2018) contended, these surfaces become disciplined interfaces between building program, structural logic, and public perception. From a design standpoint, successful integration demands species selection calibrated to microclimatic conditions and robust structural strategies capable of accommodating loads and ongoing maintenance. T. Thiesen *et al*. (2022) noted that Modular planting devices – conceived to work seamlessly with window boxes, balcony gardens, and railings – enable scalable, legible interventions across the elevation.

Within this framework, ecological aesthetics emerges as the guiding design language. Vertical rhythm is established through repetitive planting modules and trellis patterns, while seasonal legibility is rendered visible through shifting leaf colours and fruiting phenology that animate the facade across the year. J. Brandt & H. Vejre (2004) emphasised that the architectural relationship between occupants and the exterior environment is foregrounded through these choices: planting decisions become experiential cues that modulate light, texture, and silhouette from both interior viewpoints and street-level perspectives. Edible elements – fruit-bearing vines, espaliered trees, integrated herbs – are not merely productive but visually articulate the building's ecological performance over time (Fig. 6).

Figure 6. Urban farming office
by Von Trong Nghia Architects in Ho Chi Minh City
Source: J. Elangical (2023)

Functionally, facade horticulture is designed to deliver shade and microclimate moderation, yet these benefits are made perceptible through deliberate material and form decisions. K. Bohn & D. Chu (2021) noted that green walls with modular trays, climber supports, and refined edge treatments maintain sightlines and accessibility while rendering environmental services visible. The system simultaneously functions as living habitat, inviting insects and birds and contributing to urban biodiversity. H.A. Saleh & T.R. Alrobaee (2024) argued that this ecological function becomes an integral aesthetic element: habitat-friendly plant textures, the motion of pollinators, and seasonal bird activity weave biodiversity directly into the sensory experience of the facade. Through such design, ecological processes are not hidden infrastructure but legible, everyday encounters – making the building envelope a dynamic interface where food production, habitat support, and climatic responsiveness coalesce into coherent, inhabitable form.

Ultimately, the architectural language of edible facades functions as an educational medium, conveying principles of food systems, climate adaptation, and biodiversity through crafted materiality, colour, and spatial sequencing. By making ecological processes visible and accessible, these living vertical landscapes transform abstract concepts into tangible daily experiences. Passersby can observe seasonal growth cycles as edible plants progress from flowering to fruiting, revealing the temporality inherent in productive landscapes. They can witness climate adaptation strategies in action as drought-tolerant species thrive on sun-exposed surfaces while moisture-loving plants cluster near irrigation outlets, demonstrating how vegetation moderates microclimates through shading and evapotranspiration. They encounter biodiversity first-hand as pollinators are drawn to flowering crops, revealing the reciprocal relationships between urban agriculture and local

ecosystems. The deliberate layering of plant species – tall canopy plants providing shade for shade-tolerant vegetables below, trailing vines softening building edges, and brightly coloured fruits signalling harvest readiness – creates a spatial narrative that guides viewers through the logic of productive landscapes. Material choices further reinforce this educational role: trellises and support structures are exposed rather than concealed, revealing how vertical loads are distributed; planter modules are arranged to demonstrate water flow from collection points through irrigation channels; and contrasting textures between rough building surfaces and soft vegetation highlight the integration of natural systems with constructed form. This design synthesis positions building facades not merely as envelopes but as expressive, productive portraits of urban resilience and cultivated beauty – living textbooks that teach ecological principles through materiality, seasonal change, and spatial experience.

CONCLUSIONS

This study advances a mixed-methods analysis of integrating ecological aesthetics into urban agricultural landscapes, yielding a coherent ecodesign framework that operationalises aesthetic principles across multiple urban layers. Through critical examination of real-world exemplars, it identifies actionable strategies that merge visual appeal with ecological function, making ecosystem processes accessible to the public via deliberate design.–The analysis demonstrates that multilayer city landscapes operate most effectively when understood as interconnected ecological systems rather than isolated interventions. Across diverse spatial strata, productive green roofs, multifunctional corridors, community-based agricultural spaces, adaptive coastal landscapes, transitional transport edges, and vertically greened facades collectively enhance biodiversity, microclimate regulation, and resource cycling.

The study confirms that, when coordinated within an integrated framework, these spatial strategies enable green infrastructure to synthesise food production, environmental resilience, and educational value into a coherent urban design system. The findings underscore the centrality of ecological aesthetics for enriching urban agricultural landscapes, demonstrating that beauty, perception, and cultural meaning can coexist with ecosystem services and ecological performance in multi-layer urban contexts. Temporal dynamics, historical narratives, and adaptive design emerge as crucial components for resilience amidst environmental change. Future work should prioritise empirical validation of the ecodesign framework via pilot projects and long-term monitoring to assess effectiveness across diverse urban settings. Expanding inquiry into the social and cultural dimensions of ecological aesthetics – how various communities interact with and perceive these landscapes – will be essential for designing ecologically sustainable yet culturally inclusive and socially equitable spaces. This research lays a foundation for further exploration of ecological aesthetics in urban design, offering a pathway toward more resilient and engaging urban environments that balance aesthetic experience with environmental benefit.

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Проєктування з урахуванням екологічної естетики в міському сільському господарстві: впровадження принципів екодизайну в багатошарових міських ландшафтах

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Анотація. Екологічно спроєктовані міські сільськогосподарські ландшафти є критично важливою, однак недостатньо використаною стратегією зменшення втрат біорізноманіття, підвищення стійкості до зміни клімату та вирішення соціальної нерівності в сучасному міському середовищі. Основною метою цього дослідження було розробити та впровадити теоретичну та практичну основу, яка інтегрує екологічну естетику в дизайн міського сільського господарства, позиціонуючи естетичний досвід як ключовий компонент багатофункціональної екологічної ефективності. Було використано змішаний підхід, що поєднує комплексний огляд літератури з екологічної естетики з детальним аналізом прикладів дизайну з існуючих міських сільськогосподарських просторів. Дослідження створило структуровану основу екодизайну з чіткими критеріями, які синтезують естетику, екологічну функцію та стійкість у різних міських шарах, включаючи зелені дахи, зелені доріжки та фасади будівель. Було виявлено, що сенсорні якості, такі як колір, текстура та ритм, разом з культурним значенням, можуть бути цілеспрямовано узгоджені для посилення підтримки біорізноманіття, збільшення виробництва продуктів харчування та покращення регулювання клімату без шкоди для екологічної цілісності. Структура також продемонструвала, як ці естетичні стратегії можуть систематично застосовуватися у вертикальних, горизонтальних та перехідних міських просторах для створення цілісних та привабливих ландшафтів. Практична цінність цього дослідження полягає в його практичних рекомендаціях щодо дизайну та критеріях оцінки, які можуть бути використані містобудівниками, ландшафтними архітекторами та політиками для створення адаптивного, контекстуально свідомого міського сільськогосподарського середовища, яке гармонізує красу з надійною екологічною функцією та соціальною значущістю

Ключові слова: зелена інфраструктура; екологічна ефективність; типологія ландшафтів; пом'якшення мікрокліматичних змін; стратегії біорізноманіття; вертикальний урбанізм; екосистемні послуги