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Urban Permaculture as an Effective Nature-Based Solution for Advancing Sustainability in Cities: A Comprehensive Review and Analysis

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ABSTRACT
In the contemporary epoch marked by climate change, cities find themselves both impacted by and culpable for the ongoing environmental crisis, contributing up to 70% of the greenhouse gases responsible for planetary warming. As crucial hubs in the climate change narrative, cities bear the responsibility of initiating mitigation efforts at the local level. Innovative nature-based solutions, notably the application of permaculture design principles to enhance socio-ecological resilience, have garnered attention as viable strategies. However, the burgeoning body of literature on urban permaculture is currently fragmented across seemingly disparate fields, lacking consistency in terminology and conceptual frameworks. This research endeavours to rectify this fragmentation by conducting a comprehensive examination of the dynamic interplay between urban permaculture and sustainability, with a deliberate focus on the 4 Ps framework—People, Planet, Profit, and Politics. Employing a methodological synthesis that integrates systematic literature review and content analysis, this paper analyses urban permaculture literature spanning from the year 2001 onward. The systematic review aims to elucidate the overarching scope and nature of the discourse, and identifies eight factual case studies meeting strict inclusion criteria, ensuring an emphasis on empirical rather than theoretical contributions. These selected case studies form the empirical foundation of the ensuing analysis, deliberately eschewing theoretical abstractions to concentrate on tangible instances of urban permaculture implementation. The exploration of the four conventional Ps within the context of these factual case studies unveils the adherence to a fifth P —Permaculture as a guiding principle, illustrating its role in crafting urban environments that are not only ecologically resilient but also socially inclusive, economically viable, and politically astute. This research contributes significantly to the empirical understanding of urban permaculture, offering practical insights into its implications for sustainability in complex urban settings.

Keywords: *Community Empowerment; Environmental Sustainability; Economic Viability; Governance; Sustainability Pillars*

1. Background

1.1 Building Sustainable Urban Futures

With global urbanization on the rise, more than half of the world's population now resides in cities. However, this rapid urban expansion has led to significant environmental challenges, including increased greenhouse gas emissions, deforestation, and resource depletion [1]. Cities, while symbolizing societal progress, also contribute substantially to climate change and its impacts. Recognizing cities' dual role as contributors to and victims of climate change underscores the urgent need for localized strategies to mitigate environmental impact. Sustainable practices are essential not only for addressing environmental concerns but also for fostering resilient and livable communities [2]. Nature-based solutions have emerged as promising approaches to address urban sustainability challenges, with urban permaculture standing out as a potential solution. Rooted in ecological principles, urban permaculture emphasizes sustainable land use, biodiversity, and community engagement, offering a holistic framework for urban planning and development. This approach emphasizes principles such as organic gardening, renewable energy, and community collaboration to promote harmonious coexistence between urban environments and nature[3], [4].

1.2 Permaculture Principles, Practices, and Promises

Permaculture's evolution from its rural origins to encompass urban areas reflects a broader understanding of sustainable living. Initially conceived as a means to reduce reliance on energy-intensive industrial technologies, permaculture has grown into a global grassroots movement with a focus on sustainable urban development. Key components of permaculture include a worldview emphasizing holistic planning and design, a design system utilizing ecological principles, associated practices drawing from agroecology and traditional land use, and a movement for dissemination through decentralized education and local organizing [3], [5].

The spread of permaculture to urban areas has been facilitated by its adaptability and scalability, with practitioners implementing diverse projects ranging from community gardens to educational initiatives. The integration of permaculture principles into urban planning and design offers opportunities to create resilient, self-sufficient communities that thrive within planetary boundaries. Despite its potential, permaculture has faced criticism and challenges, including questions about its agricultural efficiency and appropriation of indigenous knowledge. However, recent years have seen a growing interest in research about permaculture, with emerging partnerships between practitioners and researchers [5], [6].

Bill Mollison and David Holmgren's seminal work, "Permaculture One: A Perennial Agriculture for Human Settlements" (1978), laid the groundwork for the permaculture movement, introducing the concept as an integrated system of perennial plants and animals designed to meet human needs sustainably. Holmgren's subsequent work, "Permaculture: Principles and Pathways Beyond Sustainability" (2002), expanded on these ideas, delineating 12 design principles, (Figure 1) that serve as guiding tenets for permaculture design [3], [6]. Geoff Lawton, a prominent permaculture consultant and educator, has been instrumental in spreading permaculture knowledge through practical demonstrations and educational initiatives [7]. Rob Hopkins, co-founder of the Transition Network, has championed community-led initiatives aimed at building resilience and sustainability at the local level [8]. Rosemary Morrow, a respected permaculture teacher and author, has made significant contributions to permaculture education with her practical approach and hands-on teaching methods [9].

The Permaculture Design Certificate (PDC) serves as a foundational training program for aspiring permaculturists, equipping them with the knowledge and skills needed to design and implement sustainable systems [3]. Completion of a PDC provides individuals with a comprehensive understanding of permaculture principles and practices, serving as a gateway to further permaculture studies and professional certification.

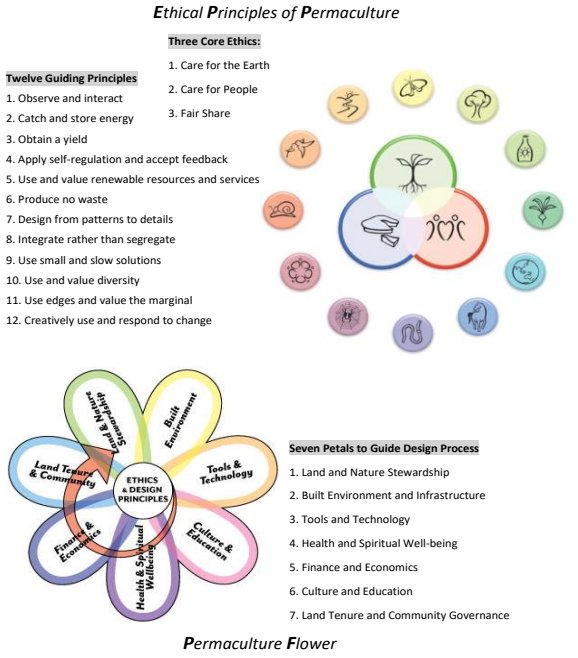
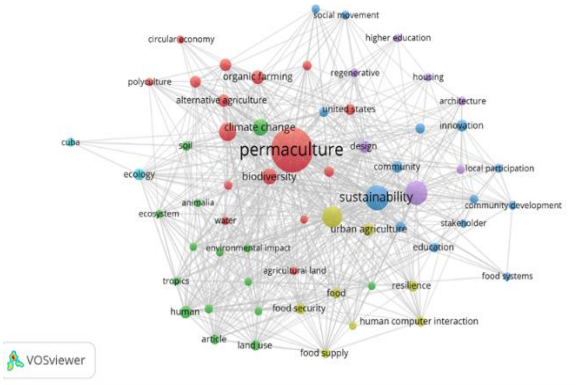


Figure 1. Three ethics and twelve principles guiding permaculture design across seven domains, representing the petals of the permaculture flower. Source: Adapted from [10], [11]

1.3 The Synergy Between Permaculture and the 4 Ps of Sustainability

The utilization of VOSviewer in bibliometric analysis reveals significant insights into the relationship between permaculture and sustainable development. By analysing data from Web of Science, Scopus, and ProQuest, a comprehensive understanding of the scholarly landscape surrounding these topics emerges. The collective dataset comprises 1740 items, indicating a substantial body of literature on permaculture and sustainable development. Specifically, the keyword "permaculture" appears in 148 items with a total link strength of 341, indicating a strong association within the literature. Similarly, the keyword "sustainability" is present in 47 items with a total link strength of 155, (Figure 2). These findings suggest a notable intersection between permaculture and sustainability within academic discourse.



id	keyword	occurrences	total link strength
1244	permaculture	148	341
1646	sustainability	47	155

Figure 2. VOSviewer network map visualizing the link between permaculture and sustainability in academic literature

The synergy between permaculture and the four pillars (4 Ps) of sustainability—People, Planet, Profit, and Politics—underscores its comprehensive approach to sustainable development.

1. **People:** Permaculture places paramount emphasis on social equity and community well-being, advocating for collaborative decision-making processes and empowerment. Its commitment to People extends beyond ecological considerations, fostering inclusivity and social cohesion [3].

2. **Planet:** Emulating natural ecosystems, permaculture significantly contributes to mitigating environmental impact. Through sustainable land use practices and the preservation of biodiversity, permaculture aligns with the imperative to safeguard the Planet [4].

3. **Profit:** Permaculture challenges conventional economic models by endorsing localized, sustainable resource use and ethical business practices. This approach fosters economically resilient systems, promoting the idea that economic viability can coexist with ecological integrity [6].

4. **Politics:** Engaging with political dimensions, permaculture advocates for policies that facilitate sustainable practices. It plays a role in influencing governance structures and resource allocation, aligning with the imperative for sustainable political engagement within urban environments [12].

1.4 Rationale for the Study

Permaculture goes beyond harm mitigation, actively fostering restoration and resilience across ecological, social, economic, and political dimensions. However, despite its potential, existing literature on urban permaculture remains fragmented across disciplines, lacking a unified conceptual framework. This fragmentation impedes a comprehensive understanding of the benefits and challenges associated with urban permaculture implementation. Given the fragmented state of current literature, there's a pressing need for a systematic review and analysis to synthesize existing knowledge on urban permaculture [13]. This research seeks to bridge these gaps by providing a consolidated understanding of the relationship between urban permaculture and sustainability, particularly focusing on the 4 Ps framework—People, Planet, Profit, and Politics. Understanding how urban permaculture aligns with the 4 Ps framework is pivotal for guiding sustainable urban development. Through the examination of empirical case studies, this research aims to reveal practical insights into the operationalization of permaculture principles and their implications for creating ecologically resilient, socially inclusive, economically viable, and politically astute urban environments.

2. Research Design and Methodology

This research aims to undertake a comprehensive investigation into the intricate relationship between urban permaculture and sustainability, specifically emphasizing the 4 Ps framework—People, Planet, Profit, Politics. To achieve a thorough understanding, a dual-method approach is employed, integrating systematic literature review and content analysis.

2.1 Systematic Literature Review

Researchers often require reviews to organize and prioritize existing knowledge. In this regard, the systematic literature review has emerged as a new method for reviewing the literature. This approach is accurate, thorough, and rule-guided, helping researchers understand large amounts of information by discovering, assessing, analyzing, and combining existing data regarding a specific research question. Systematic reviews not only present useful information but also provide evidence-based solutions, facilitating the distinction between authentic knowledge and assumed knowledge. Systematic literature reviews differ from traditional reviews in three methodological approaches: first, they begin with delineating a research strategy; second, they

identify explicit criteria for including and/or excluding the literature; and third, they aim to gather, evaluate, and interpret as much available and relevant literature as possible. These approaches address the limitations of traditional reviews, such as their generality in scope and unstructured protocol, which may lead to inconsistencies among reviews of the same topic due to bias [14], [15].

2.2 Content Analysis

Content analysis as a qualitative research method is used to analyze textual or transcribed content, focusing on both explicit and hidden aspects to reveal valuable information about specific phenomena. It involves sorting text into groups of related categories to identify similarities, differences, patterns, and associations, considering both the surface and implied meanings within the text. Content analysis can be categorized into two types: manifest and latent [16], [17], [18], [19].

- Manifest content analysis describes what is occurring on the surface and what is literally present in the text, staying close to the text and focusing on easily observable data without discerning deeper meanings
- In contrast, latent content analysis involves interpreting hidden meanings within the text, requiring the researcher to discover implied meanings and actively use mental schema and theories to understand the data.

While manifest content analysis relies on frequency counts to understand a phenomenon, latent content analysis seeks to identify patterns and constructs within the text, with distinctions between latent pattern and latent projective approaches [19].

2.3 The Dual-Method Approach

Combining systematic literature review and content analysis, this dual-method approach, provides a robust and comprehensive foundation for the exploration of the nexus between urban permaculture and sustainability within the context of the 4 Ps framework (Figure 3). The methodology ensures a thorough examination of both explicit and hidden aspects, contributing to a nuanced understanding of urban permaculture's impact and potential through the following steps:

- Literature Exploration: Prioritizing English-language peer-reviewed publications, including journal articles and university press publications, the exploration is expanded to encompass grey literature due to the scarcity of traditional sources. Each grey literature source undergoes meticulous evaluation for quality, including content examination and scrutiny of authors' expertise and institutional affiliations.
- Rigorous Methodological Framework: This research reviews pertinent literature on urban permaculture and conducts an in-depth content analysis of case studies from diverse urban settings. By delving into real-world applications, the study aims to unveil the ways in which these case studies contribute to the 4 Ps of sustainability.
- Comprehensive Analysis Process: The analysis process involves reducing the collected text volume, categorizing identified themes, and seeking understanding from both manifest (explicit facts and figures) and latent (hidden constructs and underlying trends) content. These analyses contribute to a nuanced understanding of urban permaculture's impact and potential by examining both surface-level and underlying meanings within textual data.
- Credibility Enhancement: To enhance credibility, member checking and peer debriefing are employed for critical evaluation and refinement of interpretations, and strengthening the overall credibility of the study's conclusions [20], [21].The emerging themes are also rigorously reviewed for trustworthiness, applicability, and reliability. In adherence to Marian Carcary recommendations, an audit trail is maintained, documenting all study procedures, methodological notes, and data-related aspects [22].

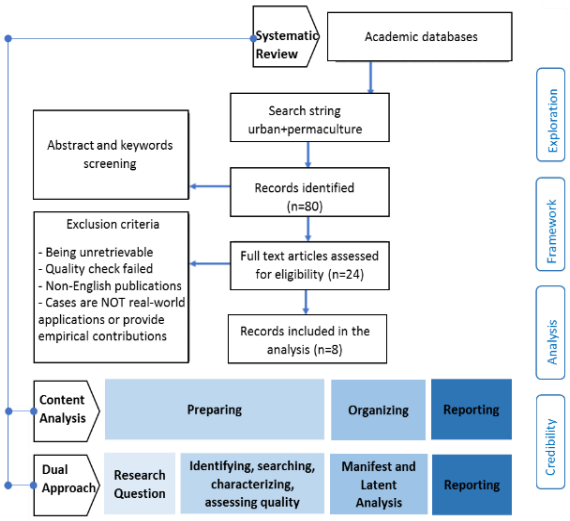


Figure 3. Research design

3. Results

3.1 Disciplinary Landscape: Abstract and Keywords Analysis

The employed search strategy systematically gathered pertinent literature on urban permaculture. Initially, the search string "Urban Permaculture" yielded a limited number of references. To enhance comprehensiveness, the search string was expanded to "Permaculture AND Urban," resulting in an extensive compilation of 80 sources retrieved from the Scopus database. Conducting an in-depth analysis of abstracts and keywords has provided valuable insights into foundational literature. This initial phase establishes the groundwork for a nuanced exploration, offering a holistic perspective on the trends, document types, subject areas, and global distribution of urban permaculture research, providing valuable insights into the multifaceted nature of this field of study, Figure (4).

1. **Trend of Publication:** This visual representation delineates the evolving nature of urban permaculture discourse by showcasing publication trends over the years. The data analysis demonstrates a progressive increase in research interest, particularly evident in notable peaks in 2019 and sustained interest in subsequent years.

2**. Document Type:** An in-depth analysis of document types within the Scopus database categorizes literature types related to urban permaculture. The predominant document type is articles, comprising 37 publications, emphasizing detailed research studies and academic articles addressing various facets of urban permaculture.

3**. Subject Area:** The examination of subjects within the Scopus database provides a comprehensive view of the thematic distribution of urban permaculture research. The multidisciplinary approach is evident, with a significant focus on Social Sciences and Environmental Science, but contributions from diverse fields such as Agricultural and Biological Sciences, Engineering, and Arts and Humanities.

4. **Country/Territory:** Geographic insights derived from the Scopus database illustrate the global engagement with urban permaculture literature. The United States leads with 24 publications, indicating a considerable research focus, followed by contributions from countries worldwide, demonstrating a collective effort to understand and implement permaculture principles in urban environments.

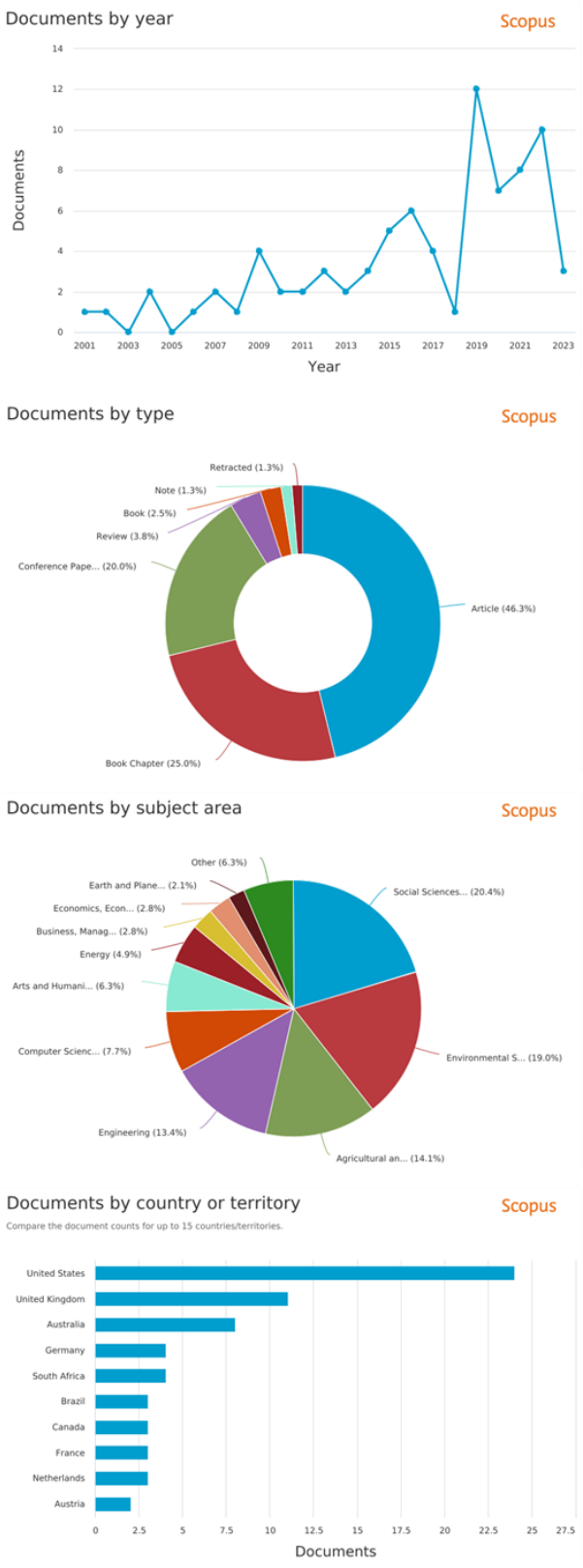


Figure 4 . Urban permaculture literature analysis

3.2 Case Studies: Full Paper - Manifest and Latent Analysis

In order to refine the focus, inclusion criteria were implemented, selecting for English-language publications and open-access articles, thus narrowing down the results to 24 sources. A meticulous screening process ensued, involving a detailed examination of the chosen papers, ultimately identifying [eight] distinct cases of urban permaculture projects. These cases, spanning diverse geographic locations, design philosophies, and objectives, lay a robust foundation for understanding the global impact of urban permaculture initiatives.

3.2.1 Manifest Analysis: Collective Results

Employing a manifest approach to analyse the eight presented cases aimed at describing observable elements. The results of this analysis prominently emphasize five key elements: type, location, implementer, objectives, and features. The type refers to the nature or category of the project. Location provides insight into the geographical context, specifying the cities and countries where these initiatives are situated. Implementer identifies the entities or individuals responsible for executing these projects. Objectives shed light on the overarching goals of each initiative, spanning from fostering community development to promoting sustainable urban agriculture. Lastly, features encapsulate the distinctive components and characteristics of the projects. This manifest analysis serves to provide a clear and descriptive overview of the observed cases, highlighting the fundamental aspects that define each urban initiative.

A. Types of Urban Permaculture Cases

The urban permaculture initiatives encompass a variety of types, each contributing uniquely to sustainable urban development. These include Urban Transformation with a focus on productive landscapes and the blue-green model [23], Collective Residential Gardening emphasizing community participation [24], Urban Farm initiatives integrating agriculture into urban settings [25], and Community Park projects creating communal spaces [26]. Blended Spaces, such as Roof Top & Courtyard Food Forests, showcase innovative design concepts [27]. Farmhouse Gardens exemplify the potential of permaculture in residential areas [28], while Urban Food Gardens address localized food production [29]. Lastly, Collective Permaculture Gardens, Biological City Farms, and 'Parks of the 21st Century' represent collaborative efforts for sustainable neighbourhood development [30]. This taxonomy underscores the diversity and significance of urban permaculture initiatives in shaping resilient and environmentally conscious urban landscapes.

B. Geographical Distribution of Urban Permaculture Cases

The examined permaculture projects showcase a global spread, illustrating the adaptability of permaculture practices across diverse continents, (Figure 5). From Skien, Norway, to Adelaide, Australia, Oasis Citadine in Montpellier, France, Vallastaden in Linköping, Sweden, Edinburgh in the United Kingdom, Anchorage in Alaska, USA, Johannesburg in South Africa, and Culemborg in The Netherlands, each location introduces unique environmental and social contexts that significantly influence the approaches and objectives of urban

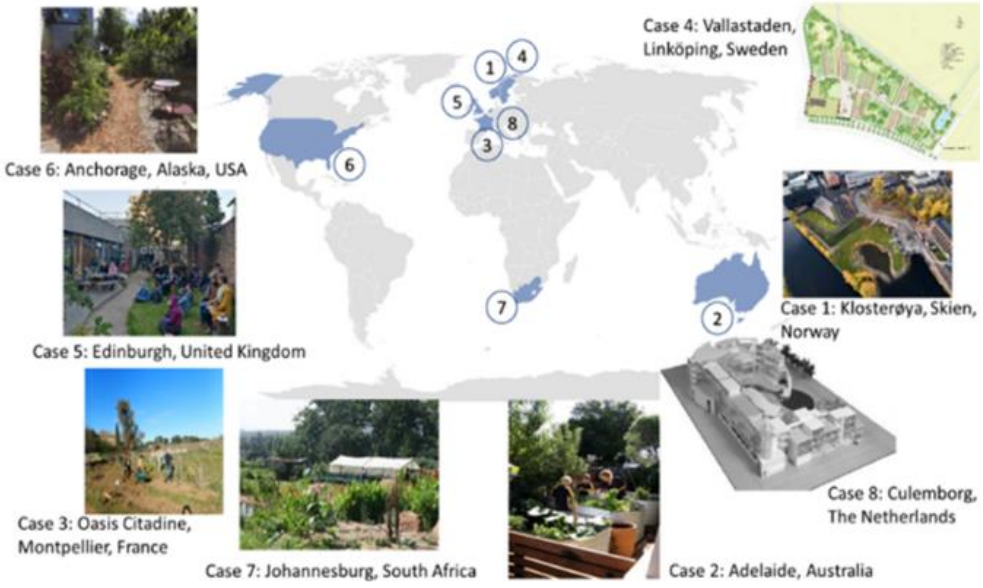


Figure 5. Geographical distribution of the eight cases

permaculture initiatives. The continental breakdown emphasizes the integration of permaculture principles in varied settings, contributing to the global discourse on sustainable urban development .

C. Implementers of Urban Permaculture Cases

Implementers span a spectrum of organizations, institutions, individuals, and collaborative efforts, underscoring the inclusive and participatory nature of urban permaculture initiatives. From educational institutions like Skien High School to collaborative efforts in The Netherlands, and individual homesteaders in Alaska, the diversity of implementers highlights the richness of stakeholder involvement in creating sustainable and productive urban spaces .

D. Objectives of Urban Permaculture Cases

The objectives of these urban permaculture initiatives range from collaboratively creating sustainable urban spaces in historical contexts to fostering community development through backyard gardens. Initiatives in Montpellier and Linköping aim to initiate urban dwellers into agriculture and promote community diversity. Edinburgh Napier University integrates technology for human and planetary health. Projects in Alaska, Johannesburg, and The Netherlands demonstrate urban permaculture potential, empower communities, and implement sustainable neighbourhood practices. These diverse objectives collectively contribute to sustainable and inclusive urban development.

E. Design Features and Layout

These initiatives showcase diverse design features, emphasizing sustainability and functionality. The first incorporates an urban fruit forest, edible rain gardens, and an outdoor classroom. The second focuses on integrated food forests, sustainable water management, and organic gardening. The third utilizes permaculture practices like mounds, mulching, and green manure. The fourth includes community spaces and a park in its masterplan. The fifth features a rooftop allotment, courtyard food forest, and an interactive storytelling chair. The sixth encompasses various garden beds, orchards, a solar greenhouse, and animal integration. Design specifics are not extensively described in the seventh. The eighth incorporates anaerobic fermentation, composting, and waste heat utilization components.

3.2.2 Latent Analysis: Permaculture's Synergy with the 4 Ps of Sustainability

Based on latent analysis, the underlying themes for the four circles of sustainability emerge, shedding light on key aspects. The 4Ps of sustainability—People, Planet, Profit, and Politics—comprehensively address various dimensions of sustainability. Social sustainability within the People circle encompasses community involvement and empowerment (CIE), social cohesion and inclusivity (SCI), health and well-being benefits for residents (HW), and education and knowledge sharing (EKS). Environmental sustainability, a crucial component under the Planet circle, involves considerations such as energy efficiency (EE), biodiversity enhancement (BE), water conservation (WC), waste management (WM), and soil regeneration (SR). Economic sustainability, represented by Profit, emphasizes factors like economic viability and cost-effectiveness (EC), local economic development (LED), employment opportunities (EO), and economic benefits for stakeholders (EBS). Lastly, Politics, focusing on governance and organization, encompasses government support and policies (GSP) and legal and regulatory aspects (LRA). The latent analysis of these themes, presented in Table (1), begins to unfold, providing insights into the intricacies of sustainable development

.

Table 1. Sustainability dimensions identified through latent analysis

People		**Planet**	
Social Sustainability		Environmental Sustainability	
•Community involvement and empowerment	CIE	•Energy efficiency	EE
•Social cohesion and inclusivity	SCI	•Biodiversity enhancement	BE
•Health and well-being benefits for residents	HW	•Water conservation	WC
•Education and knowledge sharing	EKS	•Waste management	WM
		•Soil regeneration	SR
Profit		**Politics**	
Economic Sustainability		Governance and Organization	
•Economic viability and cost-effectiveness	EC	•Government support and policies	GSP
•Local economic development	LED	•Legal and regulatory aspects	LRA
•Employment opportunities	EO	•Barriers and challenges faced during implementation	BC
•Economic benefits for stakeholders	EBS	•Community engagement in decision-making processes	CE

In order to facilitate the exploration and visualization of the sustainability dimensions discussed above, the 'Kumu' platform (https://kumu.io/) is utilized. Kumu offers a dynamic environment tailored for the creation and dissemination of interactive maps and relationship visualizations. This platform is instrumental in mapping out the intricate connections and relationships embedded within the sustainability themes under consideration, providing a visually engaging and insightful representation, (Figure 6).

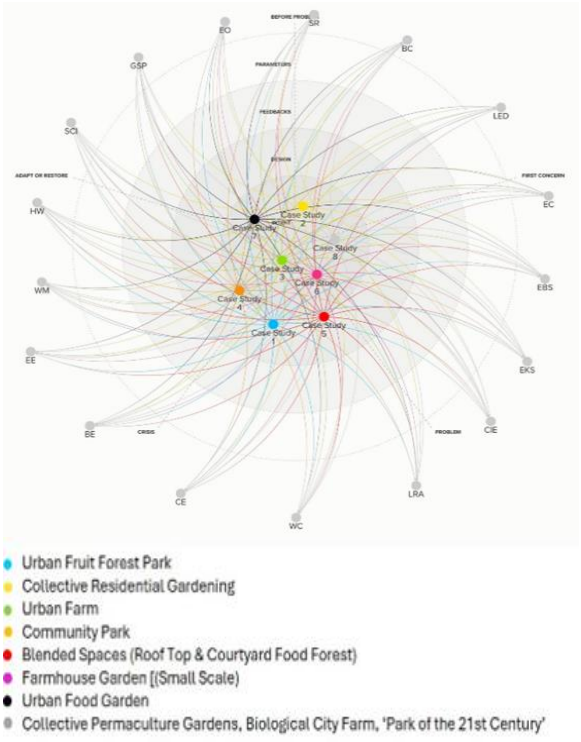


Figure 6. Sustainability dimensions visualization utilizing 'kumu' platform

In the following section, a detailed exposition of each dimension of sustainability, accompanied by its related extracted themes, will be presented. These themes are derived from an in-depth analysis of eight cases explored and identified in the preceding systematic review. This comprehensive examination aims to shed light on the nuanced connections and relationships inherent in the sustainability domains under consideration.

A. People_ Social Sustainability

As we delve into the expansive domain of permaculture, it is discernible that its principles extend beyond ecological concerns to encompass a robust social dimension. The social sustainability facet of permaculture, underscored by the analysed articles, emphasizes the construction of resilient, empowered, and inclusive communities. Figure (7, a) succinctly presents the presence and manifestation of social sustainability themes —Community Involvement and Empowerment (CIE), Social Cohesion and Inclusivity (SCI), Health and Well-being Benefits for Residents (HWB), and Education and Knowledge Sharing (EKS)— across the eight examined projects.

In the sphere of Community Involvement and Empowerment (CIE) within urban permaculture, the focus is on establishing sustainable and culturally relevant spaces. Active resident participation is integral to designing, implementing, and maintaining projects that enhance well-being for both individuals and the environment. Social Cohesion and Inclusivity (SCI) serve as foundational principles fostering strong communities by building bonds, celebrating diversity, and ensuring individuals feel connected, respected, and engaged. Health and Well-being Benefits (HWB) emerge as a central theme across diverse scenarios, showcasing the multifaceted impact of various initiatives. Urban permaculture, through its sustainable practices, contributes to improved physical, mental, and emotional well-being, fostering a healthier and more vibrant urban environment. Education and Knowledge Sharing (EKS) in urban permaculture involve sharing information and skills related to sustainable practices, ecological principles, and community engagement.

B. Planet_ Environmental Sustainability

Turning our attention to environmental sustainability, urban permaculture employs multifaceted strategies to ensure the responsible use and conservation of energy, water, soil, and waste, while simultaneously fostering biodiversity enhancement. Figure (7, b) visually represents the occurrence of environmental sustainability themes within the eight examined cases. Energy Efficiency (EE) stands out as a pivotal consideration in the realm of environmental sustainability, involving the optimization of design and practices to minimize energy consumption. Biodiversity Enhancement (BE) encompasses practices such as polyculture, rainwater harvesting, and companion planting, contributing to a more sustainable and resilient urban ecosystem. Water Conservation (WC) in urban permaculture involves various strategies like drip irrigation, greywater recycling, and smart irrigation systems, sustaining urban permaculture by minimizing water use. Waste Management (WM) includes composting, recycling, and community involvement to create sustainable urban ecosystems. Soil Regeneration (SR) focuses on revitalizing city soil through practices such as cover cropping, no-till gardening, and biochar incorporation.

C. Profit_ Economic Sustainability

In the economic sustainability realm, themes such as economic viability and cost-effectiveness (EC), local economic development (LED), employment

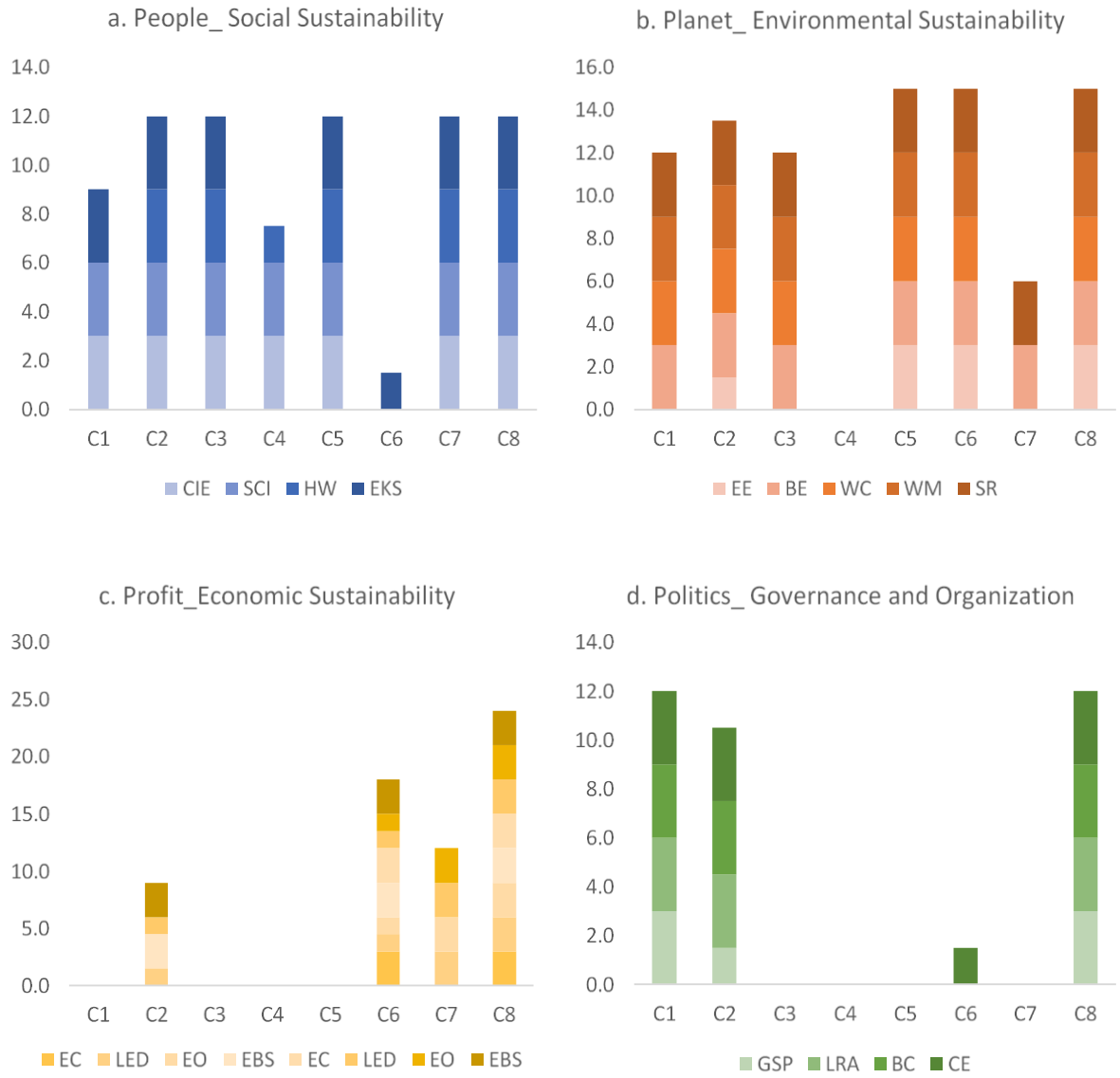


Figure 7 . Detailed exposition of sustainability dimensions and related extracted themes based on latent analysis of the eight cases

opportunities (EO), and economic benefits for stakeholders (EBS) manifest across the examined cases. Economic viability (EC) is integral to urban permaculture initiatives, ensuring their sustainability. Attention to Local Economic Development (LED) is fundamental for fostering comprehensive community and economic development. Diverse strategies addressing Employment Opportunities (EO) underscore the potential positive impacts on local economies and education. while economic sustainability themes are not explicitly detailed in every case, Figure (7, c) emphasizes the varied ways in which urban permaculture projects contribute to the economic well-being of stakeholders, fostering community welfare and individual development.

D. Politics_ Governance and Organization

Lastly, the governance and organizational aspect (Politics) of urban permaculture relies on Government Support and Policies (GSP), Legal and Regulatory Aspects (LRA), Barriers and Challenges during Implementation (BC), and Community Engagement in Decision-Making Processes (CE). Government support includes zoning policies, financial incentives, and collaboration with local governments. Navigating the legal landscape involves understanding and adhering to various regulations. Barriers and Challenges (BC) during implementation include limited space, poor soil quality, and zoning regulations. Engaging the community in decision-making processes (CE) is vital for effective urban

permaculture, fostering continuous communication and a shared sense of responsibility. Figure (7, d) highlights political themes integrated into four out of eight cases, showcasing how governance and organizational elements are intertwined in urban permaculture initiatives.

4. Discussion

4.1 Sustainability Integration in Urban Permaculture Initiatives

This paper addresses the intricate intersection of urbanization and environmental challenges through the lens of Urban Permaculture, examining its integration with the 4 Ps of Sustainability. The research design employs a dual-method approach, combining literature exploration with a rigorous methodological framework. The comprehensive analysis process involves a disciplined examination, including an audit trail for credibility enhancement. The results are presented in a structured format, encompassing disciplinary landscape analysis, visualization data, and in-depth manifest and latent case studies. The manifest analysis comprehensively explores various dimensions of Urban Permaculture cases, encompassing their types, geographical distribution, implementers, objectives, and design features, (Appendix A). Conversely, the latent analysis delves into the implicit synergy between Permaculture and the 4 Ps of Sustainability, dissecting its ramifications on social, environmental, and economic dimensions. Specifically, the analytical framework is structured around four factors representing the pillars of sustainability: People (Social Sustainability), Planet (Environmental Sustainability), Profit (Economic Sustainability), and Politics (Governance and Organization), (Appendix B).

Table (2) evaluates the integration of sustainability pillars across all cases. This involves the assignment of weights to each identified factor in every case study, ultimately culminating in the calculation of the total weight for each sustainability pillar. The outcomes of this comprehensive evaluation offer a holistic comprehension of how urban permaculture projects align with the four pillars of sustainability., underscoring the interconnected nature of social, environmental, economic, and governance dimensions. The analysis reveals varying degrees of emphasis on different themes, (Figure 8).

1. **Social sustainability**, comprising community involvement, empowerment, social cohesion, and education, constitutes a significant 33% of the overall sustainability integration. Within this theme, community involvement and empowerment, social cohesion, and education are more extensively addressed, while health and well-being receive comparatively less attention .

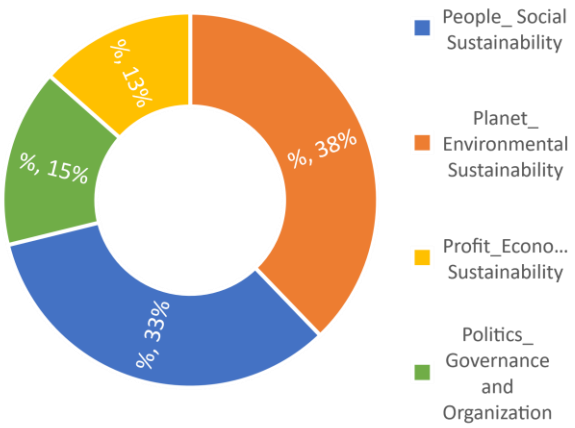


Figure 8. Sustainability pillars integration percentage across case studies

Table 2. Matrix depicting the integration levels of sustainability pillars

Urban Permacuture practices			Case studies C1	C2	C3	C4	C5	C6	C7	C8	Weight (Value/%)		
People	Social Sustainability	CIE	●	●	●	●	●	○	●	●	21.0	27%	33%
		SCI	●	●	●	●	●	○	●	●	21.0	27%	
		HW	○	●	●	◑	●	○	●	●	16.5	21%	
		EKS	●	●	●	○	●	◑	●	●	19.5	25%	
Planet	Environmental Sustainability	EE	○	◑	○	○	●	●	○	●	10.5	12%	38%
		BE	●	●	●	○	●	●	●	●	21.0	24%	
		WC	●	●	●	○	●	●	○	●	18.0	20%	
		WM	●	●	●	○	●	●	○	●	18.0	20%	
		SR	●	●	●	○	●	●	●	●	21.0	24%	
Profit	Economic Sustainability	EC	○	○	○	○	○	●	○	●	6.0	19%	13%
		LED	○	◑	○	○	○	◑	●	●	9.0	29%	
		EO	○	○	○	○	○	◑	●	●	7.5	24%	
		EBS	○	●	○	○	○	●	○	●	9.0	29%	
Politics	Governance and Organization	GSP	●	◑	○	○	○	○	○	●	7.5	21%	15%
		LRA	●	●	○	○	○	○	○	●	9.0	25%	
		BC	●	●	○	○	○	○	○	●	9.0	25%	
		CE	●	●	○	○	○	◑	○	●	10.5	29%	
			● High			◑ Low			○ Unclear				

2. **Environmental sustainability**, contributing 38%, places emphasis on biodiversity enhancement, water conservation, waste management, and soil regeneration. Biodiversity enhancement, water conservation, waste management, and soil regeneration are the more addressed aspects, whereas energy efficiency is less emphasized .

3. **Economic sustainability,** representing 13%, features more attention on economic benefits sharing and local economic development, with economic viability, cost-effectiveness, and employment opportunities receiving relatively less focus .
4. **Governance and organization**, comprising 15%, highlights themes like community engagement and legal and regulatory aspects, while government support and policies and barriers during implementation are less addressed.

This analysis elucidates the complex interplay between urban permaculture and sustainability, offering insights into how these initiatives address social, environmental, economic, and governance dimensions. By evaluating the integration of sustainability pillars across diverse urban permaculture projects, this research informs future endeavours, guiding them to navigate the multifaceted landscape of sustainable urban development effectively.

4.2 Implications and Strategic Pathways for Future Urban Permaculture Initiatives

Future urban permaculture initiatives hold significant potential for fostering holistic sustainability, resilience, inclusivity, and positive impacts across social, environmental, economic, and governance dimensions within urban landscapes. To strategically guide these initiatives and realize their potential, it is imperative to address key themes and prioritize certain pathways. This structured overview encompasses five major principles, (Table 3): Community Empowerment and Engagement, Environmental Sustainability, Economic Viability and Development, Governance and Implementation, and Interconnected Sustainability Pillars.

A. Community Empowerment and Engagement

Effective community engagement is integral to successful urban permaculture initiatives. Strategies should focus on empowering residents through participatory decision-making processes, workshops, and collaborative endeavours. Building inclusive communities is essential, emphasizing diversity, fostering social bonds, and celebrating the multifaceted identities present within urban environments. Initiatives should maximize health and well-being benefits by incorporating health-focused features into project designs, launching awareness campaigns, and collaborating with healthcare professionals. Promoting education and knowledge sharing is crucial through the development of educational programs, workshops, and online resources aimed at disseminating permaculture knowledge among residents and local stakeholders.

Table 3. Strategies and tactics to guide future urban permaculture initiatives

Strategy	Tactics
A. Empowerment	
Empowering Community Engagement	• community engagement strategies, • workshops, • collaborative decision-making, • resident empowerment,
Building Inclusive Communities	• diversity, • inclusivity, • project design, • social bonds, • multifaceted identities
Maximizing Health and Well-being Benefits	• health-focused features, • project design, • awareness campaigns, • healthcare collaboration, • health benefits,
Promoting Education and Knowledge Sharing	• educational programs, • workshops, • online resources, • permaculture knowledge dissemination, • local stakeholders
B. Environment	
Enhancing Environmental Sustainability	• energy-efficient technologies, • green infrastructure prioritization, • collaboration with ecologists, • biodiversity enhancement
Innovative Water Management and Conservation	• diversity emphasis, • inclusive project design, • social bonding, • urban identity celebration
C. Economy	
Ensuring Economic Viability and Local Economic Development	• economic partnerships, • local market exploration, • revenue strategy, • economic viability, • local development
D. Implementation	
Overcoming Governance Challenges	• local government collaboration, • regulatory compliance, • community involvement, • project acceptance
Integrating Legal Compliance	• feasibility studies, • legal experts' engagement, • adaptive management strategies
E. Sustainability Pillars	
Interconnected Sustainability Pillars for Holistic Urban Development	• interdisciplinary project teams, • unified framework, • cross-sector collaboration

B. Environmental Sustainability

Urban permaculture projects must prioritize environmental sustainability by integrating energy-efficient technologies, prioritizing green infrastructure, and collaborating with ecologists to enhance biodiversity. Innovative water conservation and waste management strategies should also be emphasized to address the unique challenges faced within urban environments.

C. Economic Viability and Development

Ensuring economic viability and local economic development is essential for the long-term success of urban permaculture initiatives. This involves fostering economic partnerships, exploring local market opportunities, and strategizing revenue streams to contribute to economic development within the community.

D. Governance and Implementation

Governance challenges must be addressed to foster community acceptance and ensure effective implementation of permaculture projects. Collaboration with local governments, adherence to regulatory frameworks, and enhancing community involvement in decision-making processes are critical. Additionally, overcoming legal compliance and implementation challenges requires conducting thorough feasibility studies, engaging legal experts, and adopting adaptive management strategies.

E. Interconnected Sustainability Pillars

To achieve holistic urban development, initiatives must recognize the interconnectedness of sustainability pillars and prioritize interdisciplinary collaboration. This involves developing interdisciplinary project teams, establishing unified frameworks that address all sustainability dimensions, and fostering cross-sector collaboration to create comprehensive urban permaculture projects.

4.3 Corroboration

The strategic pathways outlined in this study hold significant implications for the advancement of urban permaculture initiatives, aligning with the foundational principles of sustainable resource governance proposed by Elinor Ostrom [31]. By strategically addressing the themes of Community Empowerment and Engagement, Environmental Sustainability, Economic Viability and Development, Governance and Implementation, and Interconnected Sustainability Pillars, a comprehensive and inclusive approach is presented. The emphasis on community engagement and collaborative decision-making reflects Ostrom's insights into the importance of local knowledge and self-governance [32]. Furthermore, the focus on interconnected sustainability pillars resonates with Ostrom's call for polycentric governance structures that involve diverse stakeholders [33].

As urban areas continue to grapple with complex socio-environmental challenges, the proposed strategic pathways provide a roadmap for fostering resilience, inclusivity, and positive impacts across social, environmental, economic, and governance dimensions. By integrating these strategic approaches, urban permaculture can emerge not only as a nature-based solution but also as a transformative force contributing to the broader discourse on sustainable urban development. This study contributes to the ongoing dialogue on effective and holistic nature-based solutions, reinforcing the relevance of Elinor Ostrom's principles in shaping sustainable urban landscapes (Figure 9).

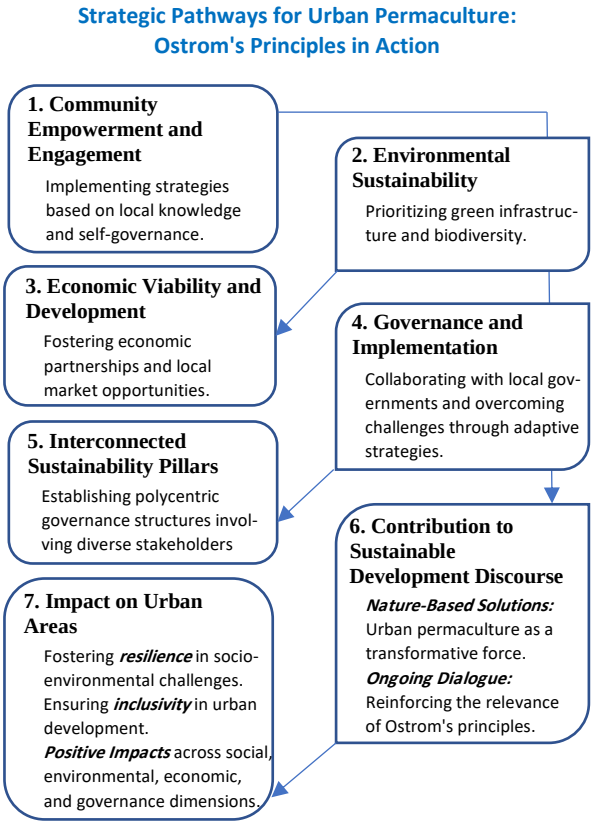


Figure 9. Strategic pathways alignment with Ostrom's principles

4.4 Limitations

This study, while providing valuable insights into the relationship between urban permaculture and sustainability through a dual-method approach of systematic literature review and content analysis within the framework of the 4 Ps (People, Planet, Profit, Politics), is subject to several limitations. Firstly, the scope of the literature review may have been constrained by language barriers and accessibility limitations, potentially overlooking relevant non-English and subscription-based sources.

Secondly, the findings may lack generalizability due to the selected sample of urban permaculture initiatives, which may not fully represent the broader landscape of such projects worldwide. Thirdly, the reliability of the findings is contingent upon the quality and accuracy of the extracted data, which may be influenced by biases in reporting and documentation. Additionally, methodological constraints, such as researcher bias in study selection and data extraction, may have impacted the robustness of the results. Furthermore, the temporal context of the study may limit its relevance to evolving trends and emerging practices in urban permaculture. Lastly, the interdisciplinary nature of urban permaculture and sustainability may introduce disciplinary biases and perspectives, potentially overlooking nuances inherent in interdisciplinary contexts. Despite these limitations, this study offers valuable insights for future research and practice in urban sustainability, highlighting opportunities for methodological refinement and interdisciplinary collaboration.

5. Conclusion

This research has undertaken a comprehensive exploration of the intricate relationship between urban permaculture and sustainability, focusing on the 4 Ps framework—People, Planet, Profit, and Politics. By employing a dual-method approach integrating systematic literature review and content analysis, this study has provided a robust foundation for understanding the nexus between urban permaculture and sustainability.

The systematic literature review facilitated the organization and synthesis of existing knowledge, offering evidence-based insights into urban permaculture's contributions to sustainability. Content analysis further enriched our understanding by delving into manifest and latent aspects of urban permaculture initiatives, uncovering both observable elements and underlying themes.

Manifest analysis highlighted key dimensions of urban permaculture projects, including their types, geographical distribution, implementers, objectives, and design features. This analysis underscored the diversity and significance of urban permaculture initiatives in shaping resilient and environmentally conscious urban landscapes.

Latent analysis revealed the implicit synergy between permaculture and the 4 Ps of sustainability, shedding light on how urban permaculture initiatives address social, environmental, economic, and governance dimensions. This analysis deepened our understanding of the nuanced connections between permaculture practices and sustainable development goals.

The examination of sustainability pillars across urban permaculture projects highlighted varying emphases on different themes, providing valuable insights for future initiatives. Strategic pathways were outlined to guide the development of urban permaculture projects, emphasizing community empowerment and engagement, environmental sustainability, economic viability and development, governance and implementation, and interconnected sustainability pillars. This study contributes to advancing the discourse on urban sustainability by elucidating the transformative potential of urban permaculture. By integrating nature-based solutions like permaculture into urban planning and design, cities can foster resilience, inclusivity, and positive impacts across social, environmental, economic, and governance dimensions. Moving forward, it is imperative to continue leveraging interdisciplinary approaches and stakeholder collaboration to realize the full potential of urban permaculture as a catalyst for sustainable urban development.

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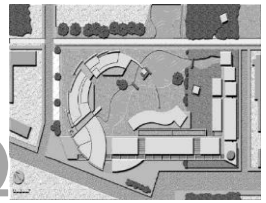
Appendix A. A Concise Manifest Content Analysis of the Eight Case Studies

Urban Permaculture Projects				
Case No.:	1	2	3	4
				
Type:	**Urban Redevelopment**	**Collective Residential Gardening**	**Urban Farm**	**Community Park**
Implementer:	Skien High School, Design Team, Private Developer	Individual households in suburban communities	Leaders and members of an urban farm, Montpellier intermunicipal body	Architectural firm "Okidoki"
Objectives:	Crafting a sustainable urban open space (UOS) through collaborative ecological design and urban agriculture on Klosterøya.	Fostering sustainable urban agriculture and community development through collaborative backyard gardens in suburban areas.	Initiating urban dwellers into urban agriculture and permaculture principles at Oasis Citadine, a community garden with diverse activities.	Fostering community and diversity with community spaces (Felleshus) and a park (Paradiset) in Vallastaden's dense neighborhood..
Design:	Features include an urban fruit forest, edible rain gardens, and an outdoor classroom	Includes integrated food forests, sustainable water management, and organic gardening.	Utilizes permaculture practices such as mounds, mulching, and green manure	Includes community spaces and a community park.
Case No.:	5	6	7	8
				
Type:	**Blended Spaces** (Roof Top & Courtyard Food Forest)	**Farmhouse Garden**	**Urban Food Garden**	Permaculture Gardens, **Biological City Farm,** 'Park of the 21st Century.'
Implementer:	Edinburgh Napier Students' Association	S. Esslinger, homesteader and permaculturist	Wits University Health Promotion Unit, Permaculture Organization.	Collaborative effort involving various tracks and stakeholders
Objectives:	Blending digital technology and permaculture for human and planetary health in Edinburgh Napier University's spaces.	Demonstrating the potential of urban permaculture through the creation of a productive and low-maintenance garden in a residential area.	Establishing Siyakhana Food Garden in Johannesburg to provide vegetables, empower participants, and serve as a model for community gardens.	Implementing Lanxmeer for a sustainable, decentralized neighborhood with waste management, water treatment, energy, and agriculture.
Design:	Includes a rooftop allotment, courtyard food forest, and an interactive storytelling chair.	Includes various garden beds, orchards, a solar greenhouse, and integration of animals.	Specifics are not extensively described	Includes components like anaerobic fermentation, composting, and waste heat utilization.

Appendix B. A Concise Latent Content Analysis of the Eight Case Studies

Case No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Type	Urban Fruit Forest Park	Collective Residential Gardening	Urban Farm	Community Park	Blended Spaces (Roof Top & Courtyard Food Forest)	Farmhouse Garden [Small Scale]	Urban Food Garden	Collective Permaculture Gardens, Biological City Farm, 'Park of the 21st Century'
Social Sustainability	- Community involvement and empowerment	- Inclusivity, community engagement	- Community involvement and empowerment, social cohesion	- Shared spaces, community engagement, social cohesion	- Community involvement and empowerment, social cohesion	- No explicit mention of community involvement	- Community involvement and empowerment, social cohesion	- Community involvement and empowerment, social cohesion
Environmental Sustainability	- Biodiversity enhancement, water conservation, waste management, soil regeneration	- Energy efficiency, biodiversity, water conservation, waste management, soil regeneration	- Biodiversity enhancement, soil regeneration	- Limited information	- Biodiversity enhancement, soil regeneration	- Energy efficiency, biodiversity, water conservation, waste management, soil regeneration	- Limited information	- Energy efficiency, biodiversity, water conservation, waste management, soil regeneration
Economic Sustainability	- Limited information	- Sharing economy, potential local economic development	- Not explicitly mentioned	- Limited information	- Not explicitly mentioned	- Economic viability, local economic development	- Limited information	- Economic viability, local economic development
Politics and Governance	- Government support, legal adherence, community engagement	- Informal community engagement	- Not explicitly addressed	- Limited information	- Community engagement and learning experience	- No mention of government support or specific policies	- Limited information	- Government support, legal adherence, community engagement