Modeling Sustainable Design Practices for Service Complexes - Systematic Review

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Abstract

In the realm of sustainable urban design, this peer-reviewed article presents a systematic review focusing on contemporary practices in mixed-use development. Emphasizing a holistic approach, the study examines renewable energy utilization, energy efficiency methodologies, sustainable materials, water conservation strategies, green space integration for ecological enhancement, and social interaction through design, waste management, and smart transportation systems. Methodologically, a framework incorporating bibliometric and content analyses was employed, reviewing scholarly literature from 2010 to 2023 using key search terms like "mixed use," "sustainable design," and "renewable energy." The findings highlight global trends including widespread adoption of renewable energy technologies, innovations in energy-efficient building methods, advances in sustainable materials, effective water resource management strategies, and the role of green spaces in urban biodiversity. The study underscores the importance of promoting social cohesion, enhancing waste management, and integrating intelligent transportation networks for sustainable urban living. It concludes on the imperative of integrated approaches, policy frameworks, technological innovations, and community engagement to achieve comprehensive sustainability in urban environments. This research contributes significantly to the discourse on sustainable urban development by addressing urban challenges and offering adaptable frameworks and practical solutions. It serves as a valuable resource for scholars, practitioners, and policymakers in architecture and urban planning, advocating for environmentally conscious, socially inclusive and economically viable development practices.

Keywords: Sustainable Design; Service Complexes; Building Information Modeling (BIM); Urban Design; Environmental Sustainability; Mixed-Use

1. Introduction

In recent decades, urban development has shifted markedly towards sustainability, driven by the imperative to mitigate environmental impacts and enhance urban living conditions. At the heart of this evolution lies sustainable urban design, which integrates environmental stewardship, social equity, and economic vitality into city planning and development.[1] Mixed-use developments exemplify this approach by combining residential, commercial, and recreational functions within cohesive urban environments, optimizing land use efficiency and serving as platforms for diverse sustainable practices.[2]

These complexes advance urban sustainability through initiatives such as energy consumption reduction, promotion of renewable energy sources, enhancement of social interaction via thoughtful design, and sustainable management of resources like water and waste. This multifaceted approach underscores their pivotal role in urban sustainability.[3] This systematic review aims to comprehensively explore and synthesize contemporary practices in sustainable design within mixed-use developments. Spanning scholarly literature from 2010 to 2023, the review identifies emerging trends, evaluates innovative methodologies, and delineates persistent challenges in sustainable

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strategy implementation. Key areas include renewable energy utilization, energy efficiency methodologies, and advances in sustainable materials, water conservation strategies, integration of green spaces for urban biodiversity, effective waste management, and integration of smart transportation systems.[4]

Focused on peer-reviewed journal articles and conference proceedings, this review synthesizes insights into sustainable design practices globally, acknowledging geographical variations and contextual diversity across regions. By illuminating these dimensions, the research seeks to advance scholarly understanding in sustainable urban design, offering critical insights for future research and practical applications in architecture, urban planning, and environmental sustainability.[5] Ultimately, this systematic review contributes significantly to ongoing dialogues on sustainable development, advocating for holistic approaches that foster environmentally responsible, socially inclusive, and economically viable urban environments.[6]

2. Literature Review

2.1. Sustainability in Urban Design

Sustainability in urban design has evolved significantly, increasingly prioritizing environmental, social, and economic considerations. This holistic approach aims to enhance urban quality of life while minimizing environmental impacts. [7] Key strategies include compact development, which promotes higher density and mixed land uses, reducing urban sprawl and preserving green spaces.[4]

Mixed land uses within neighbourhoods integrate residential, commercial, and recreational functions, fostering walkability, minimizing vehicular travel, and supporting local economies. Efficient transportation systems, including public transit, cycling infrastructure, and pedestrian-friendly designs, further enhance sustainability by reducing carbon emissions, alleviating traffic congestion, and improving urban air quality.[8]

Green infrastructure features like green roofs, urban forests, and permeable surfaces are crucial in managing storm water, mitigating urban heat island effects, and enhancing urban biodiversity. Resilient building design practices emphasize energy efficiency, sustainable materials, and passive design strategies, reducing energy consumption, operational costs, and overall carbon footprint.[9]

2.2. Sustainability in Mixed-Use Service Complexes

Mixed-use service complexes are crucial for sustainable urban development by consolidating various public functions within cohesive spaces. [10] These complexes typically integrate educational institutions, medical facilities, social services centres, commercial spaces, and cultural venues, promoting walkability and community interaction. This integration reduces long commutes and encourages vibrant social interactions among residents.[11] Reducing vehicular traffic is another significant benefit, as proximity to services decreases reliance on private cars, thereby lowering carbon emissions and improving urban air quality.

Moreover, the coexistence of diverse services supports local economies, fostering entrepreneurship and cultural activities to enhance economic resilience within communities. Promoting resource efficiency through shared infrastructure and facilities is integral to sustainable practices in mixed-use complexes. Shared heating and cooling systems, parking spaces, and green spaces optimize resource utilization while minimizing environmental impact.

2.3. Sustainable Practices in Mixed-Use Service Complexes

In contemporary urban planning, integrating sustainable design practices within service complexes is pivotal for fostering environmental resilience and enhancing community well-being in urban areas. These complexes amalgamate residential, commercial, educational, medical, social, and cultural functions within cohesive urban spaces, optimizing land use, nurturing vibrant, walkable neighborhoods, and curbing vehicular traffic. The architectural configuration emphasizes compact and efficient design principles, minimizing land footprint, preserving natural habitats, and maximizing urban infrastructure efficiency. High-density developments with mixed land uses mitigate the environmental footprint of urban expansion, promoting efficient resource allocation and sustainable urban growth.[12]

Incorporating renewable energy technologies such as solar photovoltaics, wind turbines, and geothermal systems is integral to sustainable urban design within service complexes. By harnessing clean energy sources, these developments reduce reliance on fossil fuels, mitigate greenhouse gas emissions, and enhance energy resilience, supporting environmental sustainability goals and reducing long-term operational costs. Efficient building design and technologies, including passive strategies, energy-efficient lighting, and advanced insulation, minimize energy consumption, lower carbon footprints, and improve indoor environmental quality, promoting sustainable living environments.

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Adopting sustainable building materials like recycled content, low-impact materials, and locally sourced products within service complexes reduces resource depletion and environmental degradation. These materials lower embodied carbon emissions, promote circular economy principles, and enhance building durability and resilience, supporting long-term environmental stewardship and responsible construction practices. Efficient water management practices such as water-efficient fixtures, greywater recycling, and sustainable landscaping minimize water consumption, mitigate storm water runoff, and ensure sustainable water resource management amid urbanization pressures.

Integrating green spaces such as parks, gardens, green roofs, and urban forests within service complexes serves multifaceted environmental and social functions. These green infrastructures mitigate urban heat island effects, enhance air quality, promote biodiversity, and provide recreational spaces, fostering ecological balance, improving urban aesthetics, and enhancing the well-being of urban communities. Service complexes designed to promote social interaction through mixed-use spaces and inclusive amenities foster social cohesion, encourage active lifestyles, strengthen community bonds, and promote equitable access to urban resources, enhancing community resilience.

Effective waste management practices including recycling programs, composting, and waste-to-energy technologies within service complexes contribute to sustainable resource management and environmental conservation. These practices minimize landfill waste, reduce environmental pollution, and support the circular economy by recycling valuable resources, thereby improving urban environmental quality and reducing ecological footprints. Integrating smart transportation systems such as electric vehicle charging infrastructure, bike sharing, and intelligent traffic management enhances sustainable mobility options, reduces reliance on private vehicles, improves urban accessibility, reduces greenhouse gas emissions, and alleviates traffic congestion, enhancing overall urban mobility efficiency and supporting active transportation modes.

In summary, sustainable urban design, practices within service complexes encompass environmental stewardship, social equity, and economic viability, representing a holistic approach to urban development. By integrating these practices, cities can create resilient and vibrant urban environments that enhance quality of life, promote sustainable development goals, and ensure a sustainable future for urban residents.[13]

2.4. The Role of BIM in Enhancing Sustainable Design Practices for Service Complexes

Building Information Modelling (BIM) has emerged as a transformative tool in the field of sustainable urban design, particularly in the modelling of service complexes. BIM facilitates the integration of various design aspects, enabling a comprehensive approach to sustainability that encompasses energy efficiency, resource management, and environmental impact. Through its advanced capabilities, BIM allows for the creation of detailed and accurate 3D models that incorporate real-time data and simulations. This technology supports the evaluation of different design scenarios, helping architects and planners optimize building performance before construction begins. For instance, BIM can simulate energy consumption patterns and daylight exposure, providing insights into how different design choices affects overall sustainability. Additionally, BIM's ability to integrate with other analysis tools, such as energy modelling software and environmental impact assessment tools enhances its role in ensuring that service complexes adhere to sustainable design principles. By leveraging BIM, professionals can identify potential inefficiencies, reduce material waste, and improve the management of resources throughout a building's lifecycle. This holistic approach not only contributes to achieving higher sustainability standards but also supports the development of more resilient and adaptable service complexes in the face of changing environmental conditions and regulatory requirements.

3. Methodology

The research methodology for the systematic review titled "Modelling Sustainable Design Practices for Service Complexes" employs a structured approach to explore and synthesize current practices in sustainable urban design within service complexes. Each component of the methodology is detailed below. [14]

3.1. Literature Search Strategy

The methodology initiates with a thorough literature search to identify pertinent studies on sustainable design practices in service complexes. Key academic databases such as Scopus, Web of Science, and Google Scholar were utilized, employing search terms like "sustainable design", "mixed-use developments", "service complexes", "urban sustainability", "renewable energy", "energy efficiency", "sustainable materials", "water efficiency", "green areas", "social interaction", "waste management", and "smart transportation". The search focused on articles published from 2010 to 2023 to highlight contemporary urban design practices.

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3.2. Inclusion and Exclusion Criteria

Inclusion criteria encompassed peer-reviewed journal articles and conference proceedings focusing on sustainable design practices within service complexes. Excluded were non-English articles, dissertations, books, and articles lacking accessible full texts, ensuring the review included only pertinent and high-quality sources.

3.3. Data Collection

3.3.1. Bibliometric Data Collection

Bibliometric data collection commences by retrieving relevant literature from major academic databases like Scopus, Web of Science, and Google Scholar. Keywords such as "sustainable urban design," "mixed-use developments," "renewable energy," "energy efficiency," "sustainable materials," "water efficiency," "green areas," "social interaction," and "waste management" are utilized to conduct comprehensive searches, capturing a broad spectrum of relevant studies. [15] The search focuses on the last decade to highlight recent advancements and trends in the field, emphasizing reliable sources from reputable journals and publishers known for contributions to sustainable urban design and related disciplines. Following compilation of the initial dataset, citation data undergoes analysis using bibliometric tools like Publish or Perish. This analysis yields insights into the impact and influence of individual studies or authors within the research domain, assessing metrics such as citation counts and h-index to gauge scholarly impact and productivity. Additionally, examination of annual publication rates identifies temporal trends in research output, potentially indicating emerging research areas or shifts in focus within sustainable urban design practices in service complexes. This methodological approach ensures a systematic and rigorous examination of scholarly literature, facilitating a comprehensive understanding of current practices, trends, and gaps in sustainable design within mixed-use service complexes.[16]

3.3.2. Content Analysis Data Collection

Qualitative data collection concentrated on content analysis to identify and analyze key themes and trends across the selected literature. Articles meeting inclusion criteria underwent detailed examination of their methodologies, key findings, and geographical contexts. This involved systematic categorization of themes related to renewable energy utilization, energy efficiency methodologies, sustainable materials, water conservation strategies, integration of green spaces, and social interaction facilitation through design, waste management practices, and integration of smart transportation systems.[17]

3.4. Data Analysis:

3.4.1. Bibliometric Analysis

Top Cited Authors: Bibliometric analysis will identify leading authors in sustainable urban design for service complexes through citation counts from relevant articles. This aims to highlight authors whose contributions have significantly affected the field. [18]

Table 1: The most cited researchers in previous studies

Cites	Authors	N
209	J Robinson, S Burch, S Talwar, M O'Shea…	1
145	K Lundgren, T Kjellstrom	2
84	A Gaviglio, M Bertocchi, E Demartini	3
60	K Parpairi	4
53	LW Mays	5
52	K Oda, CDD Rupprecht, K Tsuchiya, SR McGreevy	6
42	S Wilkinson, HT Remoy	7
39	V Shandas, Y Makido, S Ferwati	8
39	M Pezzagno, A Richiedei, M Tira	9

In sustainable urban design for service complexes, scholars like J Robinson, S Burch, S Talwar, and M O'Shea have collectively amassed 209 citations, indicating their significant impact. Similarly, K Lundgren and T Kjellstrom's work has garnered 145 citations, demonstrating their influence. A Gaviglio, M Bertocchi, and E Demartini have contributed substantially, with 84 citations. Others, including K Parpairi, LW Mays, and K Oda, have also provided valuable insights, as evidenced by their citation counts. Their research informs sustainable design practices and shapes future directions in urban development.

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3.4.2. Most Productive Authors

This table illustrates the number of studies authored by each group of researchers, reflecting their research output and contribution to the academic field.

Table 2: The Most Productive Authors

A. Count	Authors	Cites
6	J Ram, M Sutrisna	**37**
5	J Robinson, S Burch, S Talwar, M O'Shea…	**209**
5	A Raeva, S Usenyuk-Kravchuk, A Raev, I Surina…	**39**
5	KK Dixit, A Dharme, DP Singh, R Kalra…	**52**
5	MP Mohammadi, AS Ahmad, MHBH Ahmad, M Roshan	**22**
4	S García-Ceballos, P Rivero, S Molina-Puche…	**42**
4	A Marta, B Stefano, B Carlo, M Filippo	**33**

In the realm of sustainable urban design for service complexes, author productivity serves as a critical indicator of their impact. Several scholars have emerged as highly productive, contributing significantly to the literature with multiple research publications. For example, J Robinson, S Burch, S Talwar, and M O'Shea have collectively published 6 articles, highlighting their substantial engagement in the field. Similarly, A Raeva, S Usenyuk-Kravchuk, A Raev, and I Surina, alongside KK Dixit, A Dharme, DP Singh, and R Kalra, have each contributed 5 articles, demonstrating notable productivity. Additionally, MP Mohammadi, AS Ahmad, MHBH Ahmad, and M Roshan, along with S García-Ceballos, P Rivero, and S Molina-Puche, and A Marta, B Stefano, B Carlo, and M Filippo, have also published 5 articles each, indicating their active involvement in advancing sustainable urban design practices for service complexes. These authors' prolific contributions underscore their commitment to expanding knowledge and shaping future research directions in the field.

3.4.3. Top Cited Publishers

The table presents citations received by publishers, reflecting the extent of their research papers' academic references.[15]

Table 3: The Top Cited Publishers

Cites	Publisher	Source
209	Elsevier	… Forecasting and Social …
145	mdpi.com	Sustainability
53	iwaponline.com	Water Science and Technology
42	opus.lib.uts.edu.au	Pacific Rim Real Estate Conference
39	mdpi.com	European Journal of …

Identifying the most cited publishers in sustainable urban design sheds light on journals and publications pivotal in disseminating impactful research. One notable publication is "Forecasting and Social" by Elsevier, with 209 citations, focusing on future strategies and social planning in sustainable urban design. Similarly, mdpi.com's "Sustainability" has garnered 145 citations, emphasizing sustainable development and environmental solutions. Additionally, iwaponline.com publishes "Water Science and Technology," receiving 53 citations, addressing water technology and management challenges in urban contexts. Other significant publications include mdpi.com's "European Journal of ..." with 39 citations and "Pacific Rim Real Estate Conference" from opus.lib.uts.edu.au with 42 citations, both contributing to research in sustainable urban design. Analyzing these publishers provides insights for researchers and professionals to choose effective platforms for publishing and advancing sustainable goals in urban environments.[16]

3.4.4. Key referenced studies

The table presents the number of citations each article has garnered, alongside its publication year, reflecting the impact of these studies in academic and research literature.

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Table 4: The Key referenced studies

Cites	Title
209	Envisioning sustainability: Recent progress in the use of participatory back casting approaches for sustainability research
145	Sustainability challenges from climate change and air conditioning use in urban areas
84	A tool for the sustainability assessment of farms: Selection, adaptation and use of indicators for an Italian case study
60	Sustainability and Energy Use in Small Scale Greek Hotels: Energy Saving Strategies and Environmental Policies
53	Use of cisterns during antiquity in the Mediterranean region for water resources sustainability
52	Urban agriculture as a sustainability transition strategy for shrinking cities? Land use change trajectory as an obstacle in Kyoto city, Japan
42	Sustainability and within use office building adaptions: A comparison of Australian practices

In sustainable urban design for service complexes, identifying the most cited articles offers insights into influential works shaping the field. One standout article, "Envisioning sustainability: Recent progress in participatory back casting approaches," has garnered 209 citations, exploring participatory back casting for envisioning sustainable futures and influencing sustainability research methodologies. Another highly cited work, with 145 citations, addresses "Sustainability challenges from climate change and urban air conditioning use," highlighting critical issues and sustainable urban design strategies to mitigate environmental impacts. Additionally, "A tool for sustainability assessment of farms in Italy," with 84 citations, introduces a comprehensive assessment tool for farm sustainability, emphasizing its applicability in the Italian context. Moreover, "Sustainability and Energy Use in Small Scale Greek Hotels," with 60 citations, explores energy-saving strategies in Greek hotels, providing practical insights into sustainable energy practices in hospitality. Furthermore, "Use of cisterns during antiquity in the Mediterranean region," with 53 citations, examines historical water management practices relevant to contemporary sustainability efforts. Lastly, "Urban agriculture as a sustainability transition strategy in Kyoto city," with 52 citations, discusses urban agriculture's potential in sustainability transitions amidst urban challenges. These top cited articles contribute foundational knowledge for advancing sustainability goals in service complexes and urban environments globally.

3.4.5. Articles count per year

The bar chart titled "Articles per year" depicts annual publication trends from 2010 to 2023 in sustainable design practices for service complexes. The data illustrates fluctuations in publication counts over time, indicating changing research interest and activity in the field.[16]

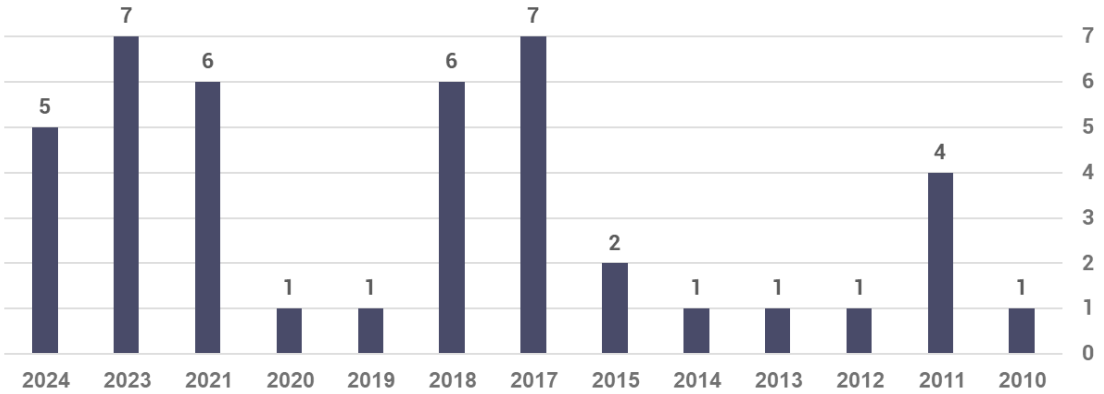

Figure 1. Article Count with Year between 2010 and 2014.

The publication rate was relatively low, averaging one to two articles annually, indicating the early stages of research exploration in sustainable urban design. Subsequently, a noticeable increase in publications occurred from 2015 onwards, with peaks in 2016, 2017, 2021, and 2022, when six to seven articles were published each year. These years signify heightened research activity and a growing emphasis on diverse aspects of sustainable practices within service complexes. Conversely, fewer publications were observed in certain years like 2018 and 2019, with

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only one article each, suggesting fluctuations or specific research focuses during those periods. Overall, the bar chart chronicles the evolving research output in sustainable design for service complexes, highlighting fluctuations in annual publication rates and underscoring the progressive evolution of research in this dynamic field.

3.4.6. Content Analysis

Comprehensive Reading and Concluding Sustainable Practices: A detailed examination of articles and research derived from quantitative analysis will be conducted to deduce sustainable practices in urban design for service complexes. The focus will be on effective strategies and technologies proven to enhance sustainability. Qualitative analysis aims to identify successful models and innovative approaches that contribute to sustainable urban development. By synthesizing literature findings, this study intends to highlight strategies such as energy-efficient building designs, renewable energy integration, sustainable materials use, water conservation methods, green space integration, waste management practices, and smart transportation systems. These practices are crucial for fostering environmentally responsible urban environments that improve livability, economic viability, and social inclusivity. Through this content analysis, the research aims to offer insights into current trends, gaps in knowledge, and future research directions in sustainable design practices within service complexes. The findings will advance understanding in urban sustainability and guide practical applications in architecture, urban planning, and environmental management.

Table 5: The most important main results of previous studies

Cites	Title	Practice's
145	Sustainability challenges from climate change and air conditioning use in urban areas	**Formation of Buildings - Energy Efficiency - Renewable Energies**
84	A tool for the sustainability assessment of farms: Selection, adaptation and use of indicators for an Italian case study	**Green Areas - Water Efficiency - Formation of Buildings**
60	Sustainability and Energy Use in Small Scale Greek Hotels: Energy Saving Strategies and Environmental Policies	**Energy Efficiency - Renewable Energies - Formation of Buildings**
53	Use of cisterns during antiquity in the Mediterranean region for water resources sustainability	**Water Efficiency - Renewable Energies**
52	Urban agriculture as a sustainability transition strategy for shrinking cities? Land use change trajectory as an obstacle in Kyoto city, Japan	**Green Areas - Water Efficiency - Waste Management**
42	Sustainability and within use office building adaptions: A comparison of dutch and Australian practices	**Mixed Use - Formation of Buildings - Energy Efficiency**
39	Rapid urban growth and land use patterns in Doha, Qatar: Opportunities for sustainability	**Mixed Use - Energy Efficiency - Green Areas - Formation of Buildings and Structures**
39	Spatial planning policy for sustainability: Analysis connecting land use and GHG emission in rural areas	**Energy Efficiency - Mixed Use - Green Areas - Formation of Buildings**
28	7D BIM for sustainability assessment in design processes: A case study of design of alternatives in severe climate and heavy use conditions	**Formation - Indoor Air Quality Improvement - Study of Elevations and Site Topography**
27	Industrial heritage: Reflections on the use compatibility of cultural sustainability and energy efficiency	**Energy Efficiency - Social Interaction - Renewable Energies - Energy Consumption Efficiency**
25	Giving meaning to the concept of sustainability in architectural design practices: Setting out the analytical framework of translation	**All of the Above**

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25	Giving meaning to the concept of sustainability in architectural design practices: Setting out the analytical framework of translation	**Waste Management - Energy Efficiency**
25	Ergonomics and sustainability in the design of everyday use products	**Waste Management - Energy Efficiency**
23	Attitude towards sustainability, study contents and the use of recycled concrete in building construction-case study Germany and Switzerland	**Sustainable Building Materials - Waste Management - Energy Efficiency**
22	in the energy transition: a mixed-method case study on residents' beliefs, attitudes, and motivation toward sustainable energy use in a zero-energy building …	**Renewable Energies - Formation of Buildings and Structures - Energy Efficiency**
22	Benchmarking sustainability practices use throughout industrial construction project delivery	**Waste Management - Energy Efficiency - Renewable Energies**
19	Deforestation and sustainable mixed-use landscapes: a view from the eastern Himalaya1	**Green Areas - Water Efficiency - Land Investment Factor**
9	Sustainable approach for developing local mixed-use streets Case study Beit Al Maqdis Street in Jeddah	**Mixed Use -- Green Areas - Formation of Buildings**
1	Sustainability by Design: Innovative Ways of Revolutionizing Production Practices for a Better Tomorrow	**Smart Transportation - Waste Management - Renewable**
0	Regeneration practices, slow mobility interventions and land use assessments for urban sustainability	**Green Areas - Water Efficiency - Sustainable Materials**
0	ARCHITECTURAL PRACTICES EMPHASIZING SUSTAINABILITY (GREEN DESIGN) AND THE EFFICIENT USE OF ENERGY	**All of the Above**
0	GUIDELINES AND PRACTICES FOR CUSTOMISATION OF SUSTAINABILITY INDICATORS FOR USE IN CONSTRUCTION PROJECTS–A REVIEW OF …	**All of the Above**
0	Giving meaning to the concept of sustainability in architectural design practices	**All of the Above**
0	A Taxonomy of Design Practices for Sustainability Towards Planetary Health	**All of the Above**
0	ARCHITECTURAL PRACTICES EMPHASIZING SUSTAINABILITY (GREEN DESIGN) AND THE EFFICIENT USE OF ENERGY	**All of the Above**
0	Sustainability Development through Passive Energy Efficiency Design Practices in Malaysia	**Formation of Buildings and Structures - Energy Efficiency**

The table presents notable studies in sustainable urban design practices for service complexes, emphasizing their impact through citation counts: Firstly, "Sustainability challenges from climate change and air conditioning use in urban areas" stands out with 145 citations, highlighting efforts to mitigate environmental impacts associated with urban air conditioning. Following closely, the study on "A tool for the sustainability assessment of farms" has garnered 84 citations, emphasizing sustainable practices in agricultural settings crucial for environmental and economic sustainability. Other studies address diverse aspects such as energy efficiency in small-scale Greek hotels, historical cistern use for water sustainability, and urban agriculture in shrinking cities like Kyoto, each contributing uniquely to sustainable urban development. Overall, the table reflects a broad range of research efforts aimed at integrating sustainable practices into urban design for service complexes, demonstrating significant interest and advancements across various dimensions of sustainability in urban environments.

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Table 6: The most important sub-findings of previous studies

	Definition	Detailed Practices	Nu
Mixed use	Mixed use refers to urban planning and development that integrates a combination of residential, commercial, cultural, institutional, or industrial uses within a single area or development project. This approach aims to create vibrant, diverse, and walkable communities where people can live, work, and interact without the need for extensive commuting.[19]	1. Zoning and Planning 2. Functional Diversity 3. Walkability and Connectivity 4. Density and Urban Form[20] 5. Economic Viability 6. Regulatory and Policy Support[21]	20 18 22 19 5 12
Formation of buildings	The formation of buildings refers to the process and principals involved in the physical arrangement, layout, and construction of structures within urban or rural settings. It encompasses architectural design, spatial organization, and the integration of functional and aesthetic considerations to create habitable and functional spaces.[22]	1. Compact and Efficient Design 2. Spatial Organization 3. Environmental Considerations 4. Regulatory Compliance 5. Adaptability and Flexibility[23] 6. Integration of Technology 7. User-Centric Design Maintenance and Longevity[5]	16 18 23 16 18 20 19
Renewable energy	Renewable energy refers to energy derived from naturally replenishing sources that are virtually inexhaustible, such as sunlight, wind, geothermal heat, and biomass. Unlike fossil fuels, which are finite and contribute to environmental degradation, renewable energy sources can be continuously replenished and are considered environmentally sustainable alternatives for meeting energy needs.[24]	1. Solar Energy 2. Wind Energy 3. Geothermal Energy 4. Innovative Technologies 5. Microgrid and Distributed Energy Systems 6. Energy Storage and Integration: 7. Net Zero Energy Buildings[25]	22 14 2 16 9 20 23
Energy efficiency	Energy efficiency refers to the practice of using less energy to perform the same task or produce the same outcome. This involves adopting technologies, processes, and behaviors that reduce energy consumption and enhance the overall energy performance of buildings, systems, and appliances.[26]	1. Building Design and Construction 2. Heating, Ventilation, and Air Conditioning (HVAC) 3. Lighting 4. Appliances and Equipment 5. Renewable Energy Integration[27] 6. Water Heating	18 16 15 11 15 4
Sustainable materials	Sustainable materials are those that have a minimal negative impact on the environment throughout their lifecycle, from extraction to disposal. These materials are often derived from renewable resources, have low embodied energy, are recyclable or biodegradable, and are produced through processes that minimize environmental harm and support social and economic equity.[28]	1. Recycled Materials 2. Natural and Renewable Materials 3. Low-Impact Materials 4. Locally Sourced Materials 5. Innovative Sustainable Materials[29] 6. Biodegradable and Compostable Materials 7. Green Concrete and Cement Alternatives	18 17 16 15 19 14 16

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Water efficiency	Water efficiency refers to the optimal use of water resources to reduce wastage and ensure sustainability. It involves employing techniques, technologies, and practices that minimize water consumption, enhance water recycling and reuse, and ensure the efficient management of water resources in residential, commercial, and industrial settings.[30]	1. Smart Irrigation Systems 2. Greywater Recycling 3. Rainwater Harvesting 4. Sustainable Landscaping 5. Water-Efficient Building Design 6. Education and Behavioral Changes 7. Industrial Water Efficiency 8. Municipal Water Management[31]	19 22 2 9 17 16 4 5
Green areas	Green areas refer to spaces within urban environments that are dedicated to vegetation and natural landscapes. These areas include parks, gardens, green roofs, urban forests, and other vegetated zones that provide environmental, social, and economic benefits to urban residents.[32]	1. Urban Parks and Gardens 2. Green Roofs and Walls 3. Street Trees and Urban Forests 4. Green Infrastructure 5. Recreational Green Spaces 6. Sustainable Landscaping 7. Water Features & Green Schoolyards 8. Health and Wellness Initiatives[33]	12 20 15 21 15 8 5 2
Social interaction	Social interaction in the context of sustainable urban design refers to the creation and enhancement of public spaces and community features that facilitate interpersonal engagement, foster a sense of community, and encourage active participation in public life. It emphasizes designing urban environments that promote social cohesion, inclusivity, and well-being.[34]	1. Community Centers and Hubs 2. Public Plazas and Squares 3. Pedestrian-Friendly Streetscapes 4. Parks and Recreational Spaces 5. Cultural and Art Spaces 6. Markets and Street Fairs 7. Cafes and Outdoor Seating 8. Community Gardens 9. Interactive Installations 10. Public Transport Integration 11. Community Events and Activities[35]	18 9 20 21 17 16 15 17 14 12 16
Waste management	Waste management in the context of sustainable urban design refers to the systematic control of the generation, collection, storage, transportation, treatment, and disposal of waste. It aims to reduce the environmental impact of waste, promote recycling and reuse, and enhance resource efficiency to contribute to a sustainable urban environment.[20]	1. Waste Reduction Programs 2. Recycling Initiatives 3. Waste Separation Systems 4. Landfill Management 5. Innovative Technologies 6. Zero Waste Strategies 7. Community Engagement 8. Collaboration and Partnerships[36]	20 18 9 5 14 19 4 7
Smart cars and bikes	Smart cars and bikes refer to advanced transportation solutions that incorporate technology and connectivity to enhance efficiency, safety, and sustainability. These vehicles leverage sensors, GPS, IoT (Internet of Things), and advanced software to optimize urban mobility, reduce emissions, and improve the overall transportation experience.[24]	1. Electric Vehicles (EVs) and Bikes: 2. Shared Mobility Services: 3. Integrated Transport Systems: 4. Autonomous Vehicles: 5. Sustainable Infrastructure: 6. Data-Driven Planning: 7. Sustainability Incentives: 8. Community Engagement: 9. Integration with Public Transport:[36]	22 23 14 19 5 8 9 13 11

The systematic review of sustainable design practices within service complexes synthesizes findings from 26 scholarly articles to emphasize the importance of ten primary sustainability practices across urban development contexts.

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4. Discussion

4.1. Discrepancies from previous studies indicate that:

Integrating findings from the reviewed literature highlights the critical role of mixed-use environments in urban planning. Defined by their integration of residential, commercial, and institutional elements, mixed-use environments promote vibrant, walkable communities that reduce commuting needs and enhance social interaction. Key practices such as zoning and planning, functional diversity, and walkability with connectivity emerged prominently, contributing to spatial efficiency and community cohesion.[37]

Compact and efficient building design, along with thoughtful spatial organization and user-centric approaches, supports sustainable architecture and spatial utilization. These practices optimize resource use while improving the aesthetic and functional qualities of urban spaces. Additionally, integrating renewable energy sources such as solar and wind energy, microgrids, and efficient HVAC systems represents crucial steps toward achieving net-zero energy goals and reducing environmental footprints.[38]

The use of sustainable materials is pivotal in mitigating environmental impacts, with recycled, renewable, and locally sourced materials promoting resource efficiency and reducing embodied energy in construction. Water efficiency strategies, including smart irrigation and rainwater harvesting, alongside green areas such as urban parks and green infrastructure, contribute significantly to water conservation and urban biodiversity.[39]

Social interaction, facilitated by community spaces and cultural hubs, underscores the importance of public engagement and inclusive urban design. Effective waste management practices, supported by recycling initiatives and zero waste strategies, complement efforts to reduce landfill dependency and promote circular economy principles.[40]

4.2. Limitations by focusing on several key points, including:

The findings contextualize sustainable design practices within the broader framework of urban sustainability and resilience. Integrating these practices enables cities to address environmental challenges while enhancing livability and social equity. The systematic integration of renewable energy, efficient resource management, and community-focused urban planning sets a precedent for future developments aimed at sustainable and inclusive growth.[40]

In conclusion, modelling sustainable design practices for service complexes provides a robust framework for urban planners, policymakers, and developers to create resilient urban environments. Continued research and implementation of these practices are crucial for meeting global sustainability targets and ensuring cities remain adaptable to future challenges**.**[41]

4.3. Importance of BIM Technologies in Modelling Sustainable Design Practices

Building Information Modelling (BIM) technologies play a pivotal role in advancing sustainable urban design practices across various domains. BIM integrates digital representations of physical and functional characteristics of buildings and infrastructures, offering a collaborative platform for architects, engineers, and urban planners to optimize design, construction, and operation processes. BIM enhances efficiency, reduces costs, and fosters sustainability through comprehensive lifecycle management and analysis of built environments.[42]

In the context of mixed-use development, BIM facilitates effective zoning and planning by providing accurate spatial data and simulations that optimize land use efficiency and integration of functions. Visualizing different scenarios helps identify configurations promoting walkability, connectivity, and economic viability within urban areas.[23]

For building design, BIM supports compact and efficient practices by enabling precise spatial organization and layout planning. Parametric modeling helps architects design structures maximizing space utilization and minimizing environmental footprint. Environmental considerations, like daylighting analysis and energy simulations, ensure compliance with standards and adaptability to environmental conditions.[11]

Renewable energy integration benefits from BIM's capability to analyze solar exposure, wind patterns, and geothermal potential, facilitating integration of systems like photovoltaic panels and wind turbines. Microgrid and energy systems can be efficiently planned and simulated, enhancing energy resilience.[43]

Energy efficiency practices benefit from BIM's ability to simulate building performance across HVAC systems, lighting configurations, and appliances, optimizing energy consumption and operational efficiency.[44]

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Sustainable material selection is enhanced through BIM's assessment of life cycles, embodied energy, and environmental impacts. It specifies recycled content, locally sourced materials, and low-impact alternatives, ensuring sustainability standards are met.[45]

Water efficiency measures, including smart irrigation and rainwater harvesting, are supported by BIM's modelling of water flow dynamics and usage scenarios, promoting sustainable water management.[46]

BIM enables comprehensive design and visualization of green areas and social spaces like urban parks and community areas, facilitating inclusive public spaces that promote social cohesion and well-being.

Waste management benefits from BIM's modelling of waste processes, optimizing recycling initiatives and supporting circular economy principles in urban settings.[25]

Smart transportation, such as electric vehicles and shared mobility, benefits from BIM's integration capabilities, optimizing infrastructure for sustainable mobility and improving transportation efficiency.[47]

In conclusion, BIM technologies are crucial for modelling and implementing sustainable practices in mixed-use developments. They provide analytical tools, collaborative platforms, and lifecycle management capabilities, enhancing efficiency, resilience, and sustainability in urban environments. Continued BIM advancements are essential for addressing global challenges and shaping a sustainable urban future.[48]

5. Conclusion

A comprehensive review of sustainable design practices in urban environments, particularly focusing on service complexes, highlights several key findings. Mixed-use developments are pivotal in creating vibrant, walkable communities that reduce commuting. Efficient building design, emphasizing compactness and environmental considerations, optimizes spatial organization and functional efficiency. Renewable energy sources like solar, wind, and geothermal energy provide sustainable alternatives to fossil fuels, [49] supported by innovative technologies and Microgrid systems. Energy efficiency measures, covering building design, HVAC systems, lighting, and renewable energy integration, are crucial for reducing energy consumption and enhancing sustainability. The use of sustainable materials, such as recycled and locally sourced materials, promotes environmental stewardship throughout construction projects' lifecycle.[50] Water efficiency strategies, including smart irrigation and rainwater harvesting, contribute to sustainable water management crucial for urban resilience. Green areas and social spaces, like parks, community centers, and pedestrian-friendly streetscapes, foster social cohesion and improve quality of life. Effective waste management practices, including waste reduction and recycling, minimize environmental impact and engage communities. Smart transportation solutions, including electric vehicles and integrated transport systems, reduce carbon emissions and enhance urban mobility. [51] These findings underscore the multifaceted approach needed for sustainable urban design, integrating environmental, social, and economic dimensions to foster resilient and inclusive communities.

- **Summary of Key Findings**

The synthesis of 26 scholarly articles on sustainable urban design emphasizes mixed-use service communities as crucial for achieving comprehensive sustainability goals in urban settings. Key findings highlight ten essential practices across planning, infrastructure, and community engagement domains. These practices include zoning and planning strategies that enhance spatial efficiency and regulatory compliance, fostering adaptability in urban development. Walkability and connectivity initiatives promote pedestrian-friendly environments integrated with efficient public transport, encouraging community interaction and reducing private vehicle reliance.[52] Compact and efficient design principles, alongside renewable energy integration and sustainable materials, significantly reduce environmental footprints and enhance energy resilience in urban areas. Water efficiency measures like smart irrigation and rainwater harvesting support sustainable water management. Additionally,[53] green spaces and community areas such as parks and cultural hubs enhance urban landscapes, fostering social cohesion and well-being. Effective waste management practices, integrated transport systems, and data-driven planning further improve urban sustainability by reducing waste and optimizing transportation efficiency.[49]

- **Concluding Remarks**

The study emphasizes holistic approaches to sustainable urban design in service complexes by integrating mixed-use development, efficient building formation, renewable energy adoption, energy efficiency, sustainable materials, water management, green spaces, social interaction, waste management, and smart transportation. These integrated strategies aim to mitigate environmental impact while improving residents' quality of life. Building Information Modeling (BIM) technologies are highlighted as essential tools, [54] facilitating data-driven decision-making and collaborative processes throughout urban development projects. BIM enables precise modeling,

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simulation, and analysis of complex urban systems to optimize sustainable design practices. Future research and innovation in BIM are critical for advancing sustainable urban development, enhancing operational efficiency, environmental performance, resilience, and adaptability in response to urban challenges and global pressures. By leveraging BIM, urban planners, architects, [43] and stakeholders can contribute to creating sustainable, livable, and equitable cities for future generations.

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