Shrinking City Planning and Urban Regeneration: A Survey

Abstract

Shrinking city planning is an essential response to the multifaceted challenges of urban decline, characterized by demographic shifts, economic downturns, and structural inequalities. This survey explores the strategic frameworks and methodologies aimed at fostering sustainable urban regeneration, emphasizing the integration of cultural heritage and community engagement. Key findings highlight the importance of adaptive reuse of infrastructure, sustainable urban development, and innovative technologies in addressing urban shrinkage. The paper underscores the significance of systemic and multi-criteria evaluation frameworks, GIS applications, and green infrastructure in enhancing urban resilience and sustainability. Case studies illustrate the effectiveness of community-driven regeneration strategies and the role of technological advancements in urban planning. Challenges such as economic constraints, social resistance, and data limitations are acknowledged, emphasizing the need for inclusive and context-sensitive approaches. The survey advocates for a holistic approach that leverages diverse strategies and technologies to transform urban challenges into opportunities for sustainable growth and revitalization. By addressing the complex dynamics of urban decline, cities can develop adaptive and resilient environments that support sustainable development and community empowerment.

1 Introduction

1.1 Significance of Shrinking City Planning

Shrinking city planning addresses the challenges of urban decline, driven by demographic shifts, economic downturns, and structural inequalities [1]. This approach is crucial for cities facing significant population and economic losses, particularly in the aftermath of the 2008 housing market collapse, which led to widespread neighborhood decline and housing abandonment [2]. Integrating innovative urban design with economic evaluation is essential for sustainable urban regeneration [3].

A critical component of this planning is the incorporation of cultural heritage into regeneration processes, which preserves local identity and stimulates economic development through tourism and cultural activities [4]. The transformation of Poblenou from an industrial area to a real estate hub exemplifies the need for careful planning that balances development with the preservation of historical and socio-economic structures [5]. Additionally, the role of migrants in urban regeneration enhances understanding of urban transformations and promotes inclusive development [6].

Sustainable urban development in shrinking cities necessitates addressing rapid urban land expansion and its environmental impacts, requiring adaptable strategies for various socioeconomic scenarios [7]. This is further complicated by the need to reconcile environmental sustainability, economic development, and social equity, which often present conflicting priorities in urban planning [8]. Empowering disadvantaged communities is crucial, as it influences mental health outcomes and strengthens community resilience [9].

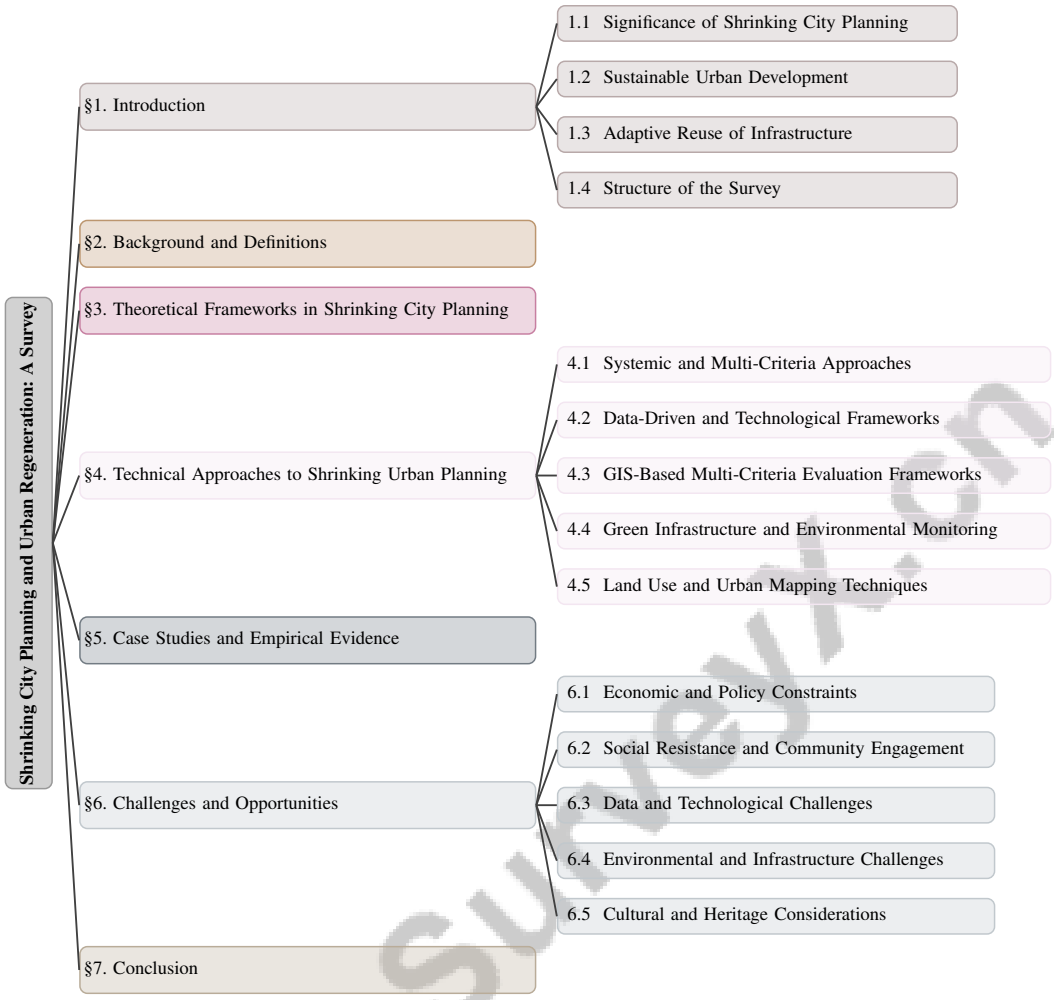


Figure 1: chapter structure

The significance of shrinking city planning is also evident in its role in addressing vacant land challenges, which can either threaten or provide opportunities for economic development [10]. Community engagement is vital in urban regeneration, especially in financially distressed cities where vacant land presents significant challenges [11]. Evaluating large-scale demolition programs for their effectiveness in reducing vacancy highlights the need for strategic interventions [12].

Ultimately, shrinking city planning is pivotal in crafting adaptive and resilient urban environments that respond to urban decline challenges while fostering regeneration and sustainable development. Diverse stakeholder involvement, including private actors and civil society, is essential for implementing effective urban regeneration policies and achieving long-term sustainability [13]. Understanding various 'rightsizing' strategies, particularly in the context of French shrinking cities, addresses the lack of awareness and action on urban shrinkage at the national level [14].

1.2 Sustainable Urban Development

Sustainable urban development is integral to shrinking city planning, addressing the multifaceted challenges of urban decline through ecological, economic, and social dimensions [15]. Urban shrinkage should be viewed not merely as an economic issue but as a dynamic process that can lead to innovative and sustainable urban solutions [16]. Implementing robust monitoring systems is necessary to ensure high-quality urban environments, particularly given the limitations of existing urban footprint data [17].

AI-generated, for reference only.

Central to sustainable development in shrinking cities is the integration of green infrastructure, which enhances urban resilience and sustains critical system functionality within complex social-ecological and technical systems [18]. Repurposing vacant land through green infrastructure improves stormwater runoff quality and reduces pollution, aligning environmental sustainability with urban regeneration efforts [19]. Additionally, incorporating environmental sustainability into heritage-led urban regeneration is crucial for promoting sustainable lifestyles and bridging the gap between sustainability rhetoric and practice.

The application of AI technologies in urban planning significantly advances Sustainable Development Goal 11 (SDG 11), which focuses on creating sustainable cities and communities [20]. These innovations, supported by datasets for monitoring SDG indicators via satellite imagery, facilitate urban challenge management and promote a comprehensive framework for sustainable development. Efficient public transport systems are also essential for meeting growing mobility demands, contributing to sustainable urban infrastructure [21].

Adapting urban environments to declining populations through 'rightsizing' strategies is crucial for sustainable urban development, particularly regarding housing stock and urban planning [14]. This approach emphasizes the importance of balancing economic growth with cultural heritage, recognizing artists as vital stakeholders in urban planning [22]. Cultural landscape-based strategies for urban regeneration offer promising pathways for achieving sustainable urban development by aligning economic viability with social and environmental goals [23].

Integrating mixed land uses within neighborhoods can enhance economic viability and foster community interaction, thereby mitigating urban decline [2]. Contextualizing shrinking cities within broader critiques of globalization provides a framework for analyzing urban revitalization policies that address social justice and equity [1]. Justice and inclusion are emphasized in planning processes, guiding smart decline initiatives [24]. Moreover, understanding urban vacancy is crucial for sustainable urban development, presenting both challenges and opportunities for economic progress [10, 25].

Incorporating crowd logistics (CL) into urban freight transport by utilizing excess capacity of passenger vehicles offers a novel approach to enhancing sustainability [26]. The role of digital civics, citizen engagement, and participatory design in community empowerment further enhances urban development sustainability [27]. The application of Artificial Intelligence Generated Content (AIGC) technology in urban planning and design, focusing on its impact on placemaking and public participation, represents another frontier in sustainable urban development [28].

Sustainable urban development within shrinking city planning requires a multidimensional approach that integrates ecological, economic, and social considerations. By leveraging innovative technologies and fostering inclusive strategies, cities can transform urban shrinkage challenges into opportunities for sustainable growth and regeneration. The CyPhA system, which combines vegetable and fish farming in a single water loop, exemplifies sustainable urban development and food production [29]. Furthermore, the inadequacies of Neighborhood Sustainability Assessment Tools (NSA tools) in promoting urban regeneration highlight the need for meaningful interventions in existing communities for sustainable redevelopment [30]. A new approach that enhances adaptability through advanced technologies is critical in the context of urban growth and infrastructure [31].

1.3 Adaptive Reuse of Infrastructure

Adaptive reuse of infrastructure is a pivotal strategy in urban regeneration, particularly within shrinking cities. This approach mitigates environmental impacts associated with new construction while preserving cultural heritage and enhancing urban resilience. Integrating existing structures into new urban forms catalyzes sustainable development, fostering economic growth and social cohesion [15]. Evaluating the conservation of cultural urban landscapes through adaptive reuse projects requires a comprehensive framework that incorporates multidimensional indicators to assess impacts, ensuring alignment with broader sustainability goals.

A significant challenge in adaptive reuse is the lack of effective communication and relational networks among stakeholders, which can impede the successful translation of sustainability discourse into practice [32]. Robust stakeholder engagement and collaboration are necessary to facilitate the seamless integration of adaptive reuse into urban planning processes. By fostering strong communication channels, cities can align the interests of diverse actors, ensuring that regeneration projects are both sustainable and inclusive.

Innovative methodologies, such as slope degree analysis, offer new avenues for informing urban regeneration strategies that enhance accessibility and sustainability in shrinking cities [33]. This method enables planners to identify opportunities for adaptive reuse that maximize existing infrastructure potential. By leveraging such analytical tools, cities can strategically repurpose underutilized spaces, revitalizing neighborhoods and contributing to a more sustainable urban environment.

1.4 Structure of the Survey

This survey provides a comprehensive understanding of shrinking city planning and urban regeneration, highlighting critical aspects of sustainable urban development and adaptive reuse of infrastructure. The paper is organized into seven main sections, each addressing specific components of the overarching theme.

The introduction discusses the significance of shrinking city planning in the context of urban decline and regeneration, emphasizing sustainable development and infrastructure reuse. The background and definitions section clarifies key concepts, exploring the interconnections between urban decline, regeneration, and resilience.

The third section delves into theoretical frameworks, tracing the evolution of perspectives on shrinking city planning and examining socio-economic and environmental theories. This theoretical grounding is essential for understanding the practical methodologies discussed in the subsequent section on technical approaches, which explores systemic and multi-criteria evaluation frameworks, data-driven methodologies, GIS applications, green infrastructure, and land use techniques.

Case studies and empirical evidence provide real-world examples of cities implementing shrinking city planning strategies, offering insights into their outcomes and effectiveness. This empirical foundation is followed by a comprehensive analysis of the multifaceted challenges and opportunities in urban regeneration, emphasizing the economic, social, environmental, and cultural dimensions influencing the revitalization of historical urban contexts, such as the role of cultural events in enhancing social cohesion and economic development in areas like the Arg neighborhood. This analysis considers the implications of urban decline in shrinking cities, where disparities in socio-economic conditions and physical infrastructure shape regeneration policies and strategies [1, 10, 34].

The conclusion synthesizes the essential findings of the study, emphasizing their implications for future research and practice. It highlights the critical need for adaptive and resilient urban environments to effectively tackle the multifaceted challenges posed by urban decline, particularly in light of rapid urbanization that exacerbates vulnerability to both natural and man-made hazards. The discussion underscores the interconnectedness of urban resilience and sustainability, suggesting that a comprehensive understanding of these concepts is vital for developing effective urban planning strategies that enhance societal well-being and environmental health in increasingly complex urban ecosystems [35, 36, 37]. The survey's structure ensures a holistic exploration of shrinking city planning, integrating theoretical insights with practical applications to foster sustainable urban development.The following sections are organized as shown in Figure 1.

2 Background and Definitions

2.1 Interconnections between Urban Decline and Regeneration

Urban decline and regeneration are interlinked processes that reflect how urban systems adapt to evolving socio-economic and environmental conditions. Decline, marked by population outmigration, economic stagnation, and inadequate adaptation, impedes revitalization efforts [12]. Regeneration strategies must address both symptoms and causes of decline, with innovative approaches needed for repurposing vacant urban land [11]. The disconnect between sustainability policies and their execution complicates regeneration, influenced by demographic changes and economic dependencies [14]. Incorporating cultural and social events is crucial for revitalizing historical neighborhoods, yet poses challenges [38]. The historical neglect of tourism in urban studies necessitates a nuanced understanding of its role in regeneration [4].

Displacement, dispossession, and regeneration significantly impact migrants navigating these complex dynamics [6]. Conflicts between multinational corporations and local artists further complicate regeneration, as they vie for space and identity in changing urban landscapes [22]. In areas like

el Raval, resistance dynamics within regeneration processes are evident, as extensive efforts have not led to anticipated gentrification [39]. Public participation is vital in regeneration, particularly in cities with disinvestment histories and population loss. Engaging local communities aids in policy development prioritizing well-being and addressing shrinkage stigma [27]. Understanding migration intentions, particularly those influenced by air pollution, informs equitable regeneration strategies [40].

2.2 Urban Resilience and Its Dimensions

Urban resilience refers to the capacity of urban systems to absorb, recover, and adapt to various shocks and stresses while maintaining essential functions and structures. This concept is crucial in shrinking cities, where social, economic, and institutional dimensions shape adaptive capacity [41]. The relationship between urban resilience and sustainability is significant, sharing dimensions and indicators relevant to addressing urban decline and fostering regeneration [36].

The social dimension of urban resilience emphasizes community involvement and cohesion in enhancing adaptive capacity. Community resilience supports population recovery and adaptation in disaster-affected areas, contributing to urban stability and functionality [42]. However, challenges in discerning genuine community needs from professional ambitions, managing biases, and ensuring lasting benefits post-engagement can hinder effective community resilience realization [27].

Economically, urban resilience involves cities' ability to withstand and recover from downturns, ensuring continuity of economic activities and livelihoods. This is crucial for shrinking cities facing economic challenges due to population decline and industrial restructuring. Institutional resilience pertains to governance structures' capacity to adapt to changing conditions, enabling effective strategies for urban regeneration and sustainability [41].

A comprehensive framework integrating urban sustainability, resilience, and transformation supports urban policy and implementation processes. Such a framework clarifies these interconnected concepts, providing a foundation for developing strategies that enhance urban systems' resilience to shrinkage challenges [37]. Addressing these dimensions holistically allows cities to better navigate urban decline and regeneration complexities, ensuring resilient and adaptive urban environments.

3 Theoretical Frameworks in Shrinking City Planning

3.1 Evolution of Theoretical Perspectives

The evolution of theoretical perspectives in shrinking city planning underscores the intertwined nature of demographic shifts, geopolitical dynamics, and economic restructuring that define urban decline and regeneration [1]. Initial frameworks focused on population metrics, but have since evolved to include trajectory typologies that consider economic and demographic shifts, providing a more nuanced understanding of urban dynamics [16]. This evolution emphasizes the importance of system dynamics to explore nonlinear interdependencies among economic, demographic, migratory, and built environment processes [43].

Contemporary frameworks highlight urban resilience through four approaches: equilibrium, systems perspectives, path dependence, and long view [41]. These frameworks stress the need for adaptive, absorptive, and transformative capacities within urban systems to maintain essential functions amid decline [36]. The integration of post-capitalism and social-innovation theories supports community-driven regeneration, aligning with Healey's governance levels concept, which distinguishes between episodes, processes, and cultural assumptions in governance change [13].

A critical perspective challenges traditional narratives by suggesting that urban shrinkage can coexist with economic prosperity, reframing the discourse to focus on opportunities rather than solely challenges [44]. Examining urban power dynamics reveals the interplay between time, space, and sensory experiences, emphasizing the importance of genuine community participation in inclusive regeneration strategies [39, 11]. The introduction of a framework categorizing crowd logistics based on characteristics, stakeholders, and sustainability implications signifies the growing importance of sustainable practices in urban planning [26].

In developing countries, context-specific frameworks have emerged due to differing urban sustainability priorities compared to developed nations [45]. This shift has led to tailored perspectives

addressing unique regional challenges and opportunities. A multiscalar perspective critiques methodological nationalism, highlighting the interconnectedness of local, national, and global processes affecting urban life [6]. This perspective is crucial for understanding the broader implications of urban shrinkage and regeneration.

The survey categorizes urban transformations into materialization, dismantling, and regeneration phases, reflecting capitalist influences on urban land use [5]. This categorization provides insights into the socio-economic forces driving urban change. The historical evolution of theories related to shrinking city planning indicates a shift towards holistic approaches. By integrating various frameworks, urban planners can address the complex issues associated with urban decline, enhancing resilience and sustainability—key concepts for societal health amid environmental changes. Such capacities are essential for fostering resilient urban environments capable of withstanding both natural and man-made hazards, ultimately improving residents' quality of life [35, 46, 16, 36].

3.2 Socio-Economic and Environmental Theories

The socio-economic and environmental dimensions of urban regeneration are pivotal in addressing the complexities of shrinking city planning. These dimensions are intertwined with heritage preservation, sustainable development, and urban resilience, forming a comprehensive framework for tackling urban decline. Integrating social, economic, and environmental aspects is crucial for achieving urban sustainability, as it recognizes the interconnectedness of these factors [30]. This holistic approach is vital for developing strategies that mitigate urban shrinkage impacts while promoting long-term sustainability and resilience.

Socio-economic theories emphasize the integration of qualitative and quantitative approaches to address urban decline comprehensively. This integration is necessary for understanding urban recovery dynamics and developing robust planning frameworks. The critique of neoliberal urbanism highlights its implications for social equity, suggesting that regeneration efforts must prioritize inclusivity and address socio-economic disparities [5]. Focusing on distributive and procedural justice in planning processes ensures that regeneration efforts are equitable and inclusive, fostering diverse communities and promoting social cohesion.

Environmental theories underscore the role of innovative methodologies and technologies in enhancing urban resilience. Advanced analytical tools, such as GIS and satellite imagery, facilitate monitoring of sustainable development goals (SDGs) and inform urban planning decisions. These tools empower planners to evaluate the environmental impacts of regeneration projects, ensuring initiatives address the needs of underserved communities while contributing to broader sustainability goals through participatory governance, social learning, and context-specific strategies [47, 46, 32, 30]. Incorporating green infrastructure and environmental monitoring into planning frameworks enhances urban systems' resilience, enabling cities to adapt to changing environmental conditions and mitigate climate change impacts.

4 Technical Approaches to Shrinking Urban Planning

Category	Feature	Method
Systemic and Multi-Criteria Approaches	Data and Systems Integration	UHD[48]
Data-Driven and Technological Frameworks	Intelligent Urban Management	ECF[31]
	Decision-Making and Evaluation	CAGAN[49]
	Spatial and Environmental Analysis	PRRS[50], SDM[33]
	Data Integration and Sensing	SSFBFM[51], CyPhA[29]
GIS-Based Multi-Criteria Evaluation Frameworks	Spatial and Temporal Dynamics	MSCNN[17], ComS2T[52]
	Stakeholder Engagement	SCSM[32]
	Data Integration Techniques	DBN-MMTM[53]
Green Infrastructure and Environmental Monitoring	Urban Green Transformation	GISP[54], VLRG[19]
	Efficient Data Collection	SAQMS[55]
	Environmental Quality Enhancement	PSANM[56]

Table 1: This table provides a comprehensive overview of various technical approaches utilized in urban planning for shrinking cities. It categorizes methodologies into systemic and multi-criteria approaches, data-driven and technological frameworks, GIS-based multi-criteria evaluation frameworks, and green infrastructure and environmental monitoring. Each category is associated with specific features and methods, highlighting the diverse strategies employed to address urban regeneration challenges.

Technical approaches are pivotal in addressing the complexities of shrinking cities, facilitating urban regeneration through systemic and multi-criteria frameworks. Table 1 presents a detailed classification of technical approaches that are instrumental in addressing the complexities of urban planning for shrinking cities, highlighting the integration of systemic frameworks, technological innovations, and green infrastructure strategies. Additionally, Table 6 provides a detailed classification of technical approaches essential for addressing the complexities of urban planning in shrinking cities, emphasizing the integration of systemic frameworks, technological innovations, and GIS-based evaluation strategies. These frameworks integrate diverse evaluation methods, offering a comprehensive perspective on urban sustainability. The following subsections detail specific methodologies within these frameworks, demonstrating their practical applications for urban regeneration.

4.1 Systemic and Multi-Criteria Approaches

Method Name	Integration Techniques	Sustainability Prioritization	Community Engagement
SSFBFM[51]	Optical Images	Sustainable Development	Volunteered Geographic Information
SCSM[32]	Social Network Analysis	Multi-criteria Decision	Stakeholders' Sustainability Visions
UHD[48]	Systems Thinking	Sustainable Lifestyles	Community Participation
ECF[31]	Multi-modal Sensor Data	-	-

Table 2: Overview of systemic and multi-criteria frameworks employed in urban planning for shrinking cities, highlighting various integration techniques, sustainability prioritization methods, and community engagement strategies. The table presents a comparative analysis of four distinct methodologies, illustrating their unique contributions to sustainable urban development.

Systemic and multi-criteria frameworks are essential in urban planning for shrinking cities, integrating economic, social, and environmental factors. Table 2 provides a comprehensive comparison of systemic and multi-criteria approaches in urban planning, emphasizing their roles in integrating sustainability and community engagement within shrinking cities. Advanced methodologies, such as the combination of optical imagery, building height, and nighttime-light data, exemplify systemic approaches in urban planning, facilitating large-scale identification of building functions through semi-supervised segmentation models [51]. The Iraqi Urban Sustainability Assessment Framework (IUSAF) utilizes the Analytic Hierarchy Process (AHP) to prioritize sustainability indicators, highlighting the necessity of mixed methods like stakeholder and multicriteria analysis to navigate urban complexities [45, 3]. Strategies like the Sustainability Communicator Score Methodology employ social network analysis and fuzzy logic to assess actor influence within regeneration networks, improving urban planning efficacy [32]. The Urban Heritage Dynamics Framework applies systems thinking to explore relationships within urban heritage, underscoring the need for holistic regeneration approaches [48].

Community-driven strategies, exemplified by 'projects of becoming', focus on cultivating new community economies, reflecting a shift from growth-centric models to those enhancing quality of life [57]. This aligns with the integration of advanced sensing technologies and decentralized operations to bolster urban adaptability, as demonstrated in the evolutionary city framework [31]. Frameworks categorizing green infrastructure by ecological, social, and economic functions reveal systemic approaches' potential to boost urban resilience [58]. The 'planner's triangle' model interlinks economic, environmental, and social goals, providing a valuable framework for evaluating urban regeneration strategies in line with sustainability objectives [46]. Ethical considerations in urban planning, as delineated through engagement stages—project initiation, expectation management, and sustainable exit—emphasize the necessity of ethical practices for inclusive governance [27].

4.2 Data-Driven and Technological Frameworks

Data-driven and technological frameworks are increasingly essential in urban planning, particularly for shrinking cities. Table 3 provides a comprehensive overview of the diverse data-driven and technological frameworks employed in urban planning, illustrating the integration of advanced technologies and data modalities to support sustainable urban environments. These frameworks leverage technologies such as Geographic Information Systems (GIS), artificial intelligence (AI), and machine learning to enhance decision-making and optimize urban environments. The synergy of GIS with multi-criteria evaluation frameworks demonstrates spatial data's ability to balance ecosystem services with stakeholder priorities, identifying optimal sites for green infrastructure [54]. Spatial

Method Name	Technological Integration	Data Modalities	Urban Sustainability
GISP[54]	Gis-based Framework	Spatial Data	Urban Resilience
SDM[33]	Gis Data	Geographic Data	Urban Regeneration
MSCNN[17]	Convolutional Neural Network	Sentinel-2 Images	Sustainable Urban Development
SSFBFM[51]	Deep Learning-based	Multi-modality Data	Sustainable Urban Environments
PRRS[50]	Kernel Density Contours	Public Apis	Cycling Infrastructure
SAQMS[55]	Cloud Storage	Video Data	Urban Planning Efforts
CAGAN[49]	Causal Inference	Satellite Imagery	Sustainable Urban Development
DBN-MMTM[53]	Cutoff Mechanism	Sar And Optical	Urban Mapping Performance
CyPhA[29]	Real-time Monitoring	Sensor Data	Sustainable Aquaponics System
ECF[31]	Ai-driven Simulations	Multi-modal Sensor	Urban Adaptability Perception

Table 3: Overview of data-driven and technological frameworks utilized in urban planning, highlighting the integration of various technologies and data modalities to enhance urban sustainability. The table lists methods incorporating GIS, AI, and machine learning, demonstrating their applications in urban resilience, regeneration, and sustainable development.

analysis techniques, including slope analysis, further refine urban design and land use, underscoring GIS's critical role in sustainable planning [33].

AI and machine learning significantly advance urban planning. The Multi-Scale Convolutional Neural Network (MSCNN) classifies local climate zones using high-quality training samples tailored for urban contexts, exemplifying AI's contribution to urban climate assessments [17]. The Semi-supervised Framework for Building Function Mapping (SSFBFM) utilizes multi-modality remote sensing data to identify building functions across extensive urban areas, showcasing AI's integration with remote sensing technologies [51]. Data-driven approaches also enhance urban mobility and safety. The Personalized Route Recommendation System (PRRS) uses continuous spatial risk estimations to provide tailored route suggestions, fostering safer cycling environments [50]. The Scalable Air Quality Monitoring System (SAQMS) integrates air quality sensors and video monitoring to analyze traffic density's impact on air pollution, exemplifying data-driven urban environmental management [55].

Utilizing diverse data sources, including satellite imagery, enriches urban studies by offering insights into dynamics. A dataset combining satellite imagery with Sustainable Development Goals (SDG) indicators enables long-term monitoring of urban sustainability [59]. The Causally-Aware Generative Adversarial Network (CAGAN) employs causal inference to create detailed light pollution maps, enhancing understanding of urban factors and their environmental impacts [49]. Innovative methodologies like the Dual-Branch Network with Multi-Modal Transfer Modules (DBN-MMTM) enhance learning from both SAR and optical data in urban mapping, demonstrating the integration of various data modalities [53]. The Cyber Physical Aquaponics (CyPhA) system exemplifies real-time monitoring of urban systems through sensor and actuator integration, showcasing a cyber-physical approach to sustainability [29].

The evolutionary city framework illustrates symbiotic intelligence mechanisms that enhance urban management through adaptability perception, parallel simulation, and autonomous decision-making [31]. These methodologies empower urban planners to devise informed and adaptive strategies, promoting resilience and sustainability in the face of urban shrinkage.

4.3 GIS-Based Multi-Criteria Evaluation Frameworks

Benchmark	Size	Domain	Task Format	Metric
LTM[10]	250,000	Urban Planning	Vacancy Prediction	Kappa, PCM

Table 4: This table provides a detailed overview of a representative benchmark utilized in GIS-based multi-criteria evaluation frameworks for urban planning. It includes information on the dataset size, domain of application, task format, and the metrics used for evaluation, highlighting the integration of vacancy prediction in urban environments.

GIS-based multi-criteria evaluation frameworks are crucial in urban planning, providing sophisticated tools for spatial data analysis and decision-making in shrinking cities. These frameworks facilitate the integration of diverse datasets, enabling comprehensive urban assessments and optimized planning strategies. The MSCNN method exemplifies GIS's role in urban planning, enhancing local climate zone classification through a multi-scale architecture [17]. Advanced methodologies like the Dual-

Branch Network with Multi-Modal Transfer Modules (DBN-MMTM) illustrate the integration of SAR and optical data in urban mapping, enhancing the accuracy of spatial analyses [53]. GIS-based frameworks also extend to analyzing urban datasets, including traffic and air quality data, under various out-of-distribution scenarios, demonstrating adaptability in addressing dynamic urban challenges [52].

These frameworks enable planners to analyze critical factors such as population decline, land use patterns, and environmental performance, ultimately supporting sustainable urban regeneration. Case studies from Japan and the United States illustrate how GIS can optimize redevelopment plans by evaluating demographic trends, vacant land dynamics, and public facility arrangements, informing proactive land use policies to tackle urban shrinkage [33, 36, 43, 35, 60]. By leveraging these methodologies, urban planners can enhance resilience and sustainability, transforming challenges into opportunities for growth and regeneration.

Table 4 presents a representative benchmark that underscores the application of GIS-based multi-criteria evaluation frameworks in urban planning, offering insights into their role in addressing urban challenges. As depicted in **??**, the "Technical Approaches to Shrinking Urban Planning: GIS-Based Multi-Criteria Evaluation Frameworks" exemplifies innovative urban planning through GIS and multi-criteria evaluation. The first image, a choropleth map of Detroit, illustrates the distribution of vacant land across census tracts, providing a visual representation of urban space utilization. The second image complements this with a flowchart detailing the sustainability assessment process, including research objectives, assessor inputs, and survey questions. Together, these visuals demonstrate how GIS-based frameworks address urban planning challenges, particularly in shrinking cities, by integrating spatial data with sustainability assessments [54, 32].

4.4 Green Infrastructure and Environmental Monitoring

Method Name	Urban Resilience	Technological Integration	Strategic Planning
VLRG[19]	Vacant Land Regreening	Land Use Prediction	Priority Areas Alignment
GISP[54]	Social-ecological Resilience	Real-time Monitoring	Priority Areas
PSANM[56]	-	Adaptive Algorithms	-
SAQMS[55]	Urban Planning Efforts	Air Quality Sensors	Urban Planning Efforts

Table 5: Comparison of methodologies for enhancing urban resilience, technological integration, and strategic planning in green infrastructure and environmental monitoring.

Green infrastructure and environmental monitoring are critical in shrinking city planning, offering sustainable solutions to urban decline challenges. Implementing green infrastructure enhances urban resilience, providing benefits such as stormwater management, flood mitigation, and biodiversity enhancement [18]. In shrinking cities, converting vacant lands into green spaces—known as Vacant Land Regreening (VLRG)—improves stormwater management and reduces runoff contamination [19]. Integrating green infrastructure into urban planning is vital for resilience against climate change and pandemics [58]. However, the GISP model indicates significant trade-offs in green infrastructure siting in cities like Detroit, where current projects often misalign with priority areas for maximizing ecosystem services, necessitating more strategic planning [54]. Table 5 provides a comparative analysis of various methodologies employed in the realm of green infrastructure and environmental monitoring, highlighting their contributions to urban resilience, technological integration, and strategic planning.

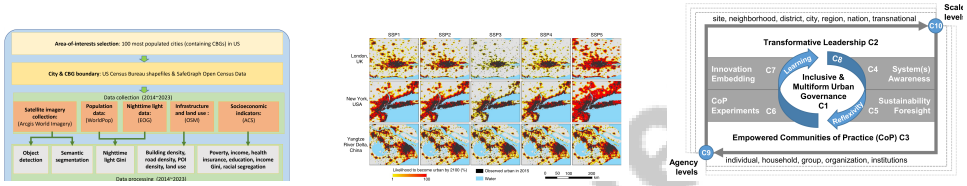
Innovative technologies are essential for environmental monitoring, supporting green infrastructure implementation. Systems like the PSANM showcase real-time platforms managing challenges like low-frequency noise pollution from construction [56]. Scalable, low-cost monitoring systems align with green infrastructure goals by facilitating widespread environmental monitoring [55]. Despite the promise of green infrastructure and environmental monitoring, existing Neighborhood Sustainability Assessment (NSA) tools face criticism for inadequacies in addressing urban regeneration complexities [30]. This highlights the need for improved methodologies that effectively integrate green infrastructure into urban planning.

4.5 Land Use and Urban Mapping Techniques

Land use planning and urban mapping techniques are fundamental for managing shrinking cities, optimizing spatial resources for sustainable development. Systematic conformance analysis evaluates

land use designations within zoning contexts, identifying discrepancies between planned and actual uses, guiding necessary zoning adjustments [61]. Advanced urban mapping techniques leverage GIS and remote sensing for comprehensive spatial analyses, enabling dynamic visualization and management of land use. The Land Transformation Model (LTM) in Chicago predicts land use shifts, including urban vacancy dynamics, by integrating multi-modal data sources like satellite imagery and building function analysis, enhancing monitoring and supporting sustainable policies [51, 7, 59, 60].

Innovative methodologies, such as slope analysis and spatial risk assessments, systematically identify areas suitable for development and conservation. Research indicates that integrating land use prediction models with green infrastructure strategies can substantially enhance urban planning, particularly in legacy cities facing decline and vacancy. Techniques like logistic regression assess mixed land uses' relationship with tax delinquency, pinpointing neighborhoods where diverse land uses may mitigate decline and bolster community resilience. Simulations in cities like St. Louis demonstrate that repurposing vacant land can significantly reduce urban contamination levels [19, 2]. These methodologies are essential for efficient resource allocation in shrinking cities, fostering sustainable growth and revitalizing urban spaces.



(a) Data Collection and Analysis for Urban Planning and Policy[59]

(b) Urbanization Projections for London, New York, and Yangtze River Delta, China, throughout the 21st Century[7]

(c) Conceptual framework for transformative leadership in urban governance, emphasizing community empowerment at various scales and agency levels.[47]

Figure 2: Examples of Land Use and Urban Mapping Techniques

As illustrated in Figure 2, the integration of technical approaches for managing land use is vital in urban planning to address urbanization challenges and promote sustainable development. The first component presents a flowchart outlining the data acquisition process, emphasizing the importance of diverse data sources like satellite imagery and socioeconomic indicators for informed planning decisions in populous cities. The second component features maps projecting urbanization scenarios for major global cities, including London, New York, and the Yangtze River Delta, throughout the 21st century, based on various Shared Socioeconomic Pathways (SSPs). The third component introduces a conceptual framework for transformative leadership in urban governance, focusing on community empowerment through a multi-level approach for inclusive and adaptive management. Together, these elements underscore the significance of technical methodologies in reshaping urban environments to meet contemporary and future needs [59, 7, 47].

In exploring the complexities of urban transformation strategies, it is essential to understand the various frameworks that guide these interventions. Figure 3 illustrates the hierarchical structure of urban transformation strategies, categorizing them into comparative analyses of shrinking and growing cities, as well as urban regeneration strategies in medium-sized and large cities. This figure highlights not only the strategic interventions employed but also the predictive and participatory approaches that are increasingly relevant in contemporary urban planning. Furthermore, it emphasizes the role of technological innovations and diverse methodologies, alongside the utilization of advanced technological and analytical tools, which are pivotal in shaping effective urban policies. By integrating these elements, we can gain a comprehensive understanding of the multifaceted nature of urban transformation.

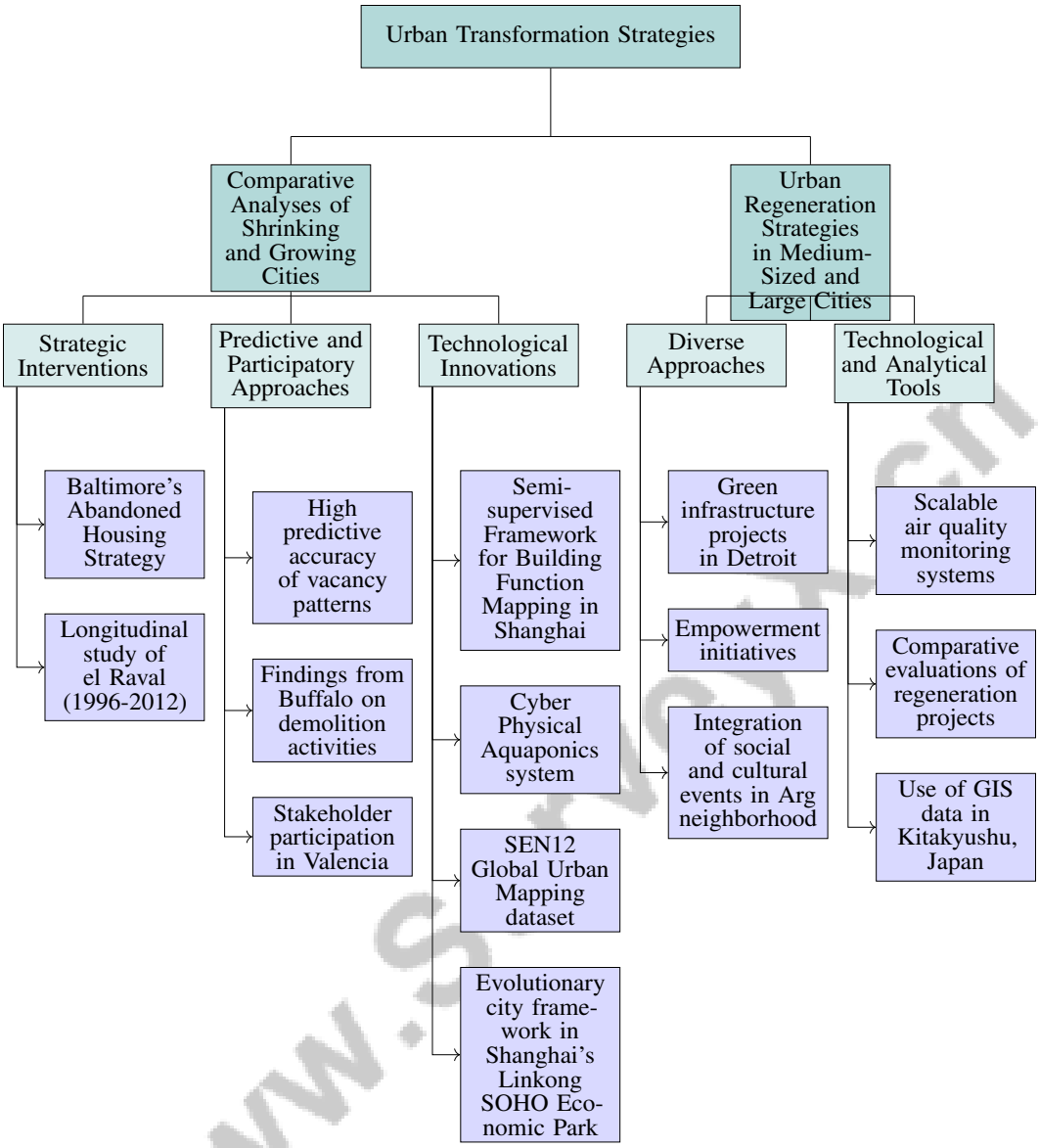


Figure 3: This figure illustrates the hierarchical structure of urban transformation strategies, categorizing them into comparative analyses of shrinking and growing cities, and urban regeneration strategies in medium-sized and large cities. It highlights strategic interventions, predictive and participatory approaches, technological innovations, diverse approaches, and the use of technological and analytical tools.

5 Case Studies and Empirical Evidence

5.1 Comparative Analyses of Shrinking and Growing Cities

Comparative analyses of urban trajectories in shrinking and growing cities offer critical insights into the strategic interventions necessary for urban transformation. Studies, such as Baltimore's Abandoned Housing Strategy, highlight the complexities of addressing urban vacancy through interviews, participant observation, and archival research [24]. Similarly, a longitudinal study of el Raval from 1996 to 2012 reveals socio-cultural dynamics in urban regeneration, underscoring the interplay between residents, planners, and community organizations [39].

Feature	Systemic and Multi-Criteria Approaches	Data-Driven and Technological Frameworks	GIS-Based Multi-Criteria Evaluation Frameworks
Integration Method	Multi-criteria Analysis	Gis And AI	Spatial Data Integration
Technological Innovation	Semi-supervised Segmentation	Machine Learning	Multi-scale Architecture
Sustainability Focus	Community Engagement	Urban Mobility	Environmental Performance

Table 6: A comprehensive comparison of various technical approaches employed in urban planning for shrinking cities, focusing on systemic and multi-criteria methods, data-driven and technological frameworks, and GIS-based multi-criteria evaluation frameworks. This table highlights the integration methods, technological innovations, and sustainability focus of each approach, providing insights into their contributions to urban regeneration and sustainability.

High predictive accuracy of vacancy patterns, validated by robust metrics, provides a framework for understanding urban dynamics essential for effective management strategies [10]. However, findings from Buffalo indicate that demolition activities alone do not significantly reduce vacancy rates, suggesting a need for comprehensive regeneration approaches [12]. Stakeholder participation, as evidenced by extensive interviews and media analysis in Valencia, emphasizes the importance of inclusive planning processes [38]. The role of designers in urban planning is crucial, as their involvement enhances aesthetic quality and alignment with design intent [28].

Technological innovations, like the Semi-supervised Framework for Building Function Mapping in Shanghai, demonstrate the potential of data-driven approaches in urban planning, offering detailed insights into building functions [51]. The integration of monitoring technologies, exemplified by the Cyber Physical Aquaponics system, supports sustainable practices through real-time data analysis [29]. Advanced methodologies, such as the SEN12 Global Urban Mapping dataset, highlight the efficacy of integrating SAR and optical data for superior urban mapping [53]. The evolutionary city framework's application in Shanghai's Linkong SOHO Economic Park illustrates the impact of adaptive strategies on reducing traffic delays [31].

These analyses underscore the necessity of tailored strategies that address the unique challenges of shrinking and growing cities. By integrating diverse methodologies and empirical evidence, urban planners can develop sustainable management practices that transform urban challenges into opportunities for growth and ecological revitalization [46, 47].

5.2 Urban Regeneration Strategies in Medium-Sized and Large Cities

Urban regeneration strategies in medium-sized and large cities incorporate diverse approaches to address urban decline's unique challenges and opportunities. These strategies often integrate spatial data and community engagement to enhance resilience and sustainability. For example, a study in Detroit highlights the importance of aligning green infrastructure projects with ecosystem service hotspots to maximize environmental impact [54].

Empowerment initiatives are crucial in urban regeneration, enhancing residents' sense of control and wellbeing, thus leading to positive health outcomes [9]. Integrating social and cultural events into regeneration efforts, as seen in the Arg neighborhood, significantly contributes to culture-led regeneration, bolstering local identity and economic vitality [34].

Technological advancements are pivotal in regeneration strategies. Scalable air quality monitoring systems track air quality and traffic density, providing insights into their interrelation and informing urban planning efforts [55]. These systems enable data-driven decision-making, allowing planners to develop targeted interventions to address environmental challenges and improve urban living conditions.

Comparative evaluations of regeneration projects reveal tensions between community needs and capitalist interests [5], highlighting the need for balanced approaches prioritizing social equity. The use of GIS data to assess urban conditions and demographic trends, as demonstrated in Kitakyushu, Japan, exemplifies advanced analytical tools' application in informing regeneration strategies [33].

6 Challenges and Opportunities

Urban regeneration in shrinking cities presents a multifaceted landscape of challenges and opportunities. This section delves into the economic and policy constraints that influence regeneration efforts, highlighting the need for adaptive strategies to address structural issues from population decline while

leveraging innovative policy frameworks. A thorough understanding of these dimensions allows urban planners to effectively engage with the dynamics of regeneration in shrinking urban contexts.

6.1 Economic and Policy Constraints

Economic and policy constraints significantly impact urban regeneration in shrinking cities. A key economic challenge is adapting policies to rectify structural maladjustments from declining populations, ensuring investment to maintain full employment [25]. Geographical and infrastructural issues, especially in steeply sloped areas, further restrict access to essential services for aging residents, worsening urban decline [33]. Speculative urban planning often results in community displacement and the erosion of historical legacies, complicating equitable regeneration [5]. Existing benchmarks frequently overlook the differing conditions of vacant land in growing versus shrinking cities, leading to inadequate predictive modeling and policy responses [10]. The rigid nature of Neighborhood Sustainability Assessment (NSA) tools fails to accommodate the diverse social, economic, and institutional contexts influencing urban development [30].

On the policy front, advancements like the PSANM system address urban noise pollution [56]. However, technologies such as the Cyber Physical Aquaponics (CyPhA) pose challenges related to initial costs and technical expertise requirements [29]. Policies must facilitate technological integration while prioritizing economic feasibility and accessibility. Comprehensive frameworks are needed to adapt to urbanization's evolving nature, enhancing adaptive, absorptive, and transformative capacities, fostering stakeholder collaboration, and addressing inherent planning conflicts. This supports diverse communities' well-being amidst urban challenges [46, 36].

6.2 Social Resistance and Community Engagement

Social resistance and community engagement are critical in urban planning, particularly in shrinking cities. Mobilizing local communities and artists is vital for advocating rights and preserving cultural identity amid economic pressures [22]. Despite growing recognition of social capital's role in urban resilience, integrating these elements into planning processes remains challenging [41]. Power imbalances in urban politics often hinder diverse community voices' inclusion in planning [24]. Community engagement enhances urban assessments' relevance and accuracy by integrating diverse perspectives and local knowledge, crucial for evaluating vacant land potential [11].

Technological integration in urban planning presents new opportunities for community engagement, fostering inclusive practices and empowering marginalized voices [27]. However, overemphasis on technical solutions can overlook social impacts, and insufficient citizen engagement may lead to outcomes that do not fully address community needs. Involving citizens in designing and implementing technological systems is essential to ensure alignment with community priorities and values. Research often neglects migrant experiences and structural inequalities, resulting in incomplete narratives that fail to capture their agency in urban regeneration. Understanding migrants' varied experiences and challenges is essential for creating inclusive and equitable urban planning processes, promoting social cohesion and mitigating issues like dispossession and displacement [16, 6].

6.3 Data and Technological Challenges

Data and technological challenges are pivotal in shrinking city planning, affecting urban planning strategies' effectiveness. A primary concern is the reliance on high-quality, comprehensive data sources, crucial for urban planning models' reliability. The identification of building functions is often hampered by single-mode data reliance and the labor-intensive process of accurately labeling numerous buildings [51]. Under-utilization of optical data can restrict model performance where such information is vital [53].

Artificial Intelligence Generated Content (AIGC) technologies struggle to fully grasp complex design contexts, necessitating human designers for creative oversight [28]. This reliance on human intervention underscores current technological frameworks' limitations in autonomously addressing urban planning's intricate demands. Existing NSA tools also exhibit limitations due to their failure to incorporate socio-economic factors and local contexts, leading to inequitable outcomes [30]. Manual sensor calibration and the need for improvements in algorithms, such as those for vehicle counting, remain substantial technological challenges [55].

Addressing these challenges requires enhancing data quality, improving model adaptability, and integrating socio-economic considerations into technological frameworks. By tackling urban shrinkage's multifaceted challenges, urban planners can devise more precise and inclusive strategies that account for diverse demographic, economic, and environmental factors influencing population decline. Understanding these factors' interconnectedness, as demonstrated by empirical analyses in cities like Chatham-Kent and Cape Breton, reveals local contexts significantly shape shrinkage dynamics. Incorporating just planning principles—such as inclusion and transparency—can enhance community engagement and ensure the voices of those most affected by decline are heard, leading to more sustainable and equitable urban development outcomes [24, 16, 43, 61, 57].

6.4 Environmental and Infrastructure Challenges

Environmental and infrastructure challenges are critical in urban regeneration, especially in shrinking cities. A significant issue is the sluggish adaptation of city resource supply systems, hindering timely and cost-effective infrastructure renovation [31]. This delay results in high time and capital costs, presenting substantial barriers to effective urban regeneration. The under-utilization of optical data in urban mapping complicates environmental assessments and multi-modality data integration [53]. This gap underscores the necessity for comprehensive data integration strategies that enhance urban planning models' precision, particularly in classifying and identifying building functions [51].

Population decline exacerbates economic challenges, necessitating a reevaluation of investment strategies and economic policies to sustain progress and full employment [25]. This economic stagnation is compounded by environmental challenges, such as inadequate stormwater management and contamination of vacant lands due to industrial activities and illegal dumping [19]. Robust management strategies are essential to mitigate pollution and enhance urban resilience. Integrating green infrastructure into urban planning remains insufficient, limiting its potential to bolster urban resilience and environmental sustainability [58]. Strategic planning is needed to fully leverage green infrastructure, improving accessibility to green spaces and supporting community well-being, particularly in times of crisis.

Heritage-led urban regeneration often fails to adequately address environmental sustainability and community involvement, leading to fragmented approaches that do not achieve long-term sustainability goals [48]. This underscores the importance of developing comprehensive frameworks that integrate environmental sustainability with community engagement.

6.5 Cultural and Heritage Considerations

Cultural heritage and landscape conservation are vital in urban regeneration, presenting opportunities and challenges in revitalizing shrinking cities. Integrating cultural heritage values into urban regeneration strategies is crucial, particularly concerning industrial heritage, where preserving historical assets can stimulate economic development and enhance community identity [5]. This approach aligns with fostering sustainable urban environments that respect historical contexts while adapting to contemporary needs.

Neoliberal urban governance often prioritizes economic outcomes over social considerations, resulting in increased inequality and social fragmentation [39]. Urban regeneration strategies must balance economic growth with preserving cultural and social values. Interdisciplinary collaboration among planners, environmentalists, and community advocates is essential to address cultural and heritage conservation's complex dynamics in urban planning [27]. Such collaboration ensures diverse perspectives are considered, promoting comprehensive strategies that balance cultural landscape preservation with urban development demands.

The socio-economic impacts of green infrastructure, including its potential to exacerbate social inequalities, remain a concern, highlighting the need for careful planning to avoid unintended consequences [18]. The sustainability of artistic communities amid ongoing urban development poses significant challenges, as current policies may fail to protect these communities from displacement and marginalization [22]. Policies prioritizing cultural asset protection and supporting artistic and cultural communities' resilience are necessary in the face of urban change.

Future research should focus on developing integrated approaches combining demolition with strategies aimed at slowing property abandonment and enhancing property reuse [12]. Comparative

studies of 'rightsizing' across different contexts are also essential to understand urban shrinkage's nuances and develop more inclusive and effective strategies [14]. The evolving nature of temporal knowledge and local narratives can inform broader discussions on urban decline, emphasizing community resilience in addressing cultural and heritage challenges [7]. Analyzing various community engagement methods highlights integrative approaches' effectiveness in addressing vacant land issues, underscoring community involvement's role in urban regeneration [11].

7 Conclusion

The exploration of shrinking city planning and urban regeneration highlights the fundamental importance of fostering urban resilience and sustainability to address the challenges associated with urban decline. The integration of cultural heritage and active community involvement is crucial in crafting sustainable urban environments. For instance, the transformation of Matera demonstrates the effective use of cultural heritage within a circular economy to bolster urban regeneration. Additionally, the role of crowd logistics is pivotal in enhancing urban transport sustainability, impacting economic viability, social equity, and environmental sustainability.

The case study of el Raval illustrates how urban regeneration is shaped by temporal and experiential dynamics, emphasizing the role of local resistance in influencing outcomes. The Slope Degree Method emerges as a valuable tool for improving accessibility and efficiency in regeneration efforts within shrinking cities. Furthermore, the LTM provides a reliable framework for predicting urban vacancy trends, highlighting the distinct socio-economic and physical factors affecting both expanding and contracting urban areas.

Engaging communities is vital in transforming perceptions of vacant land from burdens to assets, underscoring the significance of participatory governance in urban planning. However, existing Neighborhood Sustainability Assessment (NSA) tools require refinement to effectively navigate the complexities of urban sustainability. Future research should focus on integrating community needs into urban planning frameworks and examining participatory governance trends to mitigate the negative impacts of gentrification.

This survey advocates for a holistic approach to shrinking city planning, emphasizing the need for diverse strategies and innovative technologies to transform urban challenges into opportunities for sustainable growth and revitalization. By addressing the multifaceted aspects of urban decline, cities can develop adaptive and resilient environments that promote sustainable development and community empowerment.

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