Double Aging Governance and Urban Planning: A Survey

Abstract

This survey paper explores the concept of "Double Aging Governance" as a framework for addressing the dual challenges posed by the aging of populations and urban environments. The study identifies key objectives, methodologies, and findings related to urban planning strategies that ensure equitable resource distribution and intergenerational equity. It emphasizes the integration of agent-based models, participatory planning enhanced by Large Language Models (LLMs), and socio-spatial policies to manage demographic transitions effectively. The survey highlights the significance of addressing aging within urban analytics, the ethical challenges of AI integration, and the portrayal of older generations in media narratives. It also discusses the complexities of urban planning, including the inadequacy of existing methods to quantify livability, financial barriers to care, and the challenges of ensuring fair resource allocation. The paper concludes with the importance of collaborative and inclusive planning frameworks, data and methodological challenges, and the economic and environmental considerations essential for sustainable urban futures. By leveraging demographic insights, technological advancements, and participatory frameworks, the study advocates for creating adaptable urban environments responsive to the evolving needs of aging populations.

1 Introduction

1.1 Concept of Double Aging Governance

The concept of 'Double Aging Governance' is pivotal in urban planning, addressing the complex relationship between demographic changes and urban infrastructure. This governance model is essential for adapting urban environments to the dual challenges posed by aging populations and evolving urban spaces. Agent-based models are crucial for understanding citizen behavior regarding housing and mobility choices, which are integral to 'Double Aging Governance' [1]. Furthermore, the impact of spatial attributes, such as Social Overhead Capital (SOC), on land prices underscores the significance of spatial factors in this framework [2].

Participatory urban planning methods enhanced by Large Language Models (LLMs) can simulate diverse community interests, promoting inclusive governance models [3]. Transparency in policy-making, supported by provenance frameworks, is vital for effective policy analytics in Smart Cities [4]. The diversification of urban functions, as studied in urban complexity, highlights the necessity for governance models that encompass socio-economic dimensions [5].

Self-organization in urban planning shapes cities' unique characteristics through socio-economic, cultural, and political factors, which are central to 'Double Aging Governance' [6]. Moreover, methodologies prioritizing urban projects, particularly those focused on cultural heritage, align with 'Double Aging Governance' objectives to preserve urban identity amidst demographic changes [7].

Addressing time inconsistency in dynamic decision-making through intertemporal models with non-constant discounting is critical for long-term urban planning strategies, ensuring future generations

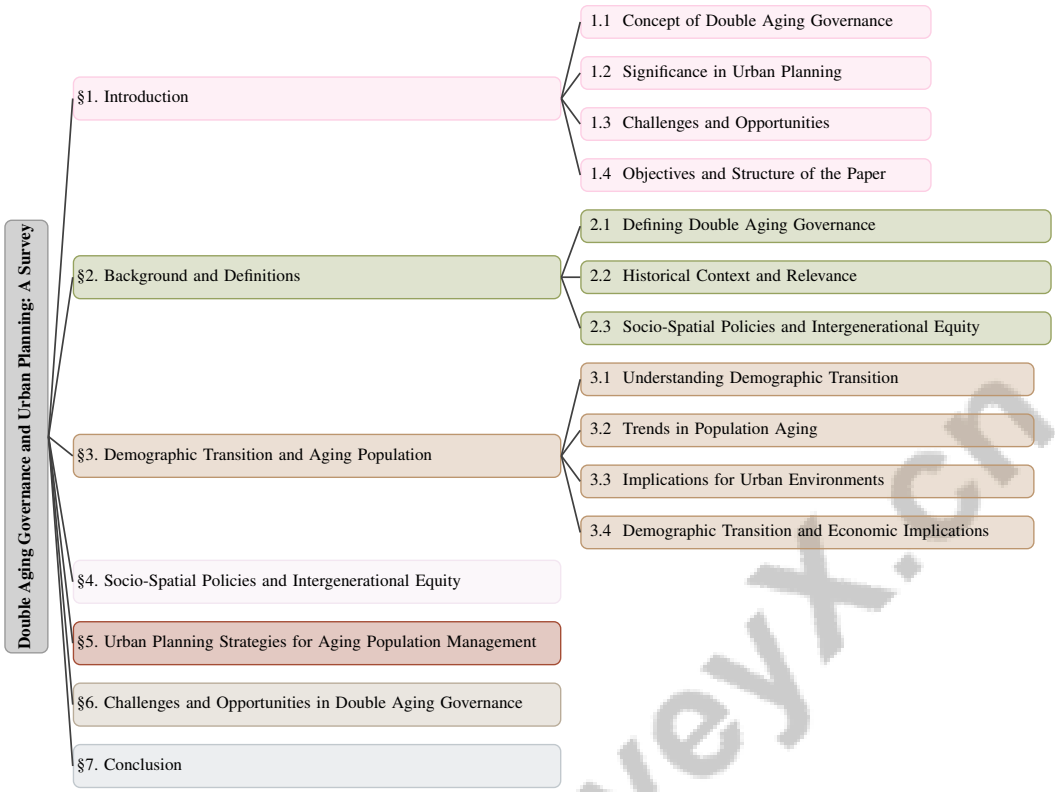

Figure 1: chapter structure

are not disadvantaged [8]. Thus, 'Double Aging Governance' serves as a comprehensive framework that addresses the immediate needs of aging populations while anticipating future challenges and opportunities for sustainable urban development.

1.2 Significance in Urban Planning

Addressing aging populations and urban environments is crucial in contemporary urban planning. Urban analytics enhances policymaking but also presents ethical challenges that must be navigated [9]. The integration of artificial intelligence into urban planning offers promising avenues for efficient resource allocation and urban resilience, essential for meeting the needs of aging populations [10].

Media narratives often portray older generations as burdensome to younger ones, influencing urban planning frameworks [11]. This necessitates inclusive planning strategies that address the needs of all age groups, fostering intergenerational equity. Discussions on occupational pension plans, particularly in light of recent legislative changes in Canada, further highlight the importance of equitable resource distribution across generations [12].

The complex interplay between chronological age, socioeconomic status, access to care, and healthy aging illustrates the factors urban planners must consider in creating environments conducive to healthy aging [13]. Economic structures and local contexts significantly shape urban dynamics, emphasizing the need for planning frameworks sensitive to the dual demands of aging populations and urban environments [5]. Addressing these multifaceted challenges is essential for fostering sustainable, equitable, and adaptive urban spaces that meet society's evolving needs.

1.3 Challenges and Opportunities

Double aging presents diverse challenges and opportunities for urban planners aiming to create sustainable and inclusive environments. A primary challenge is the inadequacy of existing methods to quantify liveability from migration data, which reflects preferences but lacks explicit indicators [14]. This is compounded by the absence of structured, machine-perceivable land-use representations,

complicating the needs of aging populations [15]. Financial barriers to care access contribute to poorer health outcomes and increased morbidity among older adults [13].

Existing human mobility prediction models often lack fairness, leading to biased predictions and inequitable outcomes, underscoring the need for more equitable frameworks [16]. The challenge of quantifying land-use configurations and developing frameworks to distinguish between well-planned and poorly-planned areas remains significant [17]. Additionally, assessing the impact of government cultural expenditure on socio-economic indicators is hindered by the lack of large-scale, fine-grained data [18].

Ensuring fair resource allocation while overcoming the limitations of existing methods, which often focus on data scientists at the expense of participatory design, is critical [19]. Furthermore, current methods inadequately account for spatial correlations and the heterogeneity among mobility services, limiting their accuracy and reliability [20]. The resource-intensive nature of comprehensive assessments and the need for expert intervention restrict the application of existing frameworks [21].

Despite these challenges, the double aging dynamic presents opportunities for innovation. Adapting urban environments for aging populations can lead to more resilient cities. Embracing technological advancements, such as digital tools for urban analysis, can help navigate ontological and epistemological uncertainties and better capture urban systems' dynamics. By addressing equitable access to urban green spaces and leveraging artificial intelligence advancements, urban planners can create inclusive environments that adapt to demographic changes and enhance community well-being [22, 10].

The challenges of forecasting housing criteria and understanding mobility patterns in areas with housing shortages and rising costs are particularly pronounced in the context of double aging dynamics [1]. Urban planning's complexity, involving diverse information and multiple stakeholders, complicates existing methods' transparency and accountability [4]. The need for structured methodologies that incorporate both qualitative and quantitative criteria for evaluating urban projects reflects the challenges posed by double aging dynamics [7].

Traditional urban planning methods often lack participatory elements, failing to incorporate diverse resident needs promptly [3]. Ensuring community decision-making simulations accurately reflect diverse perspectives emphasizes the limitations of traditional stakeholder engagement processes [23]. Furthermore, the challenges in capturing the polycentric nature of urban movements contrast with traditional monocentric models, adding to urban planners' difficulties [24].

The portrayal of older generations as a homogeneous group complicates discussions on intergenerational equity [11]. Additionally, planners' difficulties in aligning beliefs across generations create multiple equilibria, complicating double aging dynamics [8]. The interplay between individual actions and collective outcomes in urban environments adds another layer of complexity to addressing double aging challenges [6].

1.4 Objectives and Structure of the Paper

This paper aims to provide a comprehensive analysis of 'Double Aging Governance,' emphasizing its implications for urban planning amid demographic transitions and the challenges posed by aging urban environments. The exploration addresses the need for municipal leadership strategies that support the growing elderly population, focusing on adapting urban infrastructures and services to facilitate aging in place and meet the complex demands of a changing demographic landscape [25, 26, 27]. This study seeks to analyze how urban planning frameworks can adapt to the challenges and opportunities presented by these dual aging dynamics, ensuring equitable resource distribution and fostering intergenerational equity.

The paper systematically explores these themes, beginning with an introduction to 'Double Aging Governance' and its significance in urban planning. A detailed background section defines key terms and provides historical context, emphasizing the socio-spatial policies and intergenerational equity necessary for effective governance. The subsequent section examines demographic transitions and their implications for aging populations, highlighting trends affecting urban environments and economic structures.

An in-depth analysis of socio-spatial policies designed to promote intergenerational equity is presented, focusing on fair resource distribution and the critical role of public participation in policymaking. The moral and political dimensions of intergenerational justice, including public debt

management, climate change, and ethical obligations to future generations, are also addressed. By examining these interconnected issues, the paper proposes a framework that balances economic considerations with principles of equality, welfare, and reciprocity in sustainable governance [28, 29]. The exploration of urban planning strategies tailored to manage aging populations emphasizes urban mobility, accessibility, green spaces, public health, and technological integration.

Finally, the paper identifies the challenges and opportunities inherent in implementing double aging governance frameworks, stressing the importance of collaborative and inclusive planning, data and methodological considerations, and economic and environmental factors. By examining the interplay of demographic shifts, economic dynamics, mobility patterns, and ecological interactions, this paper aims to enhance the understanding and design of sustainable urban environments that adapt to society's changing demands. This approach recognizes the critical role of spatial heterogeneity in urban systems and integrates insights from social and ecological perspectives to foster resilient urban development [30, 31].The following sections are organized as shown in Figure 1.

2 Background and Definitions

2.1 Defining Double Aging Governance

'Double Aging Governance' is a strategic framework that addresses the simultaneous aging of populations and urban infrastructure, necessitating innovative policy responses. This model reshapes urban environments to meet aging demographics' needs, emphasizing automated land-use configurations generated by Dual-stage Urban Flows to support these populations [32]. It underscores the importance of demographic transition models in understanding shifts from high to low birth and death rates, informing urban resource allocation and policy adjustments [33]. Urban environments are increasingly viewed as polycentric structures where self-organization and planning interventions influence dynamics, aligning governance models with socio-economic realities, particularly in suburban areas facing pronounced challenges [6, 23]. Participatory urban planning frameworks, supported by Large Language Models, enhance governance responsiveness and inclusivity through collaborative decision-making processes [3]. Furthermore, 'Double Aging Governance' impacts healthcare infrastructure, necessitating adaptations to meet older adults' growing demands [11]. Ethical considerations of intergenerational justice must be addressed to ensure current policies do not disadvantage future generations [34]. Accurately inferring urban land use from multi-modal mobility data is essential for understanding human activities and spatial dependencies critical to effective governance [20].

2.2 Historical Context and Relevance

The historical context of double aging governance is tied to demographic transitions that have shaped societies worldwide. The Demographic Transition Theory (DTT) provides a foundational framework for understanding these shifts, demonstrating the move from high to low birth and death rates as societies industrialize, with evaluations using historical demographic data from Sweden, Mauritius, and England revealing complexities and contradictions [35]. The Second Demographic Transition (SDT) broadens demographic analysis, incorporating diverse geographical contexts and emphasizing cultural and socio-economic factors. Historical insights from countries like Serbia inform population policy implications and underscore regional dynamics [36]. Demographic convergence in India, where southern states near convergence in fertility and mortality while northern states remain divergent, illustrates varied trajectories of demographic transitions [37]. Such insights are crucial for understanding demographic changes necessitating double aging governance. The relevance of this governance is underscored by the anticipated increase in older adults, requiring healthcare system adaptations [13]. Critiques against older generations, particularly post-2008 financial crisis, highlight socio-economic challenges addressed by double aging governance [11]. An analysis of global demographic data from 195 countries from 1800 to 2020, focusing on crude birth rates and life expectancy, offers a comprehensive overview of demographic transitions and implications for contemporary governance models [38]. The intersection of urban health and demographic factors, such as age, minority status, and environmental hazards, influences health outcomes, necessitating integrated governance approaches [39]. Theories of intergenerational justice, addressing public debt and climate change, inform governance strategies that are equitable and responsive to diverse age groups [29]. These insights are vital for crafting governance models that tackle the dual challenges of aging populations and urban environments, ensuring sustainable and adaptive urban futures.

2.3 Socio-Spatial Policies and Intergenerational Equity

Socio-spatial policies and intergenerational equity are critical in urban planning, ensuring fair resource allocation among diverse demographic groups and generations, addressing issues like housing insecurity, environmental sustainability, and moral obligations toward future generations [10, 40, 29, 41]. These policies aim to mitigate spatial disparities in access to essential amenities, promoting social justice and sustainability. Strategic placement of public amenities, such as grocery outlets and parks, exemplifies efforts to enhance socio-spatial equity by reducing access inequalities and addressing health disparities among various socioeconomic groups. Intergenerational equity, a cornerstone of sustainable development, emphasizes the fair distribution of resources and obligations across generations, particularly in managing public debt, ensuring fiscal policies do not disproportionately burden future generations [28]. The choice of Social Discount Rate (SDR) in Public–Private Partnerships (PPPs) significantly affects resource distribution between current and future generations, highlighting the necessity for frameworks prioritizing fairness and sustainability [42]. In climate change contexts, intergenerational equity requires equitable distribution of mitigation costs to prevent undue burdens on future generations [43]. Incorporating fairness-aware models, like FairMobi-Net, into urban planning can enhance socio-spatial policies by ensuring equitable resource distribution across demographic groups, supporting intergenerational equity [16]. Robust methods for accounting for extinction risks in welfare evaluations are crucial for safeguarding future generations' interests, reinforcing intergenerational equity principles [34]. The significance of intergenerational equity extends to economic structures, such as occupational pension plans, where equitable allocation of costs and benefits between generations is essential [12]. Urban planning frameworks must address residents' diverse needs, ensuring fair resource allocation among different resident types to foster inclusive and sustainable urban environments [19]. As urban populations grow, managing implications for infrastructure, human resources, and economic stability becomes increasingly complex, underscoring the necessity of effective socio-spatial policies that uphold intergenerational equity [44]. By embedding these principles into urban planning, policymakers can create environments that are equitable, sustainable, and responsive to both current and future generations' needs.

In examining the intricate relationships between demographic changes and their broader implications, it is essential to consider the various frameworks that elucidate these dynamics. Figure 2 provides a hierarchical classification of key concepts related to demographic transition and aging populations. This figure categorizes essential elements such as demographic transition models, trends in population aging, and their implications for urban environments and economic structures. Each primary category is further subdivided into detailed subcategories and points, effectively illustrating the complex interplay between demographic changes and their socio-economic and urban impacts. This visual representation not only enhances our understanding of the subject matter but also serves as a critical reference point for the discussions that follow in this review.

3 Demographic Transition and Aging Population

3.1 Understanding Demographic Transition

The Demographic Transition Model (DTM) is essential for analyzing population changes across stages marked by different birth and death rates, from Pre-Industrial to Post-Industrial phases. Initial stages feature high birth rates and youth bulges, while later stages show aging populations and declining birth rates, highlighting the interplay between fertility and mortality [35, 33]. The Second Demographic Transition theory further explores shifts in reproductive behaviors and family structures impacting aging populations [36]. Quantitative analyses, such as the relationship between crude birth rate λ and life expectancy at birth e_0, enhance understanding of demographic dynamics [38].

Figure 3 illustrates the hierarchical structure of demographic transition analysis, highlighting key models, urban science advancements, and economic implications. This visual representation serves to clarify the interconnections among these components, reinforcing the theoretical frameworks discussed.

Urban science advancements, using data from mobile technologies and social networks, refine mobility pattern modeling, crucial for understanding demographic transitions [31]. Agent-based models simulate citizen decision-making, emphasizing the significance of demographic transitions for aging populations [1]. Complexity theory suggests urban systems evolve through socioeconomic and

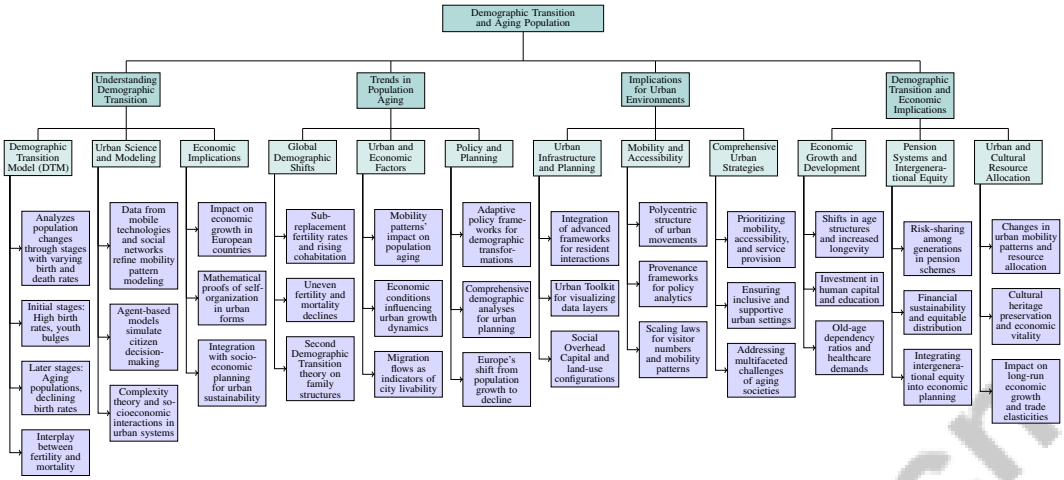

Figure 2: This figure shows a hierarchical classification of key concepts related to demographic transition and aging populations, including the understanding of demographic transition models, trends in population aging, implications for urban environments, and economic implications. Each primary category is further divided into subcategories and detailed points, illustrating the complex interplay between demographic changes and their socio-economic and urban impacts.

spatial interactions, leading to emergent properties important for analyzing demographic transitions [5].

Economic implications of demographic transitions, especially regarding aging and declining populations, have been studied in European countries, revealing impacts on economic growth [45]. Mathematical proofs of self-organization in urban forms, like scaling laws and fractal geometry, further explain urban systems' dynamic nature adapting to demographic changes [6]. Integrating demographic insights with socio-economic planning allows urban planners to create responsive environments for transitioning societies. Tools like the LLM-based Urban Sustainability Assessment (LLM-USA) automate urban sustainability initiative assessment, offering innovative solutions to demographic challenges [21].

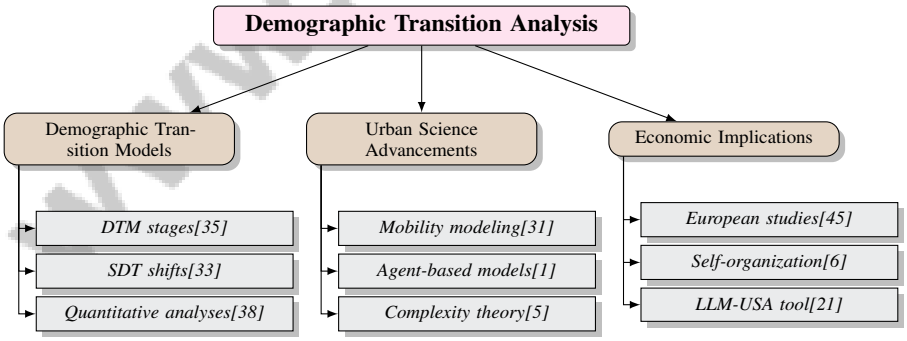

Figure 3: This figure illustrates the hierarchical structure of demographic transition analysis, highlighting key models, urban science advancements, and economic implications.

3.2 Trends in Population Aging

Current population aging trends necessitate strategic policy interventions due to significant societal impacts. Persistent sub-replacement fertility rates and rising cohabitation indicate profound demographic shifts globally [33]. These trends are complicated by uneven fertility and mortality declines, exacerbating health inequalities [37]. Serbian demographic data illustrates regional fertility rate variations, emphasizing demographic transitions' complexities [36].

Demographic transitions involve distinct phenomena governed by different mechanisms, suggesting universal pathways applicable to many nations [38]. The Second Demographic Transition theory anticipates changes in family structures and reproductive behaviors influencing aging population dynamics [27]. Urban environments are particularly affected, with studies of mobility patterns in cities like Atlanta and Harris County demonstrating mobility's impact on population aging [16]. Advanced modeling techniques in urban communities, such as Beijing, elucidate demographic profiles and urban growth dynamics interplay [46]. Migration flows are critical indicators of city livability, correlating with aging trends and urban environmental changes [14].

Economic factors significantly shape urban growth dynamics and population density. Research on urban complexity and socioeconomic indicators emphasizes economic conditions' influence on population density trends [5]. The dynamic Keller-Segel model elucidates urban growth patterns, highlighting economic conditions' impact on population density [47]. As societies confront these demographic transformations, adaptive policy frameworks are increasingly necessary. Comprehensive demographic analyses and urban studies enable policymakers to understand population aging intricacies and develop strategies addressing its multifaceted challenges. Europe's demographic transition, marking a shift from centuries of population growth to decline, underscores the urgency of addressing these trends [45].

3.3 Implications for Urban Environments

The aging population significantly influences urban settings and infrastructure, necessitating strategic adaptations to meet older adults' evolving needs. Urban environments must accommodate aging populations' diverse requirements by integrating advanced frameworks that simulate resident interactions, fostering inclusive urban planning outcomes [3]. The Urban Toolkit (UTK) provides a comprehensive framework for visualizing urban data layers in both 2D and 3D environments, facilitating infrastructure adaptation to demographic shifts [48].

The demand for Social Overhead Capital (SOC) impacts land prices and urban planning strategies, highlighting the need for effective land-use configurations responsive to changing demographics [2]. The LUCGAN+ model generates land-use configurations resembling well-planned areas, emphasizing adaptable urban designs for aging populations. Furthermore, the DSUF framework enhances interpretability and stability in urban planning processes, essential for developing supportive environments for older adults [32].

Urban movements' polycentric structure, characterized by complex interactions, requires understanding how these structures evolve over time due to social, economic, and technological factors. Integrating provenance frameworks into policy analytics can improve transparency and effectiveness in urban planning, ensuring policies align with aging populations' needs [4]. A proposed model reveals a robust scaling law relating visitor numbers to location, visiting frequency, and travel distance, providing insights into mobility patterns essential for planning age-friendly urban environments [49]. Addressing these multifaceted challenges requires comprehensive urban planning strategies prioritizing mobility, accessibility, service provision, and housing to ensure inclusive and supportive urban settings for an aging society.

3.4 Demographic Transition and Economic Implications

Demographic transitions, particularly regarding aging populations, have profound economic implications. As societies progress through demographic transitions, shifts in age structures and increased longevity significantly impact economic growth and development dynamics. The transition from high to low birth and death rates, as elucidated by the DTM, necessitates adaptive economic policies to effectively manage these changes [27].

Future phases of humanity following demographic transitions are explored through mathematical frameworks predicting shifts in economic strategies, emphasizing maximizing productivity through education rather than merely increasing population size. This shift reflects the critical need for investment in human capital, essential for sustaining economic growth in aging societies facing increased healthcare demands and workforce challenges due to rising old-age dependency ratios and chronic health conditions [45, 25, 50].

The economic impacts of aging are particularly evident in pension systems, where risk-sharing among generations becomes crucial [12]. As populations age, pension schemes' financial sustainability is challenged, necessitating reforms to ensure equitable distribution of benefits across age cohorts. Integrating intergenerational equity considerations into economic planning is vital to mitigate fiscal burdens on future generations [42].

Urban environments are significantly affected by demographic transitions, reflected in changes to urban mobility patterns and resource allocation. Robust visitation laws across different geographies provide insights into recurrent population flows, crucial for urban planning and economic forecasting [49]. These insights facilitate developing adaptive urban strategies accommodating aging populations' needs, ensuring cities remain vibrant and economically viable.

Moreover, allocating resources for cultural heritage preservation, guided by multiple-criteria methodologies, highlights demographic transitions' economic implications in urban settings [7]. Prioritizing cultural heritage projects preserves urban identity and supports economic vitality by attracting tourism and fostering community engagement.

Demographic transitions' impact on long-run economic growth is underscored by their influence on trade elasticities and productivity [45]. As demographic shifts continue reshaping societies globally, understanding their economic implications is vital for crafting policies promoting sustainable and equitable growth. By leveraging comprehensive demographic analyses and integrating intergenerational equity into economic planning, policymakers can better navigate aging populations' complexities and ensure resilient economic futures.

4 Socio-Spatial Policies and Intergenerational Equity

4.1 Equitable Resource Distribution

Socio-spatial policies aim to ensure equitable resource distribution across age groups, particularly in urban areas experiencing demographic shifts. Advanced methodologies and technologies, such as Large Language Models (LLMs), enhance participatory urban planning by simulating diverse community perspectives, thus addressing the limitations of traditional approaches [3]. This inclusivity is crucial for meeting the needs of various demographic groups. Urban planning must also consider socio-economic factors influencing fertility and cohabitation trends, which significantly impact resource allocation [33]. The spatial heterogeneity of Social Overhead Capitals (SOCs) and their effects on land prices require careful management to ensure equitable distribution [2]. Prioritizing urban projects based on their cultural, social, and economic impacts through multiple-criteria methodologies can better address diverse stakeholder needs [7].

Yurrita et al.'s model emphasizes urban characteristics such as equality, diversity, walkability, and efficiency, which are essential for equitable resource distribution [1]. Spatial proximity among various land uses enhances urban vitality and should be a key consideration in resource distribution strategies [5]. Embedding these strategies within urban planning frameworks can help policymakers create inclusive, sustainable environments that address the diverse needs of all age groups, advancing social justice and reducing disparities.

4.2 Public Participation and Policy Processes

Public participation is vital for developing equitable urban policies that reflect citizens' diverse perspectives. Incorporating citizen participation enhances policy legitimacy and acceptance while fostering transparency and accountability in governance. Open governance models, as highlighted by Javed et al., stress the importance of citizen engagement, advocating for frameworks that facilitate active public involvement [4].

Implementing participatory planning processes is essential for navigating complex socio-spatial dynamics in urban environments, especially amid demographic transitions and aging populations. Recent advancements, including LLMs, have shown potential in enhancing community engagement by simulating diverse stakeholder perspectives and facilitating collaborative feedback, thereby addressing residents' varying needs and improving satisfaction and inclusivity in urban planning outcomes [46, 51, 3]. Technological advancements, such as provenance frameworks, allow planners to create more inclusive urban policies that reflect diverse communities' aspirations and concerns.

Participatory approaches empower communities by enabling residents to engage actively in formulating urban strategies that prioritize equitable resource distribution and intergenerational equity. This engagement fosters a sense of ownership among community members and ensures diverse perspectives are considered, leading to more inclusive and sustainable urban development outcomes. Case studies, such as the management of green spaces in Kumasi, Ghana, and innovative frameworks utilizing LLMs, demonstrate the effectiveness of collaborative planning processes [46, 51, 3]. Emphasizing public participation in policy processes highlights the necessity for governance models that are open, transparent, and responsive to societal needs, ultimately advancing social justice and sustainability in urban planning.

4.3 Intergenerational Equity and Policy Integration

Integrating intergenerational equity into policy frameworks is essential for fair resource and responsibility distribution across age cohorts, addressing both current needs and future risks. This concept is based on principles advocating for equitable resource distribution between present and future generations, as identified by Pawa et al., who outline four key principles: sufficientarian, intergenerational equality, reciprocity, and the benefit principle [28]. These principles guide the development of integrated policies that balance the rights and obligations of different generations.

Figure 4 illustrates the integration of intergenerational equity into policy frameworks, highlighting key principles, policy challenges, and future directions for equitable resource distribution across generations. This visual representation underscores the ethical considerations paramount in public policy, especially in managing occupational pension plans where risk-sharing mechanisms can enhance intergenerational equity [12]. Developing integrated policies incorporating stochastic discount rates and innovative financing mechanisms can facilitate equitable mitigation efforts, particularly regarding long-term challenges like climate change.

Understanding the interplay between population density and economic factors is critical for promoting intergenerational equity in urban settings. Models like the Dynamic Keller-Segel Model, which simulates interactions between population density and economic factors over time, highlight the need for urban planning policies addressing demographic and economic aspects. This approach fosters equitable resource distribution and enhances urban development efficiency by revealing how population clusters form around economic hubs and how wealth concentration evolves [30, 47]. Addressing potential existential risks emphasizes the ethical dimensions of intergenerational equity, advocating for policies that consider long-term risks and uncertainties.

Despite advancements, significant gaps remain in effectively representing future generations in policymaking and balancing present and future individuals' rights. Capital income taxation plays a critical role in achieving intergenerational equity, influencing wealth distribution across generations. Addressing age-based distinctions that obscure constructed inequalities is vital for formulating policies that promote intergenerational equity. Recognizing how media narratives often portray older generations as disproportionately benefiting from national resources at the expense of youth can perpetuate socio-economic disparities. By considering public debt, welfare distribution, and current generations' responsibilities towards future ones, policymakers can ensure fair treatment of all age groups in decision-making processes. This holistic approach promotes fairness and addresses the cultural and psychological factors contributing to intergenerational tensions and inequities [11, 42, 41, 28, 29].

5 Urban Planning Strategies for Aging Population Management

5.1 Urban Planning and Aging Population Management

Urban planning must effectively address the challenges of an aging population to create inclusive and resilient environments. Innovative frameworks such as the DSUF framework's dual-stage generation process and Yurrita et al.'s agent-based model emphasize tailoring urban spaces to meet the mobility and accessibility needs of older adults [32, 1]. Understanding the influence of Social Overhead Capitals (SOCs) on land prices, as discussed by Kang et al., is essential for optimizing land-use configurations to enhance older adults' quality of life [2]. The LLM-based Multi-Agent Collaboration Framework aids in participatory urban planning by simulating interactions between planners and residents [3]. Incorporating cognitive aspects into urban design, as explored by Goldman et al.,

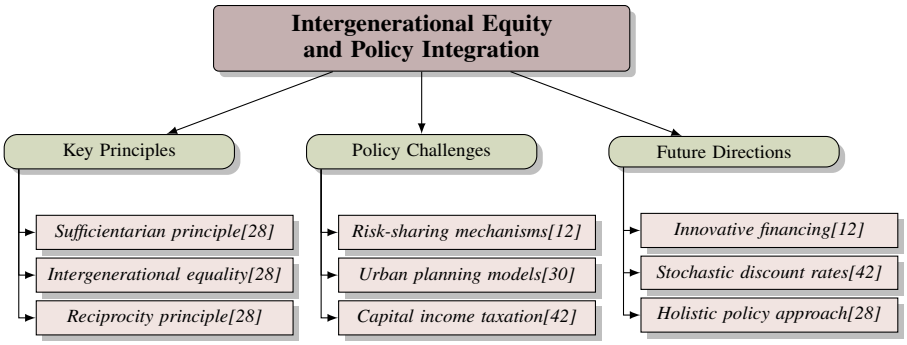

Figure 4: This figure illustrates the integration of intergenerational equity into policy frameworks, highlighting key principles, policy challenges, and future directions for equitable resource distribution across generations.

helps create age-friendly environments that foster social interaction and community engagement [6]. Ensuring transportation equity and optimizing urban features like grocery store locations support active transport and public health for aging residents. By leveraging AI and participatory frameworks, urban planners can develop sustainable environments tailored to diverse community needs [46, 10].

5.2 Urban Mobility and Accessibility

Enhancing urban mobility and accessibility for older adults is crucial, requiring innovative strategies. The application of Large Language Models (LLMs) in participatory planning improves inclusivity and responsiveness, addressing aging populations' specific needs [3]. Urban analytics, particularly through provenance frameworks, provide insights into effective policy analytics that inform mobility strategies for older adults [4]. Strategic placement of urban features, such as grocery outlets, is vital for promoting active transport and improving accessibility [52]. Agent-based models simulate mobility patterns, offering insights into adapting urban environments to support older adults' mobility needs [1]. A thorough examination of socio-spatial dynamics influencing transportation equity is necessary, as these factors relate to housing insecurity, public transit efficiency, and broader implications on marginalized communities. Understanding these interactions reveals barriers faced by older adults, guiding equitable policy development [40, 53, 9]. Prioritizing the needs of aging populations enables policymakers to create inclusive, sustainable environments that support diverse mobility requirements.

5.3 Green Space and Public Health

Green spaces are vital for promoting health and well-being among aging populations, supporting physical activity, social interaction, and mental health. Optimizing green space planning for equitable access is crucial, particularly for older adults facing mobility challenges. Leboeuf et al.'s model emphasizes integrating fairness and user behavior into green space planning to enhance health benefits [22]. Community participation in managing green spaces maximizes their health benefits, as shown in Adjei et al.'s survey in Kumasi, Ghana, where local involvement leads to designs effectively meeting aging residents' needs [51]. Strategically designed green spaces can mitigate urban heat effects, reduce air pollution, and provide restorative environments enhancing older adults' overall health. Incorporating equity, environmental justice, and community engagement into urban planning improves sustainability and resilience. Advanced optimization models and automated planning tools can identify optimal locations and designs for parks, addressing accessibility inequalities and maximizing green spaces' benefits for diverse communities [51, 30, 17, 22, 10]. Comprehensive planning and community involvement in green spaces significantly support older adults' health and quality of life, promoting active aging in urban settings.

5.4 Technological Integration in Urban Planning

Integrating technology into urban planning is essential for creating age-friendly environments catering to aging populations' diverse needs. Innovations like OSMnx have transformed urban street network

analysis and visualization, enhancing planning for accessible urban spaces for older adults [54]. The role of technology in improving healthcare delivery for elderly individuals is critical, enhancing health outcomes and quality of life [25]. Interdisciplinary frameworks combining computational methods with urban theories translate urban planning into actionable strategies addressing aging societies' complexities [55]. Explainable AI techniques, such as those in the HGT framework, enhance model transparency, aiding urban planners in addressing aging populations' challenges [20]. The Intelligible Fair City Planner (IF-City) exemplifies technology's role in participatory urban planning, providing interactive visualizations of accessibility and inequality indicators [19]. Future research should focus on hybrid models blending AI capabilities with human expertise, ensuring urban planning remains equitable and responsive to community needs [10]. The proposed method utilizing combinatorial Hodge theory to integrate migration data offers a technological approach for assessing and enhancing urban spaces' livability for older adults [14], equipping urban planners with tools to foster vibrant and inclusive cities.

6 Challenges and Opportunities in Double Aging Governance

Navigating the complexities of double aging governance requires innovative planning and policy development to address the diverse needs of aging populations in urban environments. Collaborative and inclusive frameworks are essential, fostering participatory governance and enhancing urban planning processes to better serve these communities.

6.1 Collaborative and Inclusive Planning Frameworks

Establishing collaborative and inclusive planning frameworks is crucial for addressing the diverse needs of aging urban populations. Advanced methodologies should incorporate community perspectives, ensuring urban planning is both inclusive and adaptable. The integration of Large Language Models (LLMs) into participatory planning exemplifies this approach, offering real-time feedback from simulated resident agents to comprehensively represent community voices [46]. The complexity of urban environments necessitates incorporating various socioeconomic dimensions into planning frameworks, as highlighted by Salvati et al., providing insights for strategies tailored to aging populations [5]. Similarly, Goldman et al. propose a framework elucidating the dynamic interplay between individual actions and urban forms, enhancing urban design to support diverse needs [6].

Crowdsourcing methods further enhance decision-making by facilitating public participation throughout policy development stages. Prpic et al. demonstrate how these methods empower communities to actively contribute to urban strategy development, ensuring alignment with local needs and aspirations [56]. Adjei et al. emphasize incorporating local voices in planning processes to promote social cohesion and resilience [51]. Montgomery's exploration of demographic and economic factors underscores the importance of collaboration and inclusivity in planning for aging populations, optimizing resource allocation and supporting sustainable growth [47]. Tools like LUCGAN+ and FairMobi-Net highlight the benefits of automated configuration generation and equitable mobility predictions in creating adaptable urban environments for older adults [15, 16].

By leveraging advanced technologies such as LLMs and machine learning, urban planners can design age-friendly, sustainable, and resilient environments. These frameworks facilitate engagement among diverse stakeholders, allowing planners to address community needs, optimize land-use configurations, and enhance resident well-being while promoting environmental justice [3, 46, 17, 22, 10].

6.2 Data and Methodological Challenges

Implementing double aging governance frameworks involves significant data and methodological challenges essential for effective planning and policymaking. High-quality input data is crucial, as frameworks like DSUF require precise information for optimizing urban planning outcomes [32]. Inconsistent definitions and measurements of intergenerational equity complicate stakeholder communication and decision-making [12]. The complexity of urban systems, characterized by various socioeconomic factors, poses challenges in accurately quantifying these dynamics [5].

Methodological difficulties in evaluating land-use configurations are compounded by the need for robust data collection and analysis frameworks that effectively capture qualitative criteria and stakeholder inputs [7]. The reliance on context length in LLMs during participatory planning can limit

diverse resident needs representation, complicating data collection efforts [3]. Existing models often neglect temporal dynamics, leading to misconceptions about spatial mixing and its implications for urban planning and epidemic management [49]. The absence of empirical estimates on demographic changes' economic impacts, particularly in open-economy contexts, represents a significant gap [45].

Challenges related to public expenditures and intergenerational benefits complicate data and methodological approaches in double aging governance. Evaluating these expenditures requires detailed analysis to ensure equitable resource distribution across age groups [28]. Addressing these challenges will enable policymakers to develop more effective governance frameworks responding to aging populations and urban environments, promoting sustainable and equitable urban futures.

6.3 Economic and Environmental Considerations

Understanding economic and environmental factors is essential for managing the dual challenges of aging populations and urban environments. Economic considerations are influenced by the spatial heterogeneity of Social Overhead Capital (SOC) and its effects on land prices, necessitating strategic resource allocation and infrastructure development for equitable access and sustainable growth [2]. The relationship between economic growth and fiscal policies is complicated by the fiscal costs associated with government debt, highlighting the need for governance frameworks balancing economic growth with fiscal sustainability [28]. Large-scale mobility data from cities like Greater Boston, Singapore, and Lisbon provides insights into urban dynamics, aiding policies addressing both economic and environmental challenges [49].

Environmental considerations are critical, as urban areas must adapt to the evolving needs of elderly residents while addressing the environmental impacts of demographic changes. This dual focus is vital for creating sustainable communities supporting aging individuals' well-being and environmental health [25, 26, 41]. The demand for efficient land-use configurations and sustainable infrastructure underscores the necessity of integrating environmental factors into urban planning. By leveraging comprehensive models and empirical evidence, policymakers can devise strategies addressing the multifaceted challenges of aging populations, ensuring vibrant and resilient urban spaces amidst demographic shifts.

7 Conclusion

This survey underscores the critical need for integrating specialized health and labor market policies to cater to aging populations, significantly impacting urban planning and policy development. It highlights the importance of healthcare innovation through adaptive care models and policy interventions to effectively manage demographic changes. Enhancing socioeconomic status and healthcare access is pivotal for improving health outcomes among older adults, promoting equitable urban environments.

Reevaluating the complexity of urban street networks is essential, advocating for demographic insights and technological advancements in urban design frameworks. A comprehensive understanding of community structures can guide urban planning and the creation of socially integrated infrastructure systems, enhancing urban adaptability and resilience. The LUCGAN model's capability in generating suitable land-use configurations demonstrates its utility for urban planners in crafting responsive environments for aging populations.

The conclusion also emphasizes the implications of utilizing models like the BTM for advancing research and policy development related to demographic transitions, highlighting their potential to deepen insights into aging populations. Effective management and engagement with older adults correlate with the adoption of age-friendly policies by municipalities, illustrating the strong link between participatory governance and policy success. Additionally, cultural investment plays a significant role in improving socio-economic conditions in deprived neighborhoods, offering crucial considerations for future urban planning.

Future research should focus on developing integrated models encompassing mobility, morphology, and interactions within urban systems, while exploring the impact of emerging technologies and data sources in urban science. The dynamic heterogeneity of urban systems, structured as spatially differentiated mosaics, is vital for ecosystem functioning, relevant for future urban planning. The

accuracy and fairness of FairMobi-Net highlight its potential influence on urban planning and resource allocation strategies, fostering equitable and efficient urban environments.

Moreover, the relationship between population density and economic factors shapes distinct urban patterns, carrying implications for urban planning and policy development. The study concludes that incorporating stochastic discount rates and funding mechanisms can significantly enhance intergenerational equity in climate change mitigation efforts. Finally, integrating LLMs with the ISO 37101 framework demonstrates the efficiency and consistency of urban sustainability assessments, contributing to more sustainable urban planning practices.

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