ARCHIVES OF TRANSPORT ***ISSN (print):*** *0866-9546*
Volume 74, Issue 2, 2025 ***e-ISSN (online):*** *2300-8830*
DOI: *10.61089/aot2025.fh4j7584*

BENEFITS OF A SUMP: PROVIDING ACCESSIBILITY FOR ALL

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***Abstract**:*

This paper focuses on the numerous advantages of implementing a Sustainable Urban Mobility Plan (SUMP), emphasizing its critical role in shaping the future of urban environments. As cities continue to grow and evolve, planners face the challenge of maintaining economic vitality while ensuring that urban areas remain attractive and livable for current and future residents. SUMPs offer a comprehensive framework to address these challenges by promoting more sustainable, inclusive, and efficient transportation systems. One of the primary benefits of SUMPs is the creation of public spaces that are bike-friendly, walkable, and visually appealing - factors that have become essential in attracting new inhabitants, retaining existing populations, and enhancing overall public health and well-being. Despite these benefits, urban areas worldwide are witnessing a troubling decline in everyday physical activity, largely due to increased dependence on cars. This trend has serious health implications for urban populations, especially for the elderly. SUMPs aim to counteract this by reducing car dependency and encouraging active modes of transportation such as walking and cycling. This shift not only improves public health outcomes but also fosters better social inclusion by improving access to jobs, education, health services, cultural facilities, and other essential amenities, not only for the systematic demand but also for the erratic one of the elderly. This article is significant because it emphasizes the importance of SUMPs for vulnerable populations, especially the elderly, who frequently have mobility issues. However, the benefits extend beyond older adults to include children, young adults, low-income households, and those with medical conditions or other limitations that prevent car use. By integrating land-use planning with transportation strategies, SUMPs create an environment where mobility without a car becomes practical and convenient for nearly everyone, including car owners who might choose alternative modes for daily travel. Through the use of detailed case studies, this paper illustrates how SUMPs serve as strategic plans tailored to meet the diverse mobility needs of urban populations. It demonstrates how these plans improve upon traditional transportation planning by prioritizing integration, public participation, and continuous assessment, ultimately enhancing the quality of life for all city residents, with a special focus on elderly citizens.

Keywords: *SUMP, sustainability, the elderly, transport planning*

To cite this article:

Venezia, E., (2025). Benefits of a SUMP: providing accessibility for all. Archives of Transport, 74(2), 99-116. https://doi.org/10.61089/aot2025.fh4j7584

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1. Introduction

Growing concerns about urban traffic congestion, greenhouse gas emissions, transport-related energy costs, and associated health problems have sparked increasing interest in active mobility among researchers, practitioners, and policymakers (Holienčinová et al., 2020, Monteiro et al. 2023, Pisano, 2020). In line with the broader objectives of the Green Deal and Agenda 2030, the pressing need to create Sustainable Urban Mobility Plans (SUMPs) that specifically meet the requirements of vulnerable demographic groups—especially the elderly—represents an important and cutting-edge frontier in urban planning. The need to create inclusive, customized interventions within SUMPs that successfully address the demographic shifts brought about by global aging trends and policy commitments to sustainable, equitable cities is becoming increasingly apparent, despite the fact that previous research has thoroughly studied urban mobility and aging populations separately (European Commission, 2020; UN-Habitat, 2021). By outlining innovative approaches for incorporating senior-specific mobility solutions into general urban design and emphasizing their potential to improve social inclusion, independence, and general quality of life, this study advances this developing topic.

One of the biggest demographic shifts in the globe is the aging population. According to UN estimates for 2023, there will be more than 2.1 billion people in the world by 2050, up from about 1 billion in 2020 and 1.4 billion in 2030 (World Health Organization, 2024). Given that older persons frequently have mobility limits due to physical, cognitive, and sensory impairment, this rapid demographic transition poses substantial problems for urban transportation systems (WHO, 2018; Baltes & Baltes, 1990). According to the European Parliamentary Research Service (2019), inclusive mobility planning is crucial for attaining the sustainability goals set forth in Agenda 2030 and the Green Deal, which place a premium on accessible and age-friendly urban environments, as well as for social cohesion.

The scientific literature offers a wealth of information about the complex nature of mobility issues in the elderly. Notable problems include age-related physical deterioration, which makes walking, stair climbing, and using public transportation more difficult. These issues include decreased strength, joint flexibility, and stamina (Ryan et al., 2021, 2021a; Coughlin et al., 2017). Dementia, visual loss, and hearing impairments are examples of cognitive and sensory impairments that make it difficult to navigate and use transportation systems effectively, which raises the risk of accidents and lowers confidence (Docherty et al., 2022; Satariano et al., 2020). Additionally, age-related declines in balance and reaction time increase susceptibility in crowded transport settings and at road crossings (Rausch et al., 2017, 2017a). Since many older persons rely on public, shared, or non-motorized mobility alternatives that may be limited or inaccessible, access to transportation is still a crucial issue, especially in rural or underserved urban areas (Twardzik et al., 2024; Pucher et al., 2010).

The protection of older persons' independence, which affects their capacity to fully engage in social, economic, and health-related activities as they age, depends on addressing these mobility issues (Ferris et al., 2013). Research shows that having access to transportation is strongly associated with well-being, including a decrease in social isolation, which is one of the main dangers for seniors' physical and mental health to deteriorate (Chua et al., 2025; Cacioppo & Cacioppo, 2014). Additionally, having access to dependable transportation promotes physical exercise like cycling and walking, which benefits general health (Church et al., 2000; Sallis et al., 2012). Additionally, the ability of older adults to travel on their own is associated with improved mental health, a sense of autonomy and control over their lives, and life satisfaction (Ravensbergen et al., 2022a; Van Cauwenberg et al., 2018).

Even with the increasing amount of evidence, there is still a big gap in converting these insights into practical, scalable policy measures that are integrated into SUMPs. This is especially true for those that are in line with sustainability directives and the EU's strategic commitments to inclusive urban environments (European Commission, 2020; Eltis, 2021). With a focus on the most promising novel interventions within SUMPs, this research attempts to close this gap by critically analyzing the scientific literature on senior mobility in connection to urban planning initiatives. The research is supported by a number of real-world case studies, including successful Italian examples, that are meant to encourage urban planners and decision-makers to put into practice age-friendly, efficient mobility solutions that support social justice and sustainability objectives.

All case studies can be replicated in other geographic areas. Clearly, specific similarities must be sought. Case studies considered most significant for individual countries, including Italy, have been selected.

2. Literature Review: Benefits of Sustainable Urban Mobility Plans (SUMPs)

Strategic planning tools called Sustainable Urban Mobility Plans (SUMPs) are made to address the mobility requirements of businesses and individuals in cities and their environs. Active and green transport modes such as walking, cycling, and public transit reduce emissions, improve health, and foster sustainable urban development (Becker et al., 2020, Wu et al., 2023, Gössling, 2021, Papa & Ferreira, 2021). By encouraging walking, bicycling, public transportation, and greener transportation options, they put sustainability first. Leading supporter of SUMPs, the European Commission encourages cities to implement them in order to lessen their negative effects on the environment, improve the quality of urban life, and increase economic efficiency (European Commission, 2019). Planning for urban mobility is a difficult and intricate undertaking. In order to contribute to European climate change and energy efficiency targets, planners must handle a variety of sometimes contradictory demands and requirements at the local level and even beyond. When there is political upheaval and, as is the case in many European nations now, there are significant budgetary limitations, the complexity rises. Reaching the energy and climate goals set by EU leaders is facilitated by a sustainable urban mobility plan. The European Commission has actively promoted it as a novel planning idea that may more sustainably and comprehensively solve metropolitan regions' transportation-related issues. Plans for sustainable urban mobility are anticipated to continue to be on the European Commission's and the Member States' policy agenda. The new idea, in contrast to conventional transport planning techniques, emphasizes the participation of residents and stakeholders as well as the coordination of policies across sectors, authority levels, and neighboring authorities. By involving residents directly, planning becomes more responsive to local needs and priorities.

Plans for sustainable urban mobility must have a long-term, sustainable vision for the city, consider the costs and benefits to society as a whole with the goal of "cost internalization," and emphasize the significance of evaluation. However, how can such a vision be realized? The process of planning has grown more difficult, and planners and policymakers now have to deal with numerous, frequently conflicting demands: preserving a high standard of living, while simultaneously fostering an environment that is desirable to businesses; limiting traffic in sensitive areas without obstructing the essential flow of people and goods; and guaranteeing mobility for everyone while dealing with budgetary limitations. Furthermore, there are more general concerns that need to be addressed, including as air pollution, noise pollution, oil dependence, climate change, and public health (European Commission, 2019b). Addressing these problems is a difficult task, especially in metropolitan regions, which are hubs of economic activity and are home to a growing portion of Europe's population. It is commonly acknowledged that in order to handle this complexity and choose the best set of policies, more integrative and sustainable planning procedures are required. Examples can be found in the Urban Mobility Observatory report (European Commission, 2019). This concept of an integrated approach is included in a sustainable urban mobility plan, which promotes the balanced growth of all pertinent modes of transportation while pushing for a move toward more environmentally friendly ones. Stronger urban mobility planning and the establishment of transport planning frameworks with a definition and/or guidelines on Sustainable Urban Mobility Plans have made some headway at the municipal and national levels. Creating and carrying out a Sustainable Urban Mobility Plan should be done in accordance with and by expanding upon current plans and procedures, not as an extra layer of transportation planning. Its idea was created with the greatest European models in mind, and all European towns and municipalities ought to incorporate it into their regular planning procedures. Furthermore, citizens must be the center of attention when planning for the future of our cities; whether they are tourists, businesspeople, shoppers, or customers in any other capacity, people must contribute to the solution: "Planning for People" is the key to creating a sustainable urban mobility plan (European Union, 2013).

2.1. Environmental Benefits

Air Quality Improvement

In cities, air pollution is a serious problem that is mostly caused by emissions from motor vehicles. Through integrated and sustainable mobility initiatives, Sustainable Urban Mobility Plans (SUMPs) are policy tools designed to reduce pollution associated with transportation (https://urban-mobility-observatory.transport.ec.europa.eu/). One of the main goals of SUMPs is to improve air quality, particularly in crowded cities where transportation emissions have a major negative influence on the environment and public health (European Commission, 2019).

In this light, SUMPs use a mix of interventions to lower air pollution:

- Modal shift: Promoting public transportation, walking, and bicycling over driving a private vehicle.
- Clean vehicle technologies include the promotion of alternative fuels, low-emission zones (LEZs), and electric vehicles (EVs).
- Traffic management is the process of minimizing congestion and improving urban traffic flow.
- Integration of urban planning: Creating small, mixed-use communities to cut down on travel times (Rupprecht Consult, 2019).

These solutions specifically target important pollutants that are heavily released by motorized transportation, such as carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM10 and PM2.5). SUMPs encourage electric vehicles, low-emission zones, and non-motorized transportation, all of which significantly reduce air pollution. Research conducted in places like Vienna and Copenhagen indicates that the adoption of sustainable transportation options lowers NOx and PM2.5 levels (Banister, 2008).

Some cities provide empirical evidence of improvements in air quality:

- Denmark (Copenhagen). Over the past ten years, there has been a discernible decrease in NO_2 levels thanks to Copenhagen's SUMP initiatives, which include clean buses and increased bicycle infrastructure. Urban NO_2 concentrations dropped by about 40% between 2010 and 2020 (EEA, 2020).
- Spain (Barcelona). Air quality improved locally as a result of the Superblocks program's deployment, which was a component of a larger SUMP strategy. According to studies, these pedestrian-prioritized zones can reduce NO_2 by up to 33% and PM2.5 by up to 25% (Mueller et al., 2024).
- United Kingdom (London). In the first year of its implementation, London's Ultra Low Emission Zone (ULEZ), which is part of the larger SUMP, reduced roadside NO_2 concentrations by 44% (Ding et al., 2023).
- Belgium (Ghent). Up to a 20% reduction in traffic-related air pollutants was observed in Ghent following the implementation of a circulation plan under its SUMP to limit automobile traffic in the city center (https://www.lez-belgium.be/en/low-emission-zones/ghent).

The World Health Organization (WHO) estimates that a 10 $\mu g/m^3$ reduction in PM2.5 concentrations can reduce the risk of cardiopulmonary death by roughly 6–15% (WHO, 2018). Health metrics have improved in tandem with cities installing SUMPs that target emissions (Nieuwenhuijsen and Khreis, 2016).

As for carbon emission reductions, SUMPs are essential for lowering greenhouse gas emissions because they promote modal changes from private vehicles to walking, bicycling, and public transportation. For instance, cities with properly implemented SUMPs saw a 15% reduction in CO_2, according to the CIVITAS program (CIVITAS, 2020).

The Effects of Better Air Quality on Health are related to major public health advantages of using SUMPs to improve air quality:

- Reduced incidence of asthma episodes and other respiratory illnesses.
- Decreased premature mortality as a result of lower exposure to PM2.5.
- Enhanced cardiovascular results.

Concluding on these aspects, SUMPs provide a thorough, empirically supported approach for lowering air pollution associated with transportation. They greatly support public health, climate goals, and urban air quality enhancements when properly planned and context-sensitive.

2.2. Social Benefits

The goal of Sustainable Urban Mobility Plans (SUMPs) is to provide inclusive, eco-friendly, and effective transportation networks. SUMPs have nu-

merous good social effects that affect both individuals and communities. Key social benefits include the following:

- Improved Public Health. Woodcock et al. (2009) state that SUMPs promote active mobility, which is advantageous for all demographic groups and is linked to increased physical activity and decreased incidence of respiratory problems, cardiovascular disease, and obesity. Better street design also reduces the number of fatalities and accidents. The main health benefits of SUMPs are lowering traffic accidents, improving air quality, and encouraging active transportation like bicycling and walking. Urban residents' physical and mental health is enhanced by these actions.
- Physical Health: SUMPs promote physical activity, which lowers the risk of chronic diseases like diabetes, heart disease, and obesity, by encouraging walking and cycling (Forsyth and Krizek, 2010). For instance, citizens of places like Copenhagen that have improved bike infrastructure have been found to be more physically active (Wanner et al., 2012).
- Mental Health: Because active transportation increases physical activity and exposes people to natural areas, it has been associated with better mental health (Kaufman, 2022). Walking and bicycling-friendly urban areas, which are frequently linked to SUMPs, lower stress and encourage social interaction, which improves general wellbeing.
- Reduction in Traffic Accidents: SUMPs that prioritize making roadways safer—such as implementing lower-speed zones and traffic-calming measures—help cut down on traffic accidents, which in turn lowers the number of fatalities and injuries. Street redesigns reduced traffic fatalities by 35%, according to a New York City study (New York City Department of Transportation, 2013).
- Enhanced Accessibility and Equity. By enhancing access for marginalized groups, such as the elderly, the disabled, and low-income communities, SUMPs seek to establish inclusive transportation systems. This objective is supported by policies like barrier-free infrastructure and reasonably priced public transportation (Lucas, 2012).

2.3. Economic Benefits

SUMPs prioritize improving social fairness, accessibility, and public health in addition to attaining environmental sustainability and easing traffic (Rupprecht Consult, 2019). SUMPs seek to establish a more fair and inclusive urban transportation system that benefits all social groups, especially the underprivileged, in light of the expanding urban population . Better public health, greater social participation, more mobility possibilities, and community cohesiveness are the categories into which the social advantages fall.

- Social equity and accessibility. One of SUMPs' most compelling social benefits is its ability to advance social fairness, particularly by giving underprivileged populations—like the elderly, low-income households, and individuals with disabilities—better access to transportation.
- Access to Opportunities: SUMPs make it easier for lower-income individuals and families to access employment, healthcare, education, and leisure activities by decreasing reliance on cars and enhancing public transportation, walking, and bicycling infrastructure. Research indicates that by enhancing the mobility of socially excluded groups, transportation policies that lessen car-centric planning directly contribute to the reduction of social inequalities (Lucas, 2012).
- Affordability: Owning a car can be expensive, particularly for families with low incomes. SUMPs can lower the cost barriers to mobility for economically disadvantaged communities by encouraging more reasonably priced public transportation and non-motorized transportation options (Pojani and Stead, 2015).
- Reduced Congestion and Travel Costs. Effective public transportation systems cut down on commuter expenses, increase productivity, and minimize time lost in traffic. According to the OECD (2015), time savings and higher land values are two ways that investing in sustainable transportation infrastructure yields significant financial rewards.
- Employment Creation and Economic Empowerment, and Urban Revitalization. Infrastructure improvements for bicyclists, pedestrian zones, and public transportation frequently result in the development of jobs in construction,

maintenance, and transit operations. Furthermore, pedestrian-friendly spaces can stimulate retail and local economies (OECD, 2024). A comprehensive SUMP that includes sustainable transport infrastructure has the potential to significantly increase employment in the transportation industry as well as indirectly in industries like urban development, tourism, and local company expansion.

- Transportation Job Creation: Planning, building, maintenance, and operations jobs are created by investments in public transportation, bike infrastructure, and electric vehicle charging stations. Local economies benefit from this, especially when public transit networks are improved or extended.
- Local Economic Development: Enhanced mobility has the potential to boost regional companies. Bicyclists and walkers have been found to spend more locally than drivers (OECD, 2024). Both social capital and small enterprises can benefit from this economic boost.
- Community Cohesion and Social Inclusion. SUMPs can significantly influence the promotion of social contact and cohesiveness within the community. SUMPs can build more integrated urban communities by planning public areas and transit systems that promote social interaction.
- Public Space and Social Interaction: By providing places for social interaction, public transportation systems and pedestrian-friendly zones help to build a feeling of community. Public areas created for bicycling, walking, and group activities promote constructive social interaction and lessen social isolation (Garyfallia and Garyfallia, 2024).
- Encouragement of Gender Equality: SUMPs frequently highlight the concerns of women, children, and other marginalized populations, like the elderly. Specifically, in places where cultural norms may restrict mobility, walking and cycling infrastructure might help women and children become more independent (Lecompte and Bocarejo, 2017).
- Community Engagement: To ensure that the opinions of diverse social groups are represented in urban planning, many SUMPs entail in-depth consultation with nearby communities. In the end, this participatory method improves community cohesiveness by fostering a sense of trust and ownership (Hickey et al., 2015).

2.4. Policy and Governance Benefits

Beyond transportation, SUMPs have governance and policy benefits that impact metropolitan regions' social, economic, and environmental fabric. Smarter, more resilient, and more livable cities are created by SUMPs, which support fair, sustainable, and efficient transportation solutions. Some of these benefits are listed hereby:

- Integrated Urban Planning. SUMPs promote cooperation between many governmental levels and sectors, including urban planning, transportation, health, and the environment. Long-term strategic thinking and coordinated action are encouraged by its integration (Rupprecht Consult, 2019).
- Public Participation and Stakeholder Engagement. Inclusive planning is one of SUMPs' defining characteristics. Public support is increased, openness is improved, and community needs are reflected in transportation systems when residents are involved in the planning process (Docherty et al., 2022a).

Notwithstanding its advantages, SUMPs encounter obstacles such institutional opposition, financial limitations, and data gaps. Local political will, administrative ability, and public involvement are frequently necessary for success (Pojani and Stead, 2015). The research, in summary, provides compelling evidence for the many advantages of sustainable urban mobility plans. SUMPs are vital instruments for promoting urban sustainability, from financial growth and better governance to benefits in the environment and public health. To reach their full potential, though, they need consistent dedication, flexible planning, and broad stakeholder participation.

3. Policy Brief for a SUMP dedicated to the elderly

A SUMP for the elderly is a strategy framework designed to enhance urban senior adults' mobility options and transit networks. Taking into consideration their unique mobility demands and challenges, it focuses on making sure older persons can move

around cities in a secure, comfortable, and autonomous manner.

The objectives of a SUMP for the elderly accessibility are to guarantee that seniors with different levels of mobility can use transportation systems. Safety, for example, is an element which helps to reduce the possibility of mishaps and give senior citizens a secure atmosphere. Independence makes it possible for senior citizens to go on their own without assistance and enhance older individuals' capacity to maintain social links and community involvement through social inclusion.

Therefore, a SUMP for the elderly aims to improve the quality of life and independence of older adults by providing a more convenient, safe, and inclusive urban mobility environment that meets their unique needs.

Here is a list of the main components that are usually present in such a plan:

1. Recognizing the Elderly's Needs and Mobility Issues: acknowledging the physical restrictions that frequently come with aging, such as decreased mobility, vision, and hearing problems.
2. Social Isolation: Discussing how elders' social isolation may be exacerbated by a lack of easily accessible transportation.
3. Safety Concerns: Pay attention to lowering the number of mishaps and falls as well as making public areas more accessible.
4. Accessible Public Transportation: Modernizing buses, trains, and trams to include larger doors, low floors, and areas for wheelchairs and walkers is an example of inclusive infrastructure.
5. Wider sidewalks, benches, extended crosswalk durations, and improved lighting are examples of pedestrian infrastructure that supports slower-moving walkers.
6. Transport Information: Using accessible formats (such as audio or big print) to provide information on transport schedules, routes, and real-time updates in a clear, understandable manner.
7. Better Mixed-Use Zones in Urban Design by promoting the growth of communities with easy access to amenities including shopping, healthcare, and recreational opportunities.
8. Resting Places: Putting up benches and shady spots along walkways and transit routes.
9. Signage and Safe Crossings and then making sure that pedestrian crossings are well-marked, safe, and have sufficient signal timings so that senior citizens can pass with ease.
10. Encouragement of Active Transportation by providing improved infrastructure, such as bike lanes and pedestrian-friendly zones, to promote walking and bicycling.
11. Mobility Assistance by offering senior-specific on-demand ride services, tricycles, and shared electric scooters as mobility options.
12. Innovation and Technology through smart transportation systems. Putting in place user-friendly applications that track accessibility to transportation, give real-time data, and provide senior-specific route planning. By combining many forms of transportation into a single app, Mobility-as-a-Service (MaaS) enables senior citizens to conveniently plan, schedule, and pay for multimodal travel.
13. Telemedicine and Remote Services: Including services that make healthcare and other services more accessible via telecommunication, hence eliminating the need for in-person travel.
14. Education and Public Awareness for Senior-Friendly Programs. Giving seniors free or heavily discounted passes for public transportation and supporting initiatives that promote bicycling, walking, or public transportation use.
15. Training and Support by providing information on accessible services, travel safety, and the advantages of active mobility to both senior residents and transportation operators.
16. Cooperation Among Stakeholders by involving senior citizens, caregivers, and advocacy organizations in the development and use of mobility solutions is known as community engagement.
17. Cooperation with Local Authorities by ensuring that health services, transportation providers, and municipal planners collaborate to develop a unified strategy that promotes senior mobility.

Therefore, Sustainable Urban Mobility Plans are a revolutionary method of planning urban transportation that places a high priority on social justice, economic feasibility, environmental sustainability, and accessibility. SUMPs provide a long-term approach to addressing many of the most urgent issues facing contemporary cities, such as traffic, air pollution, greenhouse gas emissions, and social exclusion, by

reorienting the focus from car-centric development to more inclusive, multimodal transport systems. The advantages of SUMPs are numerous and interrelated. In terms of the environment, they greatly aid in the mitigation of climate change by encouraging low-emission forms of transportation including bicycling, walking, and public transportation. Economically speaking, they improve urban mobility efficiency, lower transportation-related expenses, and, via innovation and infrastructure development, can promote the creation of green jobs. Socially, SUMPs seek to guarantee that all urban dwellers have access to secure, dependable, and reasonably priced transportation alternatives, irrespective of their age, income, or physical capabilities. Additionally, by promoting active transportation and lowering air and noise pollution, SUMPs promote healthier living. By freeing up public space from traffic jams and putting people before cars, they help enhance the general standard of living in cities. Importantly, SUMPs' data-driven and participatory approaches promote informed decision-making and local participation, bolstering democratic governance and guaranteeing that mobility plans are in line with the unique requirements and values of the communities they serve. In the end, putting sustainable urban mobility plans into action is about creating more resilient, livable, and inclusive communities for coming generations, not just about enhancing transportation. Making the shift to sustainable mobility is both essential and a chance to rethink urban living in balance with social goals and environmental constraints.

As for the elderly, in conclusion, this population segment can benefit greatly from Sustainable Urban Mobility Plans (SUMPs), which meet their specific mobility needs and improve their general quality of life. The need to create inclusive, accessible, and secure urban transportation systems for senior citizens is growing as cities around the world deal with rising aging populations. SUMPs are in a good position to establish urban settings where senior citizens can preserve their freedom, social ties, and active lifestyles because of their comprehensive and people-centered approach. SUMPs assist in lowering mobility barriers that frequently disproportionately impact older persons by giving priority to accessible public transportation, barrier-free pedestrian infrastructure, and safe cycling routes. By promoting active travel like walking, improved accessibility and design of various transportation options promote easier mobility, lower the risk of isolation, and enhance the health and wellbeing of senior citizens. Additionally, SUMPs directly reduce accidents and injuries among older pedestrians by lowering exposure to road dangers and enhancing street safety through improved urban design and traffic calming measures. In addition to being physically accessible, SUMPs foster social inclusion by giving senior citizens access to healthcare, recreational opportunities, community events, and other services. This promotes a feeling of inclusion and fights loneliness, which is a major issue for many elderly people. Economically speaking, sustainable mobility solutions enable seniors on fixed incomes better control their transportation costs and lessen their reliance on pricey private vehicles.

Crucially, SUMPs are predicated on participatory planning procedures that frequently involve senior residents, guaranteeing that their unique viewpoints and needs are incorporated into urban mobility regulations. The efficacy and relevance of mobility solutions designed for the elderly population are increased by this cooperative approach. Crucially, SUMPs are predicated on participatory planning procedures that frequently involve senior residents, guaranteeing that their unique viewpoints and needs are incorporated into urban mobility regulations. The efficacy and relevance of mobility solutions designed for the elderly population are increased by this cooperative approach.

In summary, sustainable urban mobility plans are essential instruments for developing age-friendly cities where senior citizens can live in security, autonomy, and dignity. They are not merely transportation policies. By adopting these strategies, legislators and urban planners may create settings that promote healthy aging and enhance the quality of life for senior citizens, ultimately resulting in more vibrant, sustainable, and equitable metropolitan communities for everybody.

4. Case studies

Incorporating the needs of elderly citizens into SUMPs is essential for fostering an inclusive, sustainable, and equitable transportation system. By focusing on accessibility, safety, affordability, and inclusivity, cities can create environments where older adults feel empowered to live active and independent lives (Ravensbergen et al. 2022**)**. Every element

of transport planning should consider the diverse abilities and challenges of the elderly to ensure they are not excluded from the benefits of modern urban mobility.

Excellent SUMPs that give senior citizens' needs top priority have been adopted by a number of communities worldwide. These cities have developed age-friendly, accessible, and inclusive transportation networks that promote social inclusion and environmental sustainability in addition to facilitating senior mobility. Here are several communities that can be considered as a reference for their SUMP design for senior citizens:

- Amsterdam. Regarding senior mobility and cycling, Amsterdam has concentrated on creating mobility alternatives that support senior citizens' usage of both private and public transportation. The city's bike infrastructure, which includes designated lanes, low-traffic areas, and senior-friendly bike-sharing choices, is especially helpful for seniors who still feel comfortable riding a bicycle. In terms of accessibility, the city's metro stations, buses, and trams are built with low floors, step-free access, and plenty of seats. Additionally, Amsterdam makes sure that its transportation services are numerous and on time, which is advantageous to senior citizens. In terms of social transportation, Amsterdam offers unique senior transportation options, such door-to-door buses, that make it easier for senior citizens who have mobility issues to go to necessary services (Transport Authority for the Amsterdam Region, 2023).
- Paris: The "Réinventer Paris" initiative, which is a component of the SUMP, prioritizes green areas, bike lanes, and pedestrianization. This leads to improved social interaction, reduced noise pollution, and better air quality. There are now more places for community meetings and cultural events thanks to the restructuring of the streets and public areas (City of Paris, 2024).
- Porto: The adoption of an SUMP in Porto, Portugal, which included establishing car-free zones, enhancing pedestrian infrastructure, and growing public transportation, resulted in better social inclusion, more equitable access to city services for marginalized communities, and enhanced public space accessibility (Porto City Council, 2020). Through initiatives like elevated platforms, which facilitate boarding for people with restricted mobility, the city has been improving the accessibility of its public transportation system. Seniors with vision and hearing problems can access audio-visual information on the city's bus and metro systems. Additionally, Porto has put in place a number of cooperative mobility options, such as allowing senior citizens to arrange and plan trips with help through digital platforms.
- The primary goals of the city's urban planning projects are to make sure that senior citizens can walk safely and to shorten the walking distances to important services. Senior citizens' mobility and safety are improved by well-lit streets, wide sidewalks, and benches.
- Barcelona: By reclaiming space for local businesses and pedestrians, Barcelona's "Superblocks" initiative, a crucial component of its SUMP, has improved social cohesion and air quality by reducing car traffic in a few neighborhoods. This program has increased community involvement and made communities more livable (Ajuntament de Barcelona, 2020). Further, Senior-Friendly Public transit sets discounts and preferential seating are just two of Barcelona's many programs that help senior citizens use public transit. For convenience, the city's metro stations have broad entrances, elevators, and escalators. In additions, the city prioritizes pedestrian zones and public areas over automobile traffic in order to create an inclusive urban design that makes it safer for senior citizens to go around. With regard to programs for social inclusion, Barcelona has put in place transportation initiatives that facilitate older citizens' access to healthcare facilities, community centers, and social gatherings, thus fostering social inclusion.
- Vienna. Regarding accessibility, Vienna's public transportation system is well known for being easily accessible. People with mobility issues can easily access the city's metro system, trams, and buses thanks to features like elevators, ramps, and low-floor vehicles. By installing broad, smooth sidewalks, pedestrian crossings with longer green lights, and enough seating in public areas, the city also aims to make the streets safer and more comfortable for

senior citizens. Finally, Vienna provides special services for senior persons, such as a "senior citizen ticket" that lowers public transportation fares, making mobility more accessible to the elderly (Telepak, 2015).

- Copenhagen: Copenhagen's SUMP includes widespread integration of accessible transport options, such as low-floor buses and elevators in all metro stations. The city's design is pedestrian-friendly, with smooth surfaces, well-marked crossings, and plenty of benches for resting. As for cycling infrastructure, Copenhagen promotes cycling as an option for the elderly by offering accessible bike-sharing services that can be used by older adults. The city has an extensive network of bike lanes that is also safe for seniors to navigate. As for public transport connectivity, with extensive and frequent public transport services, elderly people can easily travel to various areas, including healthcare facilities, without needing to transfer between different modes of transport multiple times Wulfhorst et al., 2022).
- Helsinki: Helsinki's Age-Friendly Mobility Plan: Helsinki has a thorough mobility strategy that incorporates senior-specific accessibility features. With easily accessible platforms and vehicles, the city's transportation system offers smooth connections between buses, trams, metro, and trains. As for On-Demand Transportation Services, the city has launched a "on-demand" transportation program that allows senior citizens to schedule transportation based on their individual need. Seniors in need of door-to-door service have found this service to be helpful. With regard to walkability and safety, to guarantee that senior citizens can walk without hindrance, Helsinki places a strong emphasis on pedestrian-friendly urban areas with short service distances, broad sidewalks, and secure crossings (City of Helsinki, 2022).
- Stockholm. The city prioritizes inclusivity by making sure that infrastructure and public transit are made accessible to all residents, especially the elderly. Platforms and stations on trains, buses, and ferries offer step-free access for people with limited mobility. With a single fare system and integrated schedules, Stockolm's well-integrated mobility system makes it simple for senior citizens to move between various forms of transportation, including buses, trains, and ferries. The city has initiatives in place to help senior citizens remain mobile and socially engaged, like offering affordable senior travel passes and setting up public transportation choices for social events and outings (City of Stockholm, 2022).
- Oslo. By adopting "universal design" principles, the city has made sure that everyone, even the elderly and disabled, can use the transportation system. This includes metro stations, buses, and trams that are accessible thanks to features like low steps and wider doors. In order to make sure that transportation planning is sensitive to the requirements of senior residents, the city's transportation policies entail extensive engagement with senior citizens and groups that represent them. When it comes to accessible and green mobility, Oslo incorporates senior-friendly green transportation options, such as electric buses that lower air pollution and pedestrian-friendly urban areas, which help elderly residents with respiratory disorders (European Commission, 2019a).

4.1. Case studies of SUMPs in Italy

In Italy with a particular focus on the elderly In Italy, several cities have developed SUMPs that prioritize the mobility needs of the elderly, aiming to enhance accessibility, safety, and inclusivity (https://urban-mobility-observatory.transport.ec.europa.eu/). Here are some notable case studies:

- Piacenza – Inclusive Mobility through SUM. Piacenza's SUMP, approved in December 2020, integrates accessibility for all citizens, including the elderly, into its core objectives. The plan emphasizes:
  - Zero-risk city: Reducing road traffic casualties, particularly among vulnerable users like pedestrians and cyclists.
  - Public space reallocation: Prioritizing walking and cycling over motorized traffic to enhance pedestrian safety.
  - Environmental improvements: Enhancing air quality and reducing noise pollution, benefiting public health.
  - These measures aim to create a safer and more accessible urban environment for elderly residents.

- Bergamo – Participatory SUMP with Elderly Focus. Bergamo's SUMP, approved in 2019, was developed through extensive public consultation, including input from elderly citizens. Key features include:
  - Traffic management: Implementing low-traffic zones and pedestrian areas to enhance safety.
  - Public transport improvements: Expanding and prioritizing public transportation options.
  - Inclusive design: Ensuring that mobility solutions cater to the needs of elderly users.
  - Participatory approach: ensuring that the voices of elderly residents were considered in the planning process.
- Palermo – Microtransit for Suburban Elderly Mobility. In Palermo, a microtransit service was designed to improve mobility for elderly residents in suburban areas. The service features:
  - On-demand transportation: Flexible routes and stops to meet the specific needs of elderly users.
  - Reduced waiting times: Ensuring timely pickups and drop-offs to accommodate the schedules of elderly passengers.
  - Affordability: Offering services at a cost comparable to traditional public transport.

This initiative aims to reduce social exclusion by providing reliable and accessible transportation options for elderly residents.

- Padova – Integrated SUMP with Elderly Accessibility. Padova's SUMP emphasizes:
  - Integrated planning: Coordinating transport, urban planning, and social services to create an inclusive mobility system.
  - Stakeholder collaboration: Engaging various stakeholders, including elderly advocacy groups, in the planning process.
  - Accessibility improvements: Enhancing infrastructure to accommodate the mobility needs of elderly residents.

The plan aims to create a cohesive and accessible urban mobility system that benefits all residents, with a particular focus on the elderly.

These case studies demonstrate Italy's commitment to developing Sustainable Urban Mobility Plans that prioritize the needs of elderly residents, aiming to create more inclusive and accessible urban environments. To sum up, these case studies of Sustainable Urban Mobility Plans offer priceless insights into how distinct, situation-specific approaches can successfully meet the particular mobility requirements of the senior population. These real-world examples, which highlight best practices, creative solutions, and real-world difficulties in developing age-friendly urban transportation networks, are essential teaching resources. Case studies illustrate how SUMPs can be customized to improve accessibility, safety, and inclusivity for older persons, who frequently experience unique mobility hurdles, by examining various strategies from various cities and regions. There are several advantages to looking at these case studies. They show how integrated planning can enhance pedestrian infrastructure, traffic control, and public transportation services to better meet the physical and mental demands of senior citizens. For example, based on successful implementations demonstrated in these studies, features like low-floor buses, well-kept sidewalks, clear signs, and sufficient seating can be modified and duplicated. Additionally, case studies demonstrate how well it works to include senior citizens in the planning phase, guaranteeing that mobility solutions are genuinely tailored to their real-world experiences. These instances highlight the social and health advantages of better mobility alternatives, which go beyond infrastructure. These advantages include decreased isolation, increased independence, and higher engagement in community life. They offer proof that, when implemented carefully, sustainable mobility strategies can greatly improve the health and standard of living of older populations. Crucially, the comparative character of case studies enables stakeholders, legislators, and urban planners to see shared issues—like financial limitations, opposition to change, or technology obstacles—and investigate creative solutions. By encouraging a culture of constant adaptation and improvement, this knowledge-sharing makes sure that future SUMPs will be more successful in satisfying the mobility requirements of senior adults. In the end, case studies are more than just reports; they serve as catalysts for advocacy and well-informed decision-making. By bridging the gap between theory and reality, they enable communities all over the world to create and execute SUMPs that put their elderly citizens' safety,

autonomy, and dignity first. Urban areas can get closer to creating genuinely inclusive, resilient, and sustainable spaces where senior citizens can flourish by taking lessons from these documented experiences.

5. Discussion and conclusions

Sumps should include the design of transport systems and urban infrastructure, which can greatly affect elderly mobility.

The Senior-Friendly Sustainable Urban Mobility Plan (SUMP) Strategies graph below (Fig. 1) offers a systematic framework to help policymakers prioritize initiatives based on their impact and implementation effort, thereby improving senior mobility. Strategies are grouped into three levels. Level 1 – Foundational / Immediate Priorities focuses on addressing basic needs, ensuring safety, and improving accessibility, including recognizing elderly mobility challenges, implementing safety measures to prevent falls and accidents, providing accessible public transport with low floors and wide doors, and enhancing pedestrian infrastructure through wider sidewalks, benches, crosswalks, improved lighting, and clear signage.

Level 2 – Social and Mobility Support aims to reduce social isolation, and encourage daily mobility through community transport programs, senior-friendly initiatives, accessible transport information (audio guidance, large-print schedules, real-time updates), rest areas, mobility assistance options such as on-demand rides and shared e-scooters, well-planned mixed-use zones with nearby shops, healthcare, and recreational facilities, and promotion of active transportation through bike lanes and pedestrian-friendly zones.

Level 3 – Technological and Systemic Enhancements targets long-term sustainability and system transformation, including smart applications and Mobility-as-a-Service platforms, telemedicine and remote services, education and awareness campaigns, training for seniors and operators, stakeholder collaboration, and multi-agency coordination integrating health and transport services. In the graph, the x-axis represents implementation effort, and the y-axis represents impact on senior mobility, with each strategy depicted as a bubble sized according to its potential positive effect.

Level 1 strategies cluster as low-effort, high-impact "starting points" (blue), Level 2 strategies require moderate effort (light blue), and Level 3 strategies involve high effort but offer transformative benefits (green).

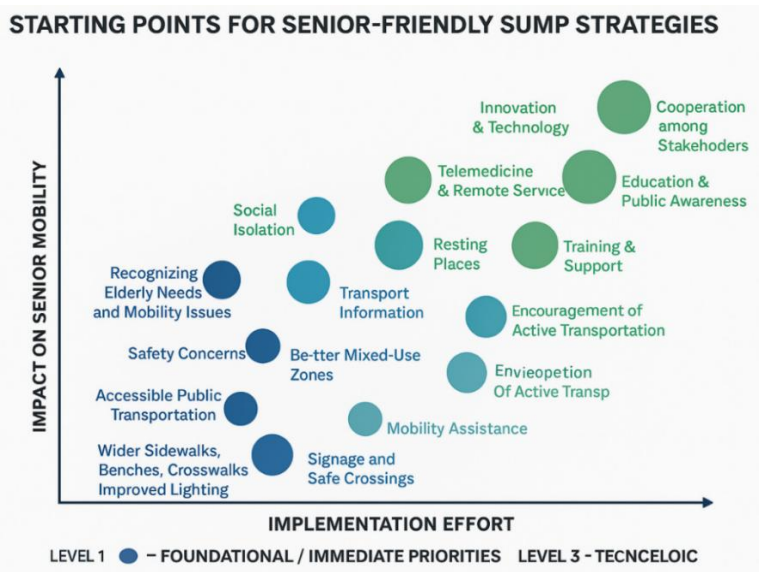

Fig. 1. Starting points for elderly-friendly SUMP strategies

The Fig. 1 clearly visualizes priorities, allows cities to start with low-effort, high-impact actions, and gradually expand toward more complex, systemic changes.

Therefore, researchers and policymakers have identified various strategies and best practices for creating inclusive transport systems for seniors. Some further suggestions are the following. According to the World Health Organization (WHO), universal design refers to creating environments that are accessible and usable by people of all ages and abilities (WHO, 2015). This includes low-floor buses, elevators, ramps, and accessible pedestrian crossings. These features are crucial for ensuring seniors can navigate transport networks independently and safely. Further, public transportation accessibility needs the availability of well-designed public transport options, such as low-floor buses and trams with step-free access, dedicated seats, and visual/audio information systems. It is essential for elderly riders. Studies have found that older adults are more likely to use public transport when these services meet their mobility needs (Bokolo, 2023). Additionally, on the basis of the presented case studies, smart mobility and technology could be very useful because technological advancements can offer solutions to improve transport access for elderly people. Apps that provide real-time information, on-demand ride-sharing services, and mobility as a service (MaaS) platforms tailored for seniors are examples of innovations aimed at improving elderly mobility (Maas, 2022). Moreover, the rise of autonomous vehicles presents new opportunities for elderly transport, though challenges remain regarding trust, accessibility, and affordability. Another crucial element is the age-friendly urban planning as urban areas that are designed with the elderly in mind—such as with wider sidewalks, benches, safer pedestrian crossings, and more accessible shops—enable seniors to navigate their environments more easily. The Age-Friendly Cities movement, led by the WHO, advocates for urban planning strategies that ensure the physical and social environments support aging populations (WHO, 2018), and SUMPs are one of the most powerful tool.

While traditional public transportation plays a vital role, there is growing interest in exploring alternative and supplementary modes of transport for elderly populations. Some examples are linked to shared mobility services like car-sharing, bike-sharing, and micro-mobility services like electric scooters which have been explored as potential solutions for elderly mobility. Research indicates that these services can be beneficial when they are adapted for elderly users, such as through vehicles with more accessible seating or modified bikes for seniors. Another solution can be On-Demand Ride Services. In this case ride-hailing platforms like Uber and Lyft have also started providing specialized services for elderly passengers, including vehicles that accommodate wheelchairs and walkers. Such services offer flexibility and convenience for seniors, especially when public transport schedules do not align with their needs (Shi et al., 2023). In addition Autonomous Vehicles (AVs) can be finalized for the elderly. The development of autonomous vehicles (AVs) could provide a transformative solution for elderly mobility, allowing seniors to travel without relying on others or traditional public transport. While AVs hold significant promise, concerns about safety, accessibility, and public acceptance remain barriers to widespread adoption (Rahman et al., 2020).

The aging population poses significant challenges for urban transportation systems, as older adults often face mobility limitations due to physical, cognitive, and environmental factors. However, with the right policies, design solutions, and innovations, cities can create transport systems that foster independence, enhance social inclusion, and improve the quality of life for seniors. In this light key takeaways from the literature include inclusive transport infrastructure which is critical for addressing the mobility needs of the elderly, including accessible public transport, improved pedestrian facilities, and smart technologies. Further, social and health benefits of mobility are substantial, as access to transport enables seniors to stay engaged in society, access healthcare, and maintain physical activity levels. Additionally, innovative solutions, such as shared mobility services and autonomous vehicles, offer promising avenues for improving elderly mobility but require further development and adaptation to meet the specific needs of older adults.

As the population ages, transportation systems need to be rethought and incorporated into Sustainable Urban Mobility Plans (SUMPs) to meet the many and changing demands of senior citizens and keep them socially engaged, active, and independent.

Promising frameworks for improving urban mobility that solve some of the present drawbacks of traditional networks are provided by Mobility as a Service (MaaS) and Mobility on Demand (MOD). These developments can improve elderly citizens' accessibility, convenience, and social inclusion by combining various types of transportation into smooth digital platforms and offering responsive, adaptable services.

However, certain limits must be recognized. With no empirical data on long-term adoption trends, user happiness, and overall efficacy for older people, a large portion of the present research on MaaS and MOD is still exploratory or based on pilot studies. Generalizing results is further complicated by the diverse demands of senior adults, which are influenced by variables like income, health, computer literacy, and geographic location. Furthermore, the potential advantages of these systems may be limited by structural issues, including unequal access in rural or peri-urban areas, affordability issues, digital exclusion, and data privacy hazards. MaaS and MOD's scalability and sustainability for senior users are still in doubt in the absence of strong institutional support and legal frameworks.

Notwithstanding these limitations, the results offered here have the potential to significantly impact transportation planning and policy. This study emphasizes the significance of putting older persons at the forefront of mobility innovation by highlighting the necessity of inclusive design, user-friendly technologies, and accessible support systems. Policymakers and planners may better predict demographic changes, lessen mobility disparities, and make sure that transportation networks are built with resilience and inclusivity in mind by incorporating these information into SUMPs. Additionally, sharing best practices can hasten the adoption of successful tactics and assist in decision-making in various urban contexts through targeted guidelines, cross-city comparisons, and the methodical evaluation of pilot initiatives.

Longitudinal studies that evaluate the true effects of MaaS and MOD on older individuals' mobility behaviors, well-being, and social participation over time should be the main focus of future research. To comprehend how geographic and infrastructural factors influence results, comparative studies across various urban, peri-urban, and rural contexts are required. Participatory methods, including co-designing services with senior citizens, can help promote inclusivity and trust while offering insightful information about user preferences and adoption hurdles. Developing scalable and sustainable solutions will require investigating the effects of MaaS and MOD integration on the economy and environment, as well as the relationship between social justice and technical innovation.

In the end, MaaS and MOD should be viewed as developing tools within a larger ecosystem of mobility services rather than as panaceas. In order to successfully include them into transportation planning, politicians, service providers, and end users must work together consistently and pay close attention to institutional, technological, and social impediments. Cities may get closer to developing age-friendly, flexible, and equitable mobility systems that promote older persons' independence, well-being, and social engagement by resolving existing constraints, encouraging information sharing, and furthering focused research.

Acknowledgement

This study was carried out within AGE-IT – Ageing well in an ageing society and received funding from Next Generation EU, in the context of the National Recovery and Resilience Plan, Investment PE8 – Project Age-It: “Ageing Well in an Ageing Society” [DM 1557 11.10.2022]. This manuscript reflects only the author' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

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