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Social Justice, Senior Mobility, and Sustainable Development in the Transportation Sector

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Abstract. In light of the United Nations Sustainable Development Goals (SDGs) and the world's aging population, achieving sustainable mobility for older individuals has emerged as a top policy goal. Even while inclusive mobility is a key component of many national and regional initiatives, there is still a continuous disconnect between these lofty goals and the practical capacity to measure and carry them out. By putting out a scientific framework for assessing the sustainability and equality of transportation systems for senior citizens, this research fills this gap. The paradigm, which is based on social justice and economic rationality, uses specific metrics to evaluate the spatial distribution of mobility resources, service accessibility, and infrastructural adequacy. The study illustrates how inclusive transport plans can increase accessibility, lower dependency costs, and promote active aging by drawing on European experiences, such as integrated mobility services in Nordic nations and accessibility-enhancing initiatives in the Netherlands and Germany. The suggested paradigm gives policymakers an evidence-based instrument for coordinating transportation investments with the SDGs' pledge to "leave no one behind" and facilitates rigorous comparisons across regional contexts. This strategy achieves the goal of sustainable development through transportation policy by combining the social, spatial, and economic aspects of mobility fairness.

Keywords: Sustainable mobility; social justice; senior mobility; transport equity; accessibility; ageing population; Sustainable Development Goals; European transport policy.

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INTRODUCTION

The importance of older individuals' mobility in advancing social justice and sustainable development agendas is becoming more widely acknowledged. The world's population is aging faster than ever before; by 2050, one in six individuals will be 65 or older, up from one in eleven in 2019 [1]. Within the same timeframe, the proportion of individuals in Europe who are 65 and older is predicted to approach 30% [2]. It is becoming both a public policy priority and a moral obligation to make sure that transportation systems continue to be accessible, inclusive, and equitable for older persons as the demographic structure changes.

Seniors' well-being is greatly impacted by mobility, which affects their ability to access vital services, social contact, healthcare, and leisure [3] [4]. Social isolation, a lower quality of life, and a decline in one's physical and emotional well-being might result from a loss of mobility [5]. Therefore, the capacity of older people to move freely

and safely is essential to their general autonomy and social engagement and is not just a transportation concern [6]. The United Nations Sustainable Development Goals (SDGs), specifically SDG 3 (Good Health and Well-Being), SDG 10 (Reduced Inequalities), and SDG 11 (Sustainable Cities and Communities), are inextricably linked to senior mobility from a policy standpoint [7].

However, transport planning and sustainability frameworks have tended to prioritize economic efficiency and environmental performance, frequently ignoring the social justice dimension, despite the growing identification of age-related mobility demands [8] [9].Vulnerable groups, notably older persons, have been disproportionately affected by the ongoing disparities in accessibility and service delivery brought about by this imbalance. This problem is made worse by the lack of reliable assessment instruments for gauging and tracking transport equity, which makes it more challenging for legislators to methodically address elderly citizens' mobility requirements within sustainability agendas.

In transportation, social justice is based on equitable allocation of mobility resources, opportunities, and services [10]. At the heart of this discussion are two interconnected ideas: resource equity and spatial equity. The balanced geographic distribution of infrastructure and transportation services is known as spatial equity, and it guarantees that no one is disadvantaged because of where they reside [11]. Regardless of age, income, or physical ability, everyone has the universal right to access mobility possibilities, which is known as resource equity. When taken as a whole, these ideas serve as the foundation for determining how inclusive and equitable transportation systems are.

While policy frameworks like the European Union's Sustainable and Smart Mobility Strategy [12] recognize the importance of inclusive mobility, they frequently fall short in offering particular operational instruments to assess equality outcomes for elderly citizens. Because of this, there is still a disconnect between strategic pledges to promote inclusion and the practical capacity to measure and implement them.

The analytical framework for evaluating the sustainability and equality of transportation networks for senior citizens is proposed in this research to close this gap. By evaluating infrastructure sufficiency, service accessibility, and the geographical distribution of mobility resources using a set of specific indicators, the framework incorporates social justice concepts into the assessment of sustainable mobility. By using this strategy, policymakers may integrate transportation policy with the SDGs' promise to "leave no one behind" and conduct rigorous benchmarking across various geographical settings that is supported by data.

LITERATURE REVIEW

According to demographic estimates, the proportion of older persons in most countries is expected to increase at a high rate in the coming years, which has heightened scholarly interest in the link between population ageing and sustainable mobility during the past 20 years [1] [2]. Seniors' mobility is a determinant of social inclusion, environmental responsibility, and economic resilience [4]. Recent studies place these trends within the larger sustainability transition, whereas early research on older adults' mobility focused primarily on their travel behavior, noting declining trip frequency, increased reliance on private cars, and heightened vulnerability to mobility loss [3] [6]. [13, 14]. Health, autonomy, and quality of life are all strongly correlated with mobility; a lack of mobility frequently results in social isolation, less community involvement, and worse health outcomes [5, 15, 16]. These concerns are strongly related to the Sustainable Development Goals (SDGs) of the United Nations, including SDG 3 (Good Health and Well-Being), SDG 10 (Reduced Inequalities), and SDG 11 (Sustainable Cities and Communities) [7]. The fair distribution of mobility opportunities and resources is referred to as "transport equity" in the context of social justice. Scholars like Lucas [8] have highlighted social exclusion related to transportation as a structural barrier, while Martens [10] has defined transport justice as the provision of equitable accessibility. This topic revolves around two interconnected equity dimensions: resource equity, which deals with equal access regardless of socioeconomic level, age, or ability [9] [6], and spatial equity, which is related to the equitable geographic deployment of infrastructure and services [11]. Inequities in any dimension can result in concrete obstacles for seniors, such as inadequate service coverage, inaccessible infrastructure, or expensive fares; research indicates that these obstacles are frequently exacerbated in suburban, rural, and peri-urban locations [17] [18] [19]. Since app-based transportation solutions run the danger of excluding older persons who are not comfortable with digital technology, more recent research also emphasizes the significance of digital inclusion in mobility systems [20] [21].

Although several approaches have been presented, such as accessibility modeling [22], composite indices [23], and GIS-based equity mapping [24], few are suited to older populations or in line with SDG monitoring frameworks, making it difficult to measure transport equality for seniors methodologically. Therefore, researchers have urged for new indicator-based approaches that combine qualitative impressions (safety, comfort, affordability, and usefulness) with quantitative measurements (distance to transport nodes, service frequency, and infrastructure accessibility) [25]

[26] [27]. Although the need for inclusive mobility is acknowledged by initiatives like the European Union's Sustainable and Smart Mobility Strategy [12], there are currently no reliable measures for assessing equality in its operationalization. This highlights the need for SDG-aligned frameworks that can capture the intricate interactions between mobility, aging, and social justice, as well as a continuing policy–practice gap [28] [29] [30]. The creation of such frameworks will facilitate evidence-based legislation that guarantees the equitable distribution of the advantages of sustainable mobility and prevents older persons from falling behind in the continuous shift to accessible, low-carbon transportation networks.

METHODOLOGICAL FRAMEWORK RATIONALE

Even with broad strategy pledges to advance inclusion in transportation systems, there is still a big disconnect between these lofty objectives and the real-world capacity to assess and provide fair mobility results, especially for senior citizens. Because seniors' limited mobility might result in higher healthcare expenses, lower labor market involvement, and worse economic production, this mismatch has significant economic ramifications [31] [32]. Additionally, social exclusion is made worse by transportation disparities, which can put a burden on public welfare systems and reduce the economic contributions of aging populations [33]. Effective resource allocation and long-term economic planning are hampered by the lack of practical instruments for evaluating equality, even as governments are beginning to recognize the significance of inclusive and sustainable transportation. The difficulties and possibilities of putting inclusive mobility policies for senior citizens into practice are demonstrated by European experiences. For instance, a number of Nordic nations have made investments in integrated mobility services that combine demand-responsive choices with conventional public transportation, showing increased accessibility and senior user satisfaction [34] [35]. Furthermore, by removing physical accessibility obstacles that are typical of older people, metropolitan regions in the Netherlands and Germany have implemented sophisticated infrastructure modifications, such as priority pedestrian zones and low-floor buses, that improve mobility equity [36] [37]. In order to maximize transport equality outcomes, these case studies highlight the significance of regionally specific approaches that take social, economic, and geographical conditions into account. By putting out a thorough analytical framework intended to analyze the sustainability and equality of transportation systems, particularly for aging populations, this research aims to close the crucial gap between strategic objectives and practical evaluation. In order to ensure effective investments that maximize social returns, the framework, which is based on social justice principles and economic rationality, uses a set of targeted indicators that capture various aspects of mobility equity, such as the spatial distribution of transport resources, service accessibility, and infrastructure adequacy [38] [20]. The methodology enables systematic benchmarking across various geographical and socio-spatial settings by combining these variables into a single evaluation technique. This helps policymakers uncover inefficiencies and enhance transportation service in accordance with economic sustainability goals. As a result, it provides policymakers with a strong, evidence-based tool to track developments and improve alignment of transportation policies with the overarching goal of the Sustainable Development Goals to "leave no one behind," thereby promoting social justice, economic efficiency, and sustainable mobility for older adults. Such frameworks are becoming more and more important to support fair, cost-effective transportation expenditures that encourage economic engagement and well-being among older people, especially in light of demographic aging and increasing public spending demands [39] [35].

In order to operationalize the evaluation of transportation equality and sustainability for older individuals, this article suggests a methodological approach. The framework incorporates social justice concepts into a multifaceted assessment structure that includes the spatial distribution of transportation resources, service accessibility, and infrastructural adequacy. A thorough assessment of transportation systems for senior citizens is made possible by the fact that each component captures a unique aspect of sustainability and justice in transportation.

Infrastructure Adequacy. It alludes to the facilities and physical attributes that allow elderly people to move around safely, comfortably, and independently. Assessing the existence, caliber, and upkeep of age-friendly transportation infrastructure is part of measuring this component. The proportion of low-floor buses and trams that allow step-free boarding, the availability and state of ramps and elevators in train and metro stations, the existence of clearly marked curb cuts and pedestrian crossings, and the size of barrier-free sidewalks and pathways are some important indicators. The application of universal design standards, such adequate lighting and auditory cues at crossings, may also be measured to evaluate inclusivity. Data on these factors—which include the physical attributes and amenities that allow older people to move around safely, comfortably, and independently—can be obtained through field surveys, accessibility audits, and infrastructure inventories carried out by transport operators. Assessing the existence, caliber,

and upkeep of age-friendly transportation infrastructure is part of measuring this component. In order to assess inclusiveness, it is also possible to quantify the use of universal design requirements, such as sufficient illumination and aural indications at crossings. Field surveys, accessibility audits, and infrastructure inventory conducted by transit operators can all provide data on these factors.

Service Accessibility. In terms of price and usefulness, it measures how well transportation services satisfy the mobility requirements of senior citizens. This dimension's indicators include the availability of demand-responsive transport services with flexible routing and scheduling, which are essential for older adults with limited mobility or who live in less populated areas; fare affordability, which is frequently expressed as the percentage of pension income needed for monthly passes or average trip costs; and service frequency and operating hours, which represent temporal accessibility. The proportion of transportation routes that directly link residential areas with important services like medical facilities, community centers, and business hubs is another metric. These metrics can be obtained via user surveys, service provider reports, fare structures, and transportation schedules.

Spatial Distribution. It discusses the spatial equality of transportation resources, emphasizing the distribution of mobility services and infrastructure among various socioeconomic categories and between urban and rural locations. The ratio of accessible transport services between urban centers and peripheral or rural areas, the average walking distance to the closest accessible transit stop, and the density of accessible transport stations per square kilometre are a few examples of spatial equality indicators. In order to map and quantify these variables and identify underserved regions and inequities in resource distribution, Geographic Information Systems (GIS) and spatial analytic techniques are essential. The geographical assessment is further enhanced by metrics of service overlap and connectedness across modes, which show the levels of integration necessary for smooth senior mobility.

By enabling rigorous benchmarking across areas, these metrics help policymakers prioritize measures, find gaps, and exchange best practices. The framework offers an evidence-based basis for coordinating mobility investments with social fairness, environmental sustainability, and economic efficiency by placing it within the larger SDG agenda. Importantly, the framework supports focused policy action to increase older persons' mobility by being flexible across governance levels and integrating into national and local transport evaluation systems.

CASE STUDY: APPLYING THE FRAMEWORK TO THE ITALIAN CONTEXT

Infrastructure Adequacy

Italy makes a strong argument for looking at how social justice, elder mobility, and sustainable transportation policy connect. Since 21% of Italians are 65 years of age or more [40], the country has one of the oldest populations in Europe, making it a crucial policy problem to provide fair mobility for the elderly. According to demographic forecasts, the population will continue to age, which will have a significant impact on social involvement, health care demand, and mobility requirements [41].

The availability of senior-friendly infrastructure in Italian urban transportation systems varies greatly. Many medium-sized cities and rural regions still lack complete accessibility measures, despite the introduction of low-floor buses, step-free metro stations, and pedestrian-friendly zones in bigger metropolitan centers like Milan, Turin, and Bologna [42]. Regional differences between the less accessible rural parts of the south and the more developed northern regions are especially noticeable. Funding for improving public transportation fleets and station accessibility is included in national transport investment plans (Piano Nazionale di Ripresa e Resilienza, PNRR) [43] [44], however implementation schedules are still inconsistent [45].

Service Accessibility

For older persons in Italy, service dependability, price, and frequency continue to be major issues. Although most areas provide discounted fares to seniors, service coverage is restricted outside of large metropolitan centers, particularly on weekends and evenings [46]. In areas like Emilia-Romagna and Lombardy, demand-responsive transport services have been tested and have demonstrated promising outcomes in enhancing mobility for those with diminished physical ability [47]. Concerns over long-term viability are raised by the fact that they are still localized and frequently rely on municipal funds.

Spatial Distribution of Mobility Resources

A continuous north-south split is revealed by geographic fairness in mobility services. While many rural villages in central and southern Italy continue to rely on private vehicles and sporadic bus services, northern urban regions enjoy the advantages of integrated transportation systems with high connectivity and multimodal alternatives [48]. Seniors who live alone or have limited access to family support networks are most affected by this geographical imbalance.

Economic and Social Implications

There are significant social and economic repercussions associated with mobility exclusion among Italian elders. Inadequate accessibility worsens health disparities, decreases economic activity, and increases reliance on social welfare programs [49]. On the other hand, by facilitating access to preventative healthcare and active aging, investments in accessible transportation have been demonstrated to increase social engagement and lower public health spending [46]. According to economic modeling conducted by the European Commission in 2022 [35], every euro spent on easily accessible public transportation yields benefits in the form of higher wellbeing, lower care costs, and improved productivity.

Framework Application and Policy Relevance

The suggested methodological framework has both advantages and disadvantages when applied to Italy. Although demand-responsive transport has shown promise advances in service accessibility, coverage is inconsistent; long-standing regional imbalances continue to impair spatial fairness; and infrastructure adequacy is increasing in metropolitan regions but remains inadequate in rural situations.

According to this research, a three-pronged approach is needed to connect Italian transport policy with the SDGs:

• Increasing demand-responsive transport models to supplement fixed-route services; • Quickening accessibility improvements in small and medium-sized cities and rural transportation hubs;

• Including spatial equality goals and SDG-aligned performance metrics in regional and national transportation planning.

Italy is a perfect place to operationalize this paradigm because of its demographics and current transportation inequalities. Policymakers may better target investments and guarantee that senior mobility is not left behind in the larger shift to sustainable transportation by methodically analyzing infrastructure adequacy, service accessibility, and spatial equality.

CONCLUSION AND POLICY IMPLICATIONS

With an emphasis on older persons, this study aimed to bridge the ongoing gap between policy goals for sustainable, inclusive mobility and the ability to quantify and operationalize these commitments in real-world settings. The research shows a feasible way to methodically evaluate infrastructure sufficiency, service accessibility, and spatial equity in transportation provision by creating and implementing a methodological framework based on social justice principles and in line with the Sustainable Development Goals of the UN. The application highlights both noteworthy accomplishments and systemic flaws in Italy, a nation with one of the oldest populations in Europe. Even though cities like Milan, Bologna, and Turin have made noticeable strides in implementing accessible infrastructure and testing out cutting-edge demand-responsive services, many rural and southern areas still suffer from persistent underinvestment, poor service coverage, and poor intermodal integration.

Evidence from an economic perspective indicates that enhancing elder mobility has advantages that extend well beyond the transportation industry. Through more frequent preventive healthcare visits and increased physical activity, improved accessibility helps older persons to engage more fully in social, cultural, and economic life, which lessens their reliance on formal care systems and lowers healthcare costs. According to European economic modeling, accessible public transportation expenditures have a high social return, with every euro spent generating long-term savings through lower care costs, higher caregiver productivity, and enhanced community resilience. These returns are not just a social need but also a strategic economic requirement for Italy, as the country's aging population is predicted to increase financial strains on its healthcare and welfare systems.

The study's conclusions suggest a well-defined policy agenda for promoting sustainable and equitable senior mobility in Italy and, therefore, throughout Europe. Beyond broad pledges to promote diversity, transport policy has to incorporate quantifiable accessibility goals into regional and national mobility plans. Strong monitoring systems that can follow changes over time and pinpoint areas of persistent underperformance should be in place to support these goals. The idea of "leaving no one behind" runs the danger of staying a lofty goal rather than a real result in the absence of such data-driven supervision.

Regional and territorial inequities should be specifically addressed in strategic investment planning. This means that national funding sources in Italy, especially those associated with the Piano Nazionale di Ripresa e Resilienza, should focus on bridging the accessibility gap between urban and rural regions and lessening the long-standing north-south split. In order to ensure that physical improvements like low-floor buses and accessible stations are matched with adaptable, demand-responsive services that can satisfy the various demands of scattered people, policy design should favor strategies that integrate infrastructure modernization with service innovation.

Furthermore, planning for transport equity should incorporate economic research as a key element. Inaction has both social and financial costs: older persons who have less mobility spend more on healthcare, are more dependent on social assistance, and are less involved in the society. On the other hand, it has been demonstrated that focused investments in accessible transportation produce significant social benefits, enhancing both the standard of living for senior citizens and the effectiveness of public spending. The political and economic case for long-term action may be strengthened by policymakers by portraying mobility inclusion as an investment with quantifiable economic returns.

In the end, the transition to a sustainable, equitable transportation system for senior citizens necessitates a comprehensive policy vision—one that acknowledges mobility as a fundamental component of economic resilience, community cohesion, and active aging. Policymakers may operationalize that vision with the help of the analytical framework this study presents, which makes it possible to match strategic promises with specific, quantifiable actions. By doing this, Italy and Europe as a whole can turn senior mobility from a side issue into a key component of sustainable development strategy.

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