

CONCEPT OF ACCESSIBILITY IN SUSTAINABLE TRANSPORT: CRITERIA AND PERSPECTIVES

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ABSTRACT

In today's world, accessibility is considered a key and complementary criterion while increasing the stability of a transportation system, in addition to the importance of proper density and spatial distribution of people and activities and land use development, which is known as urban policy and services and it is also considered a precondition for economic development. Although accessibility has been extensively explored in recent decades, transportation planners still face many challenges. Therefore, it is important to know the factors and criteria affecting access in each time period. These criteria can include mobility, quality and cost-effectiveness of transportation, the connection of transportation systems, mobility alternatives, land use patterns and socio-economic characteristics that can affect the concept of access differently; on the other hand, a more comprehensive study of accessibility can increase the range of potential solutions to transportation problems. The present study provides a general but comprehensive overview of the various dimensions and indicators of access in the form of a literature review. The results show that there is a lot of interaction with the goals of integration and sustainability, which can be achieved under the key elements. The first element is the selection of techniques that can be presented in the light of evaluation along with specific and clear objectives that can be achieved in practice and reflect their ease. The second element is the use of techniques to provide sufficient indicators according to regional patterns, taking into account all objectives, of course, as general performance indicators that are not limited to social justice. Perhaps one of the effective options is the use of visualization tools. It means using maps that provide solutions. It provides a link between transportation gaps and benefits where access-based criteria can potentially influence transportation decisions. Also, the findings show that to strengthen the accessibility goal, accessibility indicators should be clearly considered, and a distinction should be made between this concept and mobility in transportation planning.

Keywords: accessibility, criteria, transportation, land use, socio-economic dimensional.

1 INTRODUCTION

Accessibility is a concept of continuous relevance in transportation research and has been raised as an essential goal in planning in recent years. This concept is increasingly seen as an alternative to the planning and directional mobility paradigm [1] because it allows for the complex interactions between land use, transport and socio-economic conditions to provide a wholesome social view of transport [2].

It is also stated that better access reflects the socio-economic benefits of the network, that is, in terms of land values and quality of life. Because it seeks to establish fair access for all population groups to additional services such as health care [3]. Access to transportation is an essential driver of urban growth and the key to the sustainable development of cities. The growing interest in this development has emphasized the importance of accessibility as a key indicator for evaluating urban transport investment and urban form; that is, it can link land use and transport together and thus provide a basis for comprehensive and integrated policies to include coordinated actions on a daily basis simultaneously [4]. Accessibility to businesses, services, and other destinations of interest has long been recognized as key to sustainable transportation development and essential spatial planning strategies [5]. Increasing emphasis is also placed on this key indicator of economic development, as the movement of people, goods, and environmental goals such as reducing emissions of



greenhouse gases and pollutants from different modes of transportation and how they are used to support economic performance, it is considered essential and effective. Hence it makes effective performance in the economy possible [6].

On the other hand, based on accessibility and its interaction with sustainability, Hansen [7] shows a strong correlation between the accessibility of an area within the city and its ability to attract urban development or investment and is stated that with regard to social equality, economic, development and environmental effects of accessibility as a key element in urban sustainability should be considered.

2 METHODOLOGY OF THE LITERATURE REVIEW APPROACH

A systematic literature review and articles were used to complete this article that was selected based on their importance, relevance to the purpose of the article, and publications of recent years have been used, and then a brief overview of the obtained results was made. This selection of bibliographic sources is based on authoritative publications such as Marwal and Silva [8], Kelobonye et al. [9], Siddiq and Taylor [10] and Bivina et al. [11]. It can be said that one of the most important articles in the field of accessibility belongs to Marwal and Silva [8], who reviewed the accessibility literature in the last 5 years. However, according to the purpose of this article, which is not a comprehensive review of all articles related to access, and considering that the evolution of cities is always accompanied by many challenges and in recent years, it is moving more and more toward achieving sustainability. The concept of accessibility is not an exception to this rule and is changing with a new definition, so based on sustainability goals, we seek to know the new era of accessibility and its indicators. In this regard, from the key concepts (access, access criteria, sustainable mobility) based on the topic, a research was conducted in Google Scholar, Gate Researcher, Scopus or Academia.edu to obtain the necessary information. Therefore, the search was limited by the article's aim to collect approximately 107 publications (e.g., articles, books, dissertations). The selected publications mainly focus on documents published since 2007 (Fig. 1).

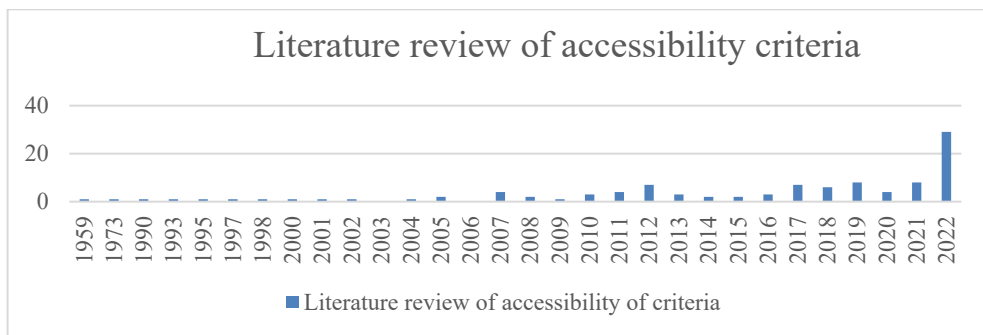


Figure 1: Year of publication of the 107 documents selected in the literature review of accessibility criteria.

3 THE CONCEPT OF ACCESSIBILITY AND ITS TYPES

There are several definitions of accessibility in the literature. However, a general definition by Wachs and Komagai [12] states that accessibility is the ease or difficulty with which opportunities (for example, employment) or services can be obtained from a place. Geurs and

van Wee [13] define accessibility as the ability to reach activities or destinations by an individual or a combined mode of transportation. Accessibility is the effort necessary to overcome spatial and spatial separation (e.g., Paez et al. [48], Merlin and Hu [27], Litman [15], Halden [22]), and it usually reflects the utility (e.g., home to work) associated with travelling to places [14].

Accessibility is defined as the potential to achieve distributed opportunities (employment, recreation, social interaction, etc.), and it can be considered one of the primary spatial outputs and the joint result of the transportation network and the geographical distribution of activities (e.g., Geurs and van Wee [13], Papa and Coppola [25], Lucas et al. [46], Pajares et al. [36]), In other words, accessibility can be seen as the ease of obtaining services and activities [15]. According to this definition, accessibility depends to a large extent on the spatial distribution of destinations, the land use component and the ability to move from one place to another, and the transportation component [13]. The concept of access in a suitable framework for achieving sustainable land use and transportation system and environmental and climate concerns has been of special importance (e.g., Kinigadner and Büttner [44], Banister [42], Levine et al. [41], Siddiq and Taylor [10]). This concept provides a suitable framework for integrated land use and transport planning and is a key factor in achieving sustainable mobility [16], [17]. Based on one of the long-standing concerns of researchers, they find it is useful for informing basic urban planning and policies (e.g., Proffitt et al. [20], Halden [22], Delbosc and Currie [47]).

3.1 Types of accessibility

According to the literature, accessibility can be divided into three categories: accessibility to public transportation, auto accessibility, and transportation. As already mentioned, accessibility has been raised as a significant goal in recent years, but one of the most important challenges is the lack of sufficient knowledge about public transport and automated access, even when who decide where to live and value it differently (e.g., Foth et al. [3], Ariza-Álvarez et al. [49], Levine et al. [41], Cervero et al. [31], Nasri and Zhang [29]).

Despite this, it has been stated that all three types of access are essential determinants in choosing a residential location, and transit access has a statistically significant and positive effect. In the case of automatic access, the results show that commuting time with automatic mode has the most significant impact among these three variables and is independent, but access to non-work destinations seems to be of little importance (e.g., Næss et al. [32]). Research also states that due to restrictions such as housing supply, households are often forced to live in neighbourhoods with a lower level of accessibility than they prefer.

This point shows the undeniable influence of access in the culture of people's lives. Therefore, transportation planners should pay more attention to this concept and pay attention to existing inconsistencies. From an equity point of view, comparisons between types of access for different modes of transport are needed [18] because, on the one hand, the car tends to provide significant levels of access in most urban areas. On the other hand, according to the concept of sustainable urban development, access to cars due to the globalization of car ownership and use barriers (costs, legal requirements and physical ability) and in the environmental dimension (greenhouse gas emissions and energy consumption). Has undergone many changes, especially in recent years with the emergence of alternative methods. Therefore, it is necessary to compare types of access at the regional level because it provides insight into the level of access of people or households without cars at a level comparable to people who own cars in the same area.

4 MOBILITY AND ACCESSIBILITY

A growing number of transportation planning researchers and practitioners are discussing the shift from mobility-based planning to accessibility-focused planning, as accessibility is an alternative approach to mobility-based planning. Accessibility is a compelling concept that is more difficult to operationalize than mobility, which many accessibility criteria have been developed to explain, thereby making accessibility-based planning more efficient and taking into account active public transport and inclusion. These criteria use policies that reduce the distance between activities [19].

Accessibility captures the complex interactions between different perspectives, while mobility simply reflects the ease of movement and ease of reaching desired destinations, which is actually the reason people want to travel [20]. Accessibility in the literature is one of the most comprehensive measures to evaluate a region's complex functions of land uses and transportation systems. In this regard, it has been mentioned as a factor in reducing the use of cars, which increases social equality and supports economic development. In a study to quantitatively assess America's transportation, Proffitt et al. [20] found that accessibility is increasingly included in plans, especially in large metropolitan areas, but is still marginally addressed compared to mobility.

Similarly, in an evaluation of four plans in California, Handy [21] found that programs based on mobility were created. However, these plans also addressed some concerns about access. In the UK, accessibility was also widely discussed and used, mainly due to the creation of accessibility programs that were designed and implemented at the behest of the government [22]. But still, with all interpretations, the practical implementation of limited access remains.

Another article evaluated 32 urban transportation plans from North America, Europe, Asia and Australia. According to the goals and performance indicators of access, the results showed that there is a tendency towards greater integration of access. However, still, few plans showed access-based indicators that can guide the decision-making process. Therefore, it has been stated that by strengthening the approach based on equal access to transportation, programs should clearly define the goals of access and differentiate between access and mobility. Hence, indicators need to guide the decision-making process [23].

5 ACCESSIBILITY CRITERIA

In the literature, many researchers have studied access indicators. For example, many of the indicators identified by Handy and Niemeier [24] were still valid at the time of the Geurs and van Wee review [13], including the need to improve land use and transportation assessment. Accessibility index in a wide base of theoretical, operational, interpretability and communication capabilities open the way to be used for evaluation purposes. Some of these criteria are normative and are justified according to how much people should travel or how much travel is reasonable for people. Some are based on positive accessibility that can be understood in terms of the distance that people actually travel, or in other words, normative accessibility. It is defined in terms of an expectation from an analyst or policy maker, but positive access is defined as the actual experiences of people who pass through the space to engage in outdoor activities.

What has been shown in the literature, accessibility with four prominent indicators, can be seen and investigated in all studies. Geurs and van Wee [13] illustrate the indicators well and consider and distinguish four accessibility criteria: transportation index, land use index, time-based index and person-based component. Some of these indicators include several other subcategories to be complete, so it should be noted that the research and application of



these indicators are fundamental. On the other hand, it requires sufficient knowledge and awareness in this field.

5.1 Criterion based on location and land use

The first discussed index is the location-based index which includes land use and housing. This component includes the distribution of different types of uses in space, which is defined in terms of quantity (residential density, employment) and quality (level of employment, value of housing or the importance of services such as large hospitals and educational and cultural institutions). Measures based on this index provide insight into locations (for example, the number of jobs within 30 minutes of the place of origin).

This measure is mainly used by policymakers because it provides comprehensive measures of land use and transportation at the regional level and by location. As a central indicator of location advantage, this index is the primary measure of land use and transportation performance; on the other hand, accessibility based on this criterion has become a fundamental issue in fields such as urban planning, geography, and transportation economics.

It is also stated that the location-based index can facilitate land use and transportation, and policymaking in integration with each other. This index is able to analyze land use and transportation. By using this index, the access levels in different spatial units are specified and are comparable, so the lack of access, potential land use and transportation solutions can be deduced [16]. Based on this, the number of opportunities that can be created from a specific location is usually calculated based on the cost of travel to the destination using a particular mode of transportation.

The relationship between this criterion and accessibility has been strongly positive and significant, and the relationship of other accessibility variables of this index has been estimated as marginally significant. The results also show that in places where access to public and automatic transportation has a substantial effect on choosing a residential place, the automatic commuting time has the most significant effect on the choice, and the calculation of travel times that It can also include the mode index, often based on existing data. Therefore, this index can be generalized to the following set, which is very important and practical in examining actions based on it:

5.2 Gravity-based criterion

An attraction-based measure where all travel opportunities and costs generally decrease based on travel time or distance. This measure better reflects the journey, which is very suitable for travellers' understanding of time. From a scientific point of view, this criterion has a strong theoretical basis that is well accepted in the field of transportation. In addition, the spatial modelling framework considers the distribution of demand and the level of access to opportunities (competition effects). In principle, it can consider the changes between people. In other words, according to the characteristics of the people who are used, access is determined differently [25].

Research indicates that this measure is theoretically more correct (because it is not limited to a time or distance limit) and therefore has superiority over the measures of cumulative opportunities [10], [13]. It has been stated that this criterion identifies and smooths difficult destinations by using travel behaviour to make access easier. But by weighting opportunities based on distance or time, it makes the task easy and comprehensible. It can be understood

as equivalent to the number of jobs compared to the cumulative opportunities that represent destinations at the one-time (or distance) predefined interpretation [26].

5.3 Cumulative opportunities

Cumulative opportunities only count opportunities that are within a specific range, and within the threshold of attraction-based travel costs, i.e., it estimates achievable opportunities at a predetermined or defined threshold. This index is essential from the perspective of policy and practice, even evaluating the positive impact of any type of access for choosing a residential location, for at least two reasons: it can clarify the debates related to budget allocation. Second, the investigation shows the different extent that people value access to different travel methods. Cumulative opportunity is the broadest measure in operational planning, but at the same time, it is among the smallest due to the lack of consideration of the effects of competition for opportunities. This criterion is of interest due to its ease of interpretation, reproducibility and direct comparison between cities [9], [27].

But one of its limitations, which is widely accepted in politics, is its failure to combine the effect of competition for existing opportunities. Because this criterion assumes that people use the closest opportunities and more to choose a residential place, further, it is assumed that there is no limit to the capacity of these opportunities. Therefore, the concept of more opportunities and more choices without considering competition or potential demand for opportunities can be misleading [28].

5.4 Criterion based on travel mode

When studying the location-based index, we come to another measure called travel mode. Since private cars, public transport and active are the most used modes of travel, the types of access that are usually investigated originate from these modes, especially in the field of transport choice. It is also important to note that studies that use location-based access indicators to assess access differentially by car and transit provide relatively simple estimates of mode-based travel time to compare levels, and it should be noted that these indicators are at the spatial scale of analysis. They are usually much larger than a typical study focusing on neighbourhoods or transit areas, and the calculation of mode-based travel times is often based on available data from transit demand models and schedules.

The paper reported that the share of the location-based index was higher for residents who lived near significant rail transit stations in 35 metropolitan areas across the United States. They examined the built environment and transportation accessibility at the neighbourhood and regional levels to determine the relationships between accessibility and commuting mode share. They showed that at the regional level, the level of access to jobs and transportation and the overall shape of the city affects how much people use each mode of transportation [29].

This is one of the articles that analyze the contribution of the travel mode at the national scale with the location-based index and the built environment. Of course, several studies have been conducted in the past that show that the development of mixed land use with high density and the choice of travel mode affects the way people commute to/from the workplace [30]–[32].

Accordingly, Kaufman et al. [33] found in his studies that car use was mainly explained by the local and sub-regional built environment (e.g., walkability, access to work by bus) rather than rail access and Efforts to activate dense and mixed areas in places beyond the areas adjacent to the railway station should be considered.



5.5 Proximity-based criterion

In the meantime, some researchers point to another new criterion known as the proximity index. This index is based on proximity to key destinations such as city cores and proximity to transportation infrastructure such as transit stations. This index is strongly associated with walking in many places, while it is generally assumed that households generally prefer lower density living. Several residential location selection models have reported a positive relationship between population density and this index and residential location selection [34]. It is interesting to note that residential preferences for walking and access to transportation among college-educated youth living in single-person households are strong when considering the location index and this index [35]. This is suggested by the classical theory of urban economics, which assumes that households will pay higher prices for more accessible land to save on commuting costs. Proximity-based index by low-carbon mobility programs helps to create favourable conditions for activity and carbon-neutral mobility [36].

5.6 Travel time-based criterion

The relationship of this criterion with access has been strongly positive and significant, and other access variables of the location-based index sub-group are estimated to be marginally significant. The results also show that in places where, in particular, access to public and automatic transportation has a significant impact on choosing a residential location, commuting time (automatically) had the greatest impact on the choice. Travel time calculations can also include a mode index, often based on available data from transportation models and programs. Many empirical studies show that travel time uncertainty has significant effects on people's travel planning [37], [38]. For example, Abdel-Aty et al. [39] determined that this issue is either the most important or the second most influential factor in travellers' decision-making. Also, previous studies have shown that people exposed to travel time uncertainty tend to avoid the risk of being late and consider additional travel time to ensure the probability of arriving on time to participate in activities. Another research in China shows that travel time should be included in location-based access because it may lead to better and more reliable decision-making. Therefore, urban planning can adopt better policies for different social groups with travel reliability [40].

6 TRANSPORT-BASED CRITERION

The transportation-based criterion describes the transportation system, expressed as its usefulness for covering the distance between the origin and the destination using a specific transportation method. Some studies consider transportation-based accessibility based on accessibility to transportation stations as a criterion for accessibility, although destinations are not included in it [41]. This criterion can accommodate the other subcategories and refer to them as well: measures based on infrastructure and measures based on the environmental dimension.

6.1 Measures based on infrastructure

Infrastructure-based measures are transport-based measures that provide insight into the performance or service level of transport infrastructure (such as average travel speed on the road network). Considering that it is related to the transportation component, it hardly communicates with other indicators because it focuses on the quality of the transportation network and does not provide insight into the levels of access experienced between different areas or household groups in the same area. On the other hand, compact urban development



with mixed-use, following low-carbon transportation systems is considered a vanguard for mobility. Such conditions allow travellers to choose sustainable modes of transportation or minimize travel time [13], [42]; however, it is of secondary importance.

6.2 Measures based on the environmental dimension

In terms of the environmental dimension, attention has been focused on the difference between transportation methods in terms of energy consumption and their external effects [43]. This criterion also emphasizes the degree of dependence of an urban area or a part of it on a type of transportation method based on the accessibility. Considering the side effects related to the transportation methods that have placed car accessibility significantly higher than public access, it is possible to define a car-dependent area. It is expected that when the share of car and medal systems in an area is high, the negative side effects related to transportation are practical. Of course, this indicator can be reduced to the lowest level by improving accessibility with alternative transportation methods. Therefore, the comparison between access to the car versus public transportation at the level of a region can be discussed and analysed. An article shows that reducing greenhouse gas emissions related to transportation becomes a kind of access tool and considers the main implementation barriers to be the separation of land use and transportation planning, which describes the relevance of an integrated concept [44].

7 TIME-BASED CRITERION

This index reflects time constraints, such as the availability of opportunities at different times of the day and the time available to individuals to engage in specific activities (such as work, study, or recreation). Automatic access in this index indicates that delays caused by It include congestion, while for the transit-based index, travel time is used as an input to calculate accessibility. Other time components such as arrival and departure time, waiting time and total travel time can be included in this index using multiple estimates. Therefore, looking at the literature, we can see that they calculate the time at the level of the neighbourhood or region. This review is sufficient for automatic access because a few minutes of additional driving time in the neighbourhood is not necessary for access, but the walking time to the transportation station is for access. Public transport is critical. Since the total transit travel time is also strongly related to the access time of the exit as well as the assumptions related to the waiting time and the number of transfers between the transit lines that are allowed, therefore the accurate assessment by this indicator gives a more realistic picture of the access gaps. It will be shown between families without cars versus people who own cars.

8 CRITERION BASED ON THE INDIVIDUAL COMPONENT AND THE SOCIAL DIMENSION

This index includes access at the individual level, taking into account personal facilities and limitations (the number of activities that a person can participate in at a given time) and socio-economic characteristics. According to research, people have different perceptions of access levels based on individual indicators, and as a priority or limitation, different people show different levels of willingness to travel in order to achieve opportunities, so according to this access index, the concept becomes relative, which can lead to biased results when the absolute parameter of well-being and sustainability is considered.

This indicator is highly dependent on input data and, therefore, difficult to apply at the level of an urban area. The relationship between this index and social ideals has also stimulated conceptual and experimental research in recent years, which contributes to our



progress and understanding of the mechanisms and has an impact on examining access, the access status of disadvantaged populations, and the consequences of limited access. At the same time, this index is taken into consideration that the social justice dimension of sustainable development draws attention to the distribution of benefits and burdens of society members, which starting from transportation as a derived need and access as an indicator of the level of participation of all groups in activities. Which are considered normal for sociologists, such as access to employment and essential services.

The study examines the factors affecting the satisfaction of pedestrians in accessing the metro station, taking into account the socio-economic characteristics of the pedestrians and the built environment factors, and shows that under this criterion, access significantly affects the satisfaction of the pedestrians [11]. This index is sometimes included with population classification in location studies; based on this, age group or socio-economic characteristics are considered based on the classification of destinations [45].

Another study examines physical access to food and stores using this index. In this research, the elderly is considered as the target group because this index is significant for participation in social life in the respective societies [46], and on the other hand, the age of people is considered as a key branch in this index, while attention has attracted a limited. In addition, the growing rate of the population, especially the elderly population in developed countries, has raised concerns about access to other prominent places. In a study of bus station accessibility in Melbourne, Australia, Delbosc and Currie [47] found that the low-income population had the lowest level of accessibility after the elderly. This issue becomes important since senior citizens use public and non-motorized transportation methods more than others to cover their daily needs and are dependent on them [48].

A study in Granada, Spain, also shows that the preference to access retail on foot, despite the presence of numerous stores throughout the city, was related to age and social and personal status. Of course, it has also been stated that elderly people with vehicles prefer to use their own vehicles for commuting [49].

9 CONCLUSION

Access refers to people's ability to reach destinations, activities and services, and their quality will have direct and indirect effects. Improving access and its value is often considered as the goal of transportation policy and planning and as one of the channels for improving sustainability, and optimal planning in this case also requires a more comprehensive analysis of access, and no single method can Evaluate all access factors. Therefore, the discovery of a new era of the concept of accessibility will have a significant impact on achieving greater sustainability. The selection of superior evaluation techniques will be very effective, and they can be used to select more than one indicator to help solve transportation and urban planning problems and achieve access to a new way with a decision mechanism that is decisive. Therefore, hybrid scenarios that target a sustainable economy and choose a transportation system by reducing the use of private vehicles and increasing accessibility and creating a liveable city that also minimizes environmental impacts are considered. Because improving access can help achieve many economic, social and environmental goals by reducing related costs. On the other hand, many factors are influential in achieving this concept, such as people's transportation needs and abilities, the quality and affordability of transportation options, land use patterns, and the quality of transportation alternatives; Of course, consultation with local authorities and economic activists in this field should not be ignored. Because consultation with local authorities and economic stakeholders is essential for improvement, and the publication and visual display of accessibility criteria can significantly



increase understanding and include a wide range of stakeholders. Therefore, it will help to further present this critical challenge.

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