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Developing a Common Narrative on Urban Accessibility:

A Transportation Perspective

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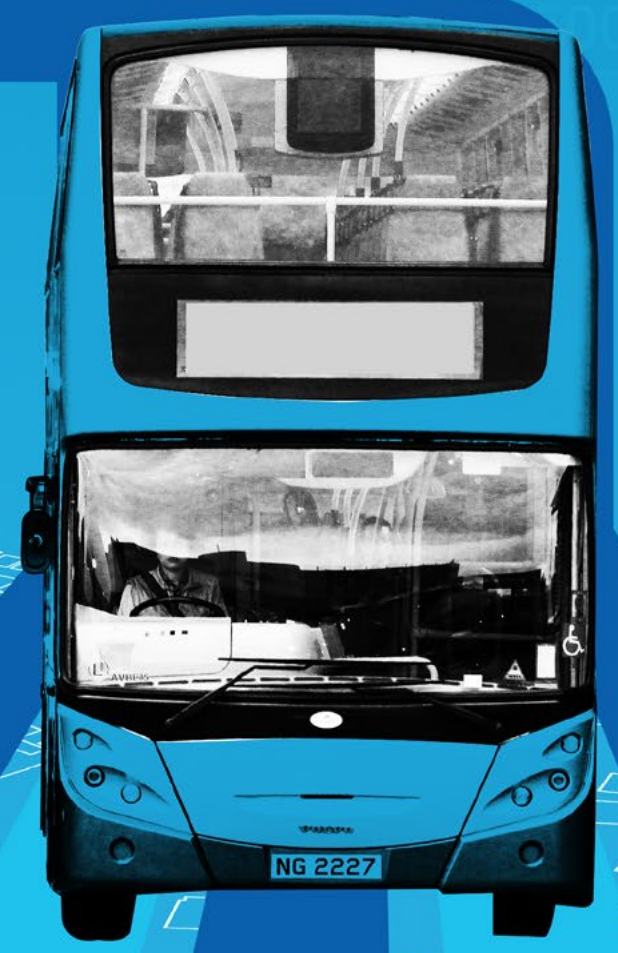

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Executive summary

Over the course of the 20th century, transportation professionals considered maximizing speed a fundamental pursuit of transportation plans, policies, and practices. This "traffic-based" view led to investments that better connected communities, inspired new technologies within vehicles, and improved infrastructure quality, especially where congestion existed. In turn, a focus on "mobility" began to emerge for moving as many people as efficiently as possible. However, this view focused too narrowly on transportation performance, in the process ignoring the underlying considerations of who takes trips, to where, and how they choose to travel. Accessibility expands on this view.

The underlying goal of any regional transportation system is to connect people to economic opportunity, and accessibility is the umbrella concept to measure the ease of reaching a destination, whether it is a park in one's neighborhood or a job 20 miles away. Accessibility requires an integrated view of transportation and land use, since decisions made under each policy discipline will intrinsically affect the other. The accessibility concept is also flexible. It can integrate demographic and financial considerations—such as household income or pricing, for example—alongside traditional transportation outputs like travel time to enable a better understanding of how broader economic and social outcomes relate to local transportation design.

Such objective-driven thinking has generated deep support for accessibility theory among academics and practitioners, and a number of developed and developing cities and countries have begun to formally implement accessibility policies into their transportation, land use, and fiscal frameworks. There is now an emerging volume of knowledge and precedent about how an accessibility approach to transportation planning, investment, and operation can improve economic and social outcomes across urban areas.

However, the concept in some ways struggles due to its contextual flexibility. Accessibility can be used as a strict definition of infrastructure quality—like distances to a major highway or transit stop—or as an expansive classification of how well neighborhoods connect to one another. Accessibility can serve a sociological role, helping to explain people's travel behavior. Accessibility measures can even be used to prescribe new policy solutions related to transportation, land use, and financial needs.

This kind of contextual variability can be seen through the global regions deploying accessibility concepts within their formal transport planning and assessment processes. In the case of the United Kingdom, officials used the objective of reducing social exclusion to incorporate standardized core and local indicators of accessibility. This extensive process created greater coordination between different public agencies, although it failed to move most decision making out of transportation departments. In the United States, national and local governments tend to promote ad hoc accessibility goals without formal regulations tied to specific measures. Meanwhile, some Global South cities now use accessibility policies to better connect their residents to opportunity, but minimal application is still the norm in most metro areas.

Encouraging more global cities and regions to adopt accessibility practices will require addressing a series of major constraints and barriers. Shifting political interests can lead to inconsistent support for accessibility policies, while governance structures often dissuade the kind of cross-agency collaboration critical to advancing accessibility goals. Conceptually, governments and their civic peers still struggle with connecting transportation decision making to broader regional objectives, whether these objectives concern equity issues, land development, or financial sustainability. Additional exploration of accessibility pricing and its impact on equity is another area of

need. However, several emerging approaches show promise in implementing accessibility practices worldwide, including the availability of open data and software, community engagement tools, and new modeling approaches.

1. Introduction

Accessibility has long been recognized as a core concept in transportation, perhaps as *the* core concept, as the vast majority of travel is undertaken for the purpose of interacting with opportunities at the destination. Its importance is acknowledged in the transport policies of many countries worldwide, and accessibility features explicitly among the objectives of investments in transport infrastructure, especially public transport, in both developed and developing countries. Accessibility—its meaning, measurement, and application—is a popular topic among academics and researchers in transportation planning and related fields, and has become part of the discourse between transport and spatial planners, geographers, and others.

Yet the application of accessibility in transportation is characterized by a wide range of definitions, measurement approaches, and policy objectives. The absence of a common conceptual understanding is evidenced by the range of interventions that have been and continue to be undertaken with the stated goals of enhancing accessibility, including the adoption of automobile-oriented highway expansion programs and road design standards, public transport investment at various levels, the placement of public service facilities, and pedestrian-oriented street design in the new urbanist mold. Depending on how the questions of access to *what, for whom,* and *how* are answered, one might arrive at different approaches to enhance urban accessibility and sustainability in the long run.

The objective of this piece is to provide a brief overview of the ways in which accessibility has been defined and applied in urban transportation over the last 50 years. Rather than trying to present an exhaustive review (an impossible task given the size and evolving nature of the literature), this paper attempts to sketch the experience in broad strokes to help seed a discussion around accessibility with other disciplines. The references are selective and representative rather than comprehensive.

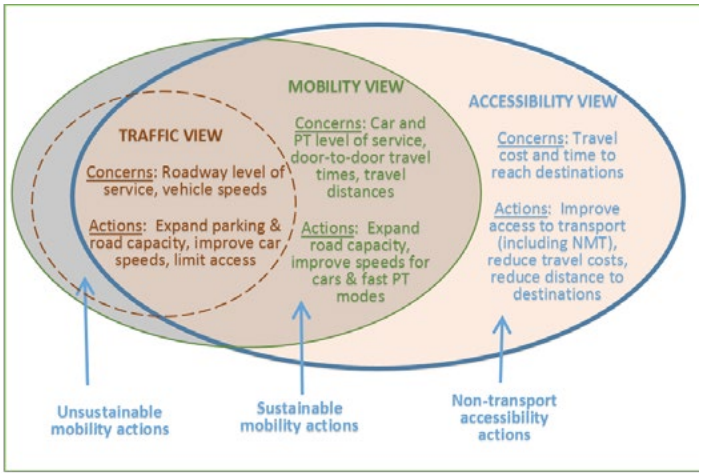
The paper starts with a brief historical outline of the evolution of perspectives in the transportation profession, and then presents a categorization of applications of the concept of accessibility for descriptive, explanatory, evaluative, and planning/management purposes. The major types of indicators used to measure accessibility within each approach are discussed, together with a critical assessment of major achievements and limitations. Given the focus of the project on promoting the use of accessibility as a cross-sectoral tool within urban management, the next section zooms in on the particular experience of using accessibility planning within transportation, both as part of a normative, structured process, as in the United Kingdom, and as an ad hoc planning and assessment tool, as in the United States. The application of accessibility measurement in transport within countries of the Global South is also explored. Finally, the discussion identifies knowledge gaps, barriers to adoption, and emerging approaches that might help shape the path toward more widespread adoption of the accessibility paradigm in a collaborative framework with other disciplines.

2. From mobility to accessibility: Tracing the conceptual evolution

The transportation and urban planning literature commonly positions accessibility, defined as the ease of reaching destinations or activities, or the potential for interaction,[1] as the antithesis of mobility, which is the ease of traveling along the network, or the potential for movement. Yet when tracing the evolution

of these concepts as planning paradigms, it becomes clear that mobility is in fact largely embedded within the concept of accessibility. While defining a clear framework can be quite challenging and be subject to a variety of interpretations, it is suggested here that it might be more useful to see accessibility and mobility as nested concepts (Figure 1).

Figure 1: Traffic, mobility, and accessibility as nested concepts, with typical concerns and actions taken



PT=public transport
NMT=non-motorized transport
Source: Adapted from Litman 2003.

The cost of travel has always been of central importance to transport planners and engineers. Under the assumption that travelers attempt to minimize cost within constrained budgets, less time and money spent traveling means more that can be allocated to other pursuits or more places that can be reached within a certain budget.[2] Although there is an intuitive link here with the spatial distribution of those places—one way to reduce travel costs is to change the location of activities—transport professionals have tended to take the land use component as fixed, and so have historically focused on minimizing travel costs as an end in itself.

Thus, the transport problem has essentially been defined as one of low speeds, which is taken to be a consequence of ineffective or incomplete networks, inappropriate and slow vehicle technology, or insufficient infrastructure capacity (manifested as congestion). Problems are identified and measured using speed-based metrics including operating speed, vehicle delay, volume/capacity ratios, congestion, and roadway level of service—a qualitative measure expressing the quality of transport service from the point of view of the user and largely seen as a function of speed.[3] Given that higher vehicle speeds are the "fundamental criterion for success,"[4] the conventional solutions to the speed problem—especially since the advent of the automobile era—are to add roadway capacity and to design wide, limited-access roadways that reduce friction between cars and adjacent properties.

From the 1970s onward, this "traffic-based" view of urban transport was increasingly challenged as focusing solely on the concerns of motorists instead of all transport users,[5] leading to entrenched automobile dependence and intractable congestion problems.[6] The broader concept of "mobility" allowed for a more multimodal perspective, recognizing that some people rely on public transport, walking, and cycling. But if its central concern is to move as many people (rather than vehicles) as efficiently as possible, the mobility paradigm still prioritizes transport interventions that raise travel speeds, such as road capacity expansion (including high occupancy vehicle (HOV) lanes), public transport investments (especially high-capacity modes such as rail), and efficiency-enhancing traffic flow improvements (e.g., traffic signal coordination). Typical performance measures include, besides most of the speed-based measures listed above, also multimodal door-to-door travel time[7] and travel time reliability.[8]

Criticisms of the speed-based orientation of the traffic and mobility perspectives came from both outside and, increasingly, inside the transport community. Criticisms centered largely around two issues. First, by ignoring the connections between transport and

land use, the speed-based approach provides an incomplete definition of the problem, leading to unanticipated countereffects such as urban sprawl and reduced liveability.[9] Second, there are concerns with the equitable distribution of mobility benefits across the population. As Ewing puts it, "the ability of some to travel far and fast does not translate into mobility for all. The young, old, poor, and handicapped are worse off now than they were before the automobile. In an automobile-centric society, they suffer from 'deprivation of access.'"[10] In less-developed parts of the world, such marginalized populations are likely to be in the majority, raising serious equity questions.

A key problem is that speed-based measures focus only on the time or monetary cost of transport, ignoring the benefits users gain from travel. The implications of this are illustrated by El-Geneidy and Levinson, who note that, according to the congestion indices published yearly by the Texas Transportation Institute, the U.S. cities with the highest congestion levels (and thus in many ways, the most constrained mobility) are not the least attractive cities to live in.[11] Clearly these cities, which include Los Angeles, San Francisco, and Washington, offer some benefits in terms of their size and the range and quality of activities to engage in. Levine et al. make a similar point when they demonstrate that denser metropolitan areas like New York are more accessible to residents due to higher proximity to destinations, despite slower travel speeds resulting from congestion. Thus, speed is sometimes the opposite of accessibility, and not the best indicator of desirable outcomes.[12]

Academics initially suggested accessibility as an alternative transportation planning goal in the 1950s,[13] although it wasn't until the 1970s that scholarly interest in its meaning and measurement started to emerge.[14] In the United Kingdom, A.G. Wilson had by 1972 already identified a shift in transport planning from a focus on "traffic congestion" to "accessibility provision."[15] The definitions of accessibility have varied widely over time (as discussed below), but most contain the common element of linking travel to the activity, purpose, or land use at one or both ends of the trip.

By supporting an integrated view of transportation and land use systems, accessibility is thus seen as a more balanced, holistic concept focusing on the system as a whole, rather than on aspects of the transport system only.[16] This view creates space for more flexible solutions to the fundamental problem of providing people with access to opportunities, including coordinated planning of land use and transport systems. So Cervero claims that the accessibility-based approach "gives legitimacy" to land use initiatives and urban management tools such as the compact, mixed-use development embodied in New Urbanist communities and transit-oriented development (TOD) by both shortening travel distances and prompting travelers to walk instead of drive.[17] Accessibility does not in principle favor certain modes over others, but values each mode according to its contribution to meeting users' needs. Thus, it avoids favoring longer trips via faster modes if shorter trips and slower modes provide adequate access to a certain type of activity.[18] The asserted benefits of using an accessibility framework therefore include reductions in vehicle travel and associated impacts on energy consumption, air quality, and societal and personal costs.[19]

Despite the fact that accessibility thinking seems to be making inroads in transportation, supported by a voluminous and fast-expanding body of literature, it is not yet embedded within the practice of transportation planning and engineering, either as an analytical concept or as a practical tool. Transport professionals still largely see their work in terms of the objectives of the mobility domain. To make matters worse, there has been some amount of conflation of terms, with both terms being used to describe attributes of mobility.[20] It is therefore worthwhile trying to establish crisper

definitions of terms and a clearer understanding of the relationships among them.

Mobility is necessary for providing accessibility—at least for as long as physical movement is required to access opportunities—and so we do have to pay attention to the quality of mobility. But it is neither sufficient nor universally beneficial. Efforts to improve mobility are needed, but as an enabler of accessibility rather than as an end in itself. Zegras groups such efforts together under the term *sustainable mobility,* suggesting that its goal could be defined as "maintaining the capability to provide non-declining accessibility in time."[21] What such policies, systems, and actions look like will clearly vary by context. In less-developed areas, for instance, developing incomplete transport networks and decongesting roads through effective traffic management may greatly enhance urban accessibility. In developed economies there may be a role for strategies that smooth traffic flow and reduce bottlenecks, especially if they benefit a range of transport modes. But other mobility-enhancing efforts may in the long run be detrimental to accessibility, especially if they benefit only private car users, making these efforts harder to justify. Thus, we arrive at an understanding of mobility as being only partially nested within accessibility (Figure 1), with the distinction between sustainable and unsustainable mobility-enhancing strategies being the test of whether or not they maintain/improve accessibility over time.

The following section provides an overview and broad classification of four major ways in which accessibility has been applied within transportation research and practice over the past 40 years.

3. Application of the accessibility concept within transportation

A number of reviews of accessibility applications and indicators have appeared in the last three decades within the transport, planning, and geography literatures.[22] All authors agree that the notion of accessibility has been defined and operationalized in a large variety of ways, sometimes to the detriment of theoretical rigor and consistency. Almost 40 years ago Dalvi observed that there was "much confusion over terminology and over the precise role that these new concepts should be assigned in the planning process,"[23] and almost three decades later Geurs and Van Wee called accessibility an "often…misunderstood, poorly defined, and poorly measured construct."[24] Significant progress has been made since with regard to understanding the concept better and measuring it more accurately, due in part to advances in the availability and computability of spatial data. The gap between the academic literature and the practical application of accessibility measures, identified by Handy and Niemeier,[25] has started to close.

Among the most influential reviews of accessibility measures is the paper by Geurs and Van Wee,[26] in which the authors present a comprehensive review of accessibility indicators found in the literature and offer a theoretical framework for the definition of various classes of measures. They identify four types of components that are used to define accessibility: *land use*, including the locations and characteristics of both origins and destinations or opportunities; **transportation,** including the quality and performance of transport networks and services; the **temporal** component, including variations in the availability of opportunities across the day; and the **individual** component, including the needs, abilities, and opportunities of individuals. (To these Lucas adds the **cognitive** component, which reflects people's ability to interact with the transport system, but this aspect could arguably fall under the individual component).[27]

A key insight from this work is that there probably is no ideal accessibility measure. The most theoretically correct measure should ideally take into account all components and elements within these components. Accessibility, in its broadest definition, is influenced

by all of these components, and should therefore be sensitive to changes in any one of them. However, Geurs and Van Wee acknowledge that incorporating all components into a single measure would imply a level of complexity and detail that is probably unachievable in practice. Practical measures have to strike a balance between relevance, computability, and interpretability—to be useful the measure needs to have meaning to users, including non-technical people and decision makers. So most practical measures have focused on one or a subset of these dimensions, and therefore offer only a partial view of accessibility. It is important to acknowledge the limitations of any chosen indicator in terms of what it describes (and doesn't describe), and the implications for how it may be interpreted.[28]

Within transportation planning, the transport component has been pre-eminent, with poorer representation of (in decreasing order) land use, temporal, and individual constraints on accessibility. Some progress is being made in constructing and measuring more complete indicators, but these are either in the developmental stage (see the discussion of promising emerging approaches below), or acknowledged as too complex for practical use (see the discussion of evaluative applications of accessibility). The indicators used within transportation vary according to the purpose of the application. We identify four broad areas in which accessibility has been applied, namely for descriptive, explanatory, evaluative, and normative planning/management purposes. The objectives, main types of indicators, and successes or limitations of each approach are discussed below.

3.1 Descriptive applications of accessibility

Accessibility is first useful as a way of summarizing a great deal of information regarding land use/transportation systems. Depending on which salient features of the system are included in a measure, wide variation occurs in a measure's aims and content.

Some of the confusion regarding the meaning of accessibility alluded to earlier stems from this variety of uses of the term. Accessibility has been used descriptively in three ways, namely as a measure of the quality of mobility, of access to transport, and of access to opportunities.

3.1.1 Quality of mobility

Some accessibility indicators referred to in the literature are used to express simply the quality and performance of the transport network. Typical measures include network connectivity, travel times and speeds, level of service, and congestion. The measures are applied to individual roadways or links in the transport network, or across larger areas such as metropolitan, regional, or national levels. They play an important role in the transport policies of many countries including in Europe[29] and the United States.[30] For example, in the Netherlands travel speeds on the national railway network, travel time ratios between car and public transport, and road-based congestion were until recently defined as accessibility indicators to evaluate transport plans.[31] More recent advances in measuring the quality of mobility include the expansion of generalized travel cost indicators to include all costs made by travelers for their trip, including time, (un)reliability, out-of-pocket costs, and discomfort.[32]

These kinds of accessibility measures, termed *infrastructure-based measures* by Geurs and Van Wee, are in fact measures of mobility rather than accessibility as defined above.[33] They completely ignore the land use component of accessibility. The use of mobility indicators is deeply embedded within transportation engineering practice: data are easily obtainable from in situ measurement or transport models, problems are clearly definable, and results are easy to interpret and use when prioritizing remedial action. However, it is important that mobility indicators should be understood for what they are—limited measures of one component of the land use/transport

system—and not as indicators of accessibility per se. It is likely that the definitional conflation of mobility and accessibility measures is a major factor hampering constructive engagement with the accessibility concept within the transport sector.

3.1.2 Access to transport

A second application of accessibility is to describe the ease with which people can use and take advantage of the transportation system itself. Such measures consider the proximity and connectivity of trip origins in relation to roads, transit, sidewalks, and bike paths.[34] While they capture some linkage between transport and land use, this is notably only at the origin (or destination) end of the trip, and ignores the purpose of travel.

This measure of accessibility has been widely applied in the area of transit service planning. Many short-term transit plans, for instance, monitor what share of a bus or rail route lies within a 400-meter radius of households within a service district.[35] Access-to-transit goals are also reflected in many longer-term objectives for transit coverage, such as the City of Johannesburg's aim to provide 85 percent of its residents with access to a public transport stop or station within 1 kilometer of their homes.[36] Access to transit has been frequently applied in relation to equity or social exclusion, where the concern is with differential access across subgroups of the population and how this links to transport deprivation[37] and poverty.[38]

A few tools have been developed for mapping access to public transport using geographic information system (GIS) data analytics.[39] The more sophisticated ones consider not only access to the route but also selected properties of the service itself. Perhaps the most well-known is Transport for London's Public Transport Access Level (PTAL) measure, which calculates, for any given origin, an index reflecting the quality of access to public transport as a function of proximity to the nearest bus stop or rail station, and the frequency of service on the route(s). PTAL is used as an indicator of public transport density, for instance, during the determination of housing densities and parking requirements.[40]

The PTAL example illustrates also the most important limitations of access-to-transport indicators: they are essentially indicators of supply, and say nothing of the ability to reach opportunities. Bus stops or rail stations are interim but not final destinations[41]—a range of additional factors such as network coverage, transfers, costs, and hours of operation determine whether any given destination can be reached within available time and money budgets. A further criticism (although this also applies to true access to opportunity measures; see below) is that a purely network-based description of travel impedance might create a false impression of an individual's actual ability to travel. As noted by Lucas, "'softer' barriers to access such as low travel horizons, cognitive and mental mapping abilities… can often be more of a barrier than the availability and timing of transport services."[42] This speaks to the need for incorporating, or at least acknowledging the importance of, individual characteristics in accessibility measurement.

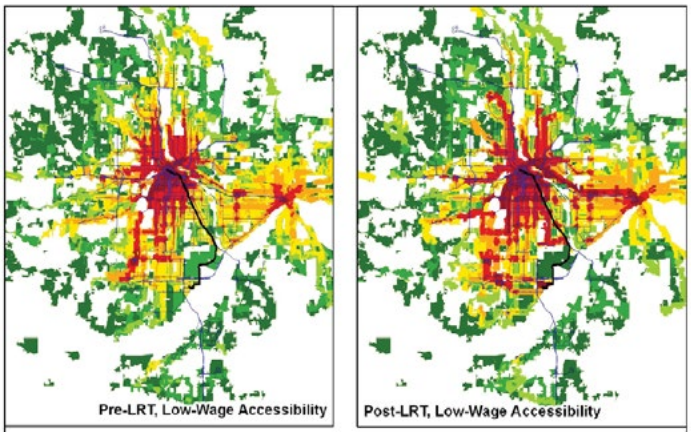
3.1.3 Access to opportunities

A third class of applications considers land use at both ends of the trip. Termed access-to-opportunity measures here, these are closest to the classic definition of accessibility as consisting of "an origin and a destination combined with potential activity at the destination and travel time or cost."[43]

Variously termed location-based metrics, potential measures, contour measures, and so forth, access-to-opportunity measures have been operationalized in a number of ways to describe the interaction between land use and transport systems in shaping the "opportunity surface" provided by an urban system. In the planning and geography literatures such measures are used to describe macro-level urban structure.[44]

The interest of transportation researchers in this has been to map and understand the ways in which the benefits of transport policy and network deployment are distributed spatially and across user groups.[45] For instance, Fan et al. plot the number of jobs that can be reached within 30 minutes' travel time from home for the Minneapolis-St. Paul region before and after the opening of the Hiawatha light-rail line, and show that the line has a significant impact on accessibility to low-wage jobs (see Figure 2).

Figure 2: Example of contour measure used to assess impact of light rail transit (LRT) project on low-wage accessibility to jobs, Minneapolis-St. Paul, 2002 and 2006



Source: Fan et al. 2010.

Cumulative opportunity (or contour) measures of this kind together with gravity-type measures seem to be the most popular accessibility indicators used in descriptive studies. Gravity-type measures discount the opportunities at a given destination as a function of the distance, time, or cost of reaching them, to reflect the diminishing attractiveness of more distant locations.[46] El-Geneidy and Levinson compare cumulative opportunity and gravity-based measures to describe job accessibility patterns, and conclude that the measures tend to give similar results when travel time is near the average commute time of 20 to 30 minutes.[47] Cumulative opportunity measures tend to be easier to understand and interpret by planners and decision makers, and measure a real, observable thing (the number of destinations, say jobs) that can be reached in a given time threshold, by a given mode, at a specific time. A shortcoming common to both types of measures is their sensitivity to parameters that must be chosen or calibrated by the researcher, reducing their transferability and interpretability.[48] Cumulative opportunity measures at a given threshold are directly comparable across areas and times. Pegging the "right amount" of accessibility is, however, arbitrary. Accessibility can be monetized using real estate values, but this is infrequently done, and varies over time. Thus, the greatest utility of cumulative opportunity measures seems to be as comparative rather than as absolute indicators, used for instance when comparing accessibility benefits for the same city across different population groups,[49] across transport scenarios,[50] or over time,[51] or between cities.[52]

3.2 Explanatory applications of accessibility

The application of accessibility for explanatory purposes is premised on the assumption that the concept captures properties of the urban system that are relevant to people's behavior. Ben-Akiva and Lerman (quoted in Morris et al.) noted that travel choices or decisions are "highly dependent upon individual household members' perceived accessibilities to various opportunities by a given transportation system," and went on to show that utility-based indices of accessibility are consistent with microeconomics and discrete choice theory.[53] A large body of literature has subsequently emerged attempting to link accessibility with behavioral theories and phenomena. Some of the areas of inquiry include:

- *Travel activity:* Many researchers have examined the question of whether people use the greater opportunity for interaction associated with greater accessibility for engaging in more travel. The evidence is mixed. Earlier studies indicated that higher accessibility correlates with higher trip rates for non-work activities,[54] but more recent

studies indicate the effect on shopping trip rates to be negligible.[55] Trip distances tend to increase with increasing accessibility, especially for work trips, suggesting that people use greater access to opportunity to search for suitable jobs over a larger area.[56] Thus, overall vehicle miles traveled strongly increase with regional accessibility.[57] However, over time this effect might be weakened, due to co-location of jobs and housing to keep average travel times constant.[58]

- *Car ownership and mode choice:* Ample evidence exists that accessibility by car and public transport affects car ownership in various countries.[59] However, scale is important: while greater *neighborhood* accessibility is associated with reduced car ownership due to the proximity to more opportunities within walking distance,[60] *regional* car accessibility has been found to be positively correlated with car ownership.[61] Local accessibility (walk distances) to public transport[62] and regional access to opportunities by public transport[63] affect mode choice, both helping to explain greater use of public transport.
- *Location decisions:* Many studies have examined accessibility as an explanatory variable in models of residential location choice. Most evidence shows that access to work opportunities is a strong driver of residential location,[64] while other evidence points to the importance of accessibility to a range of opportunities, including open space, schools, and recreation, when people choose where to live.[65]
- *Real estate value and land development:* Hansen, one of the first researchers to operationalize empirical accessibility measurement, showed that residential land development was strongly correlated with accessibility to employment and population. This is largely due to the fact that the benefits of accessibility can be capitalized into property prices.[66] Many studies have found local or neighborhood accessibility to transport to be a significant factor affecting land prices.[67] Proximity to transport can affect house prices positively or negatively, as for instance in San Diego, where significant disamenity effects (due to noise, vibration, and traffic factors) were measured for single-family homes lying within half a mile of a trolley station.[68] At the level of regional accessibility to jobs and other amenities, some studies fail to detect a correlation with house prices,[69] although many hedonic price studies have found accessibility very useful to help explain variations in house prices, after controlling for local amenity and housing quality factors.[70]

In summary, significant progress has been made in understanding the role of accessibility in travel behavior and decision processes. Such work is critical if accessibility-based planning is to be evidence-driven, effective, and sustainable. However, areas of conflicting results remain, while many questions regarding the transferability of findings between different parts of the world remain to be examined. In addition, since accessibility is a latent construct that cannot be directly observed, any attempt to include it in an explanatory model is contingent on the researcher's choice of measurement instrument and the way in which it is calculated. It is possible that measurement differences account for at least some of the conflicting findings mentioned above. Further work to strengthen the robustness of our findings with regard to variations in measurement approaches will be very useful.

3.3 Evaluative applications of accessibility

Accessibility indicators are often used in the appraisal of transport projects. "Infrastructure-based" accessibility measures reflecting changes in generalized travel costs (travel time and travel cost)—which are really indicators of mobility rather than access, as argued above—have been widely used in conventional cost-benefit analysis to measure the direct benefits of transport investment.[71] It has

been repeatedly pointed out that this method is not capable of fully measuring the total accessibility benefits of integrated land use/transport strategies, especially if they result in changes in land use patterns over time.[72] Shifts in the distribution and density of activity locations—for instance, accelerated infill development around new rail stations or transport interchanges—increase accessibility benefits for public transport users (though the new development might reduce accessibility for car users due to increased congestion).[73] The report of the U.K.'s Standing Advisory Committee on Trunk Road Assessment in 1999 pointed out that ignoring the land use effect might lead to significant errors in the calculation of benefits; the larger the land use response or the change in demand, the larger the error.[74] Thus, the first requirement for more accurate ex ante appraisal of land use/transport projects is to have adequate models of land use/transport interaction, accounting for feedback between transport conditions and the location decisions of developers, firms, and households. The use of such models in practice remains limited, partly due to their complexity and data needs.[75]

A class of accessibility measure that has been shown to adequately capture the full accessibility benefit of land use/transport interventions is utility-based measures. Such measures, first derived by Ben-Akiva and Lerman,[76] are derived directly from random utility discrete choice models. Sometimes referred to as "logsum" values due to the underlying mathematical form, utility-based accessibility measures represent the expected maximum utility or benefit that an individual expects to derive from all the choices available to the individual for engaging in activities. If the choice set contains all feasible activity destinations and mode options for getting there, then this maximum benefit can be interpreted as accessibility. The logsum value has a direct relation to traditional consumer surplus measures, as it can be converted into monetary units (by dividing it by the travel-cost coefficient in the utility model), leading to values that can be compared across scenarios or projects.

Based on a comprehensive review of accessibility measures, Geurs and Van Wee conclude that utility-based measures are the most theoretically sound (based on their incorporation of both land use and transport components, and individual constraints and preferences), and most appropriate as "indicators for the impacts of land use and transport developments and policy plans on the functioning of society in general."[77] In addition, utility-based measures are consistent with conventional cost-benefit analysis.[78] Despite this glowing recommendation, only a few examples exist of their use in appraisal studies.[79] The main reasons for this seem to be their dependence on complex destination/mode choice models in combination with integrated land use/transport models, which are not (yet) in common use; and the difficulties encountered with communicating the results to non-expert audiences.[80] While most people will understand a benefit expressed in monetary terms, they will find it difficult to interrogate the results or to understand how it is calculated, as that would require knowledge of relatively complex concepts and theories.

Utility-based accessibility measures provide perhaps the best example of a fundamental dilemma in the application of accessibility within transport: the more theoretically correct and comprehensive our measurement of accessibility becomes, the costlier and complex it becomes to implement, and the more difficult it becomes to communicate and incorporate in decision-making processes involving non-technical audiences. Nevertheless, further work on the economic value of accessibility (also including its effect on land values and property prices) is critical as a means of supporting the development of appropriate funding mechanisms for transport.

3.4 Transportation planning and management applications of accessibility

Apart from the positive (i.e., descriptive) applications of accessibility discussed up to now, the concept can also be applied in a normative (i.e., prescriptive) manner to design policy and planning interventions, given a desired outcome.[81] In fact, Farrington contends that the concept of accessibility is at its most useful when applied normatively.[82] Two major (although in many ways conflicting) normative applications of accessibility to date have been its incorporation into the formal transport planning process in the United Kingdom, and its widespread use in road access management within transportation engineering practices worldwide.

Chapman and Weir define accessibility planning as follows:

> Accessibility planning can be defined as a structured process for the assessment of, and planning for, accessibility. It uses quantitative and qualitative data and employs tools such as geographical information systems to systematically assess a range of accessibility-related information, including origins, the location and delivery of key activities and the transport links to and from them, and to assist in the development of a set of accessibility indicators. This enables actual accessibility to be assessed against the indicators, which in turn allows accessibility problems to be identified, addressed and monitored. When fully developed the process is a continuous one and provides evidence of changes in accessibility over time.[83]

Since 2004, some version of such a process has been in place in the United Kingdom, based on national and regional policies for transport authorities to facilitate accessibility planning by other government departments and agencies. This has largely been driven by concerns with the failure of traditional planning processes to address the social exclusion of certain population groups from economic and social opportunities.[84] Although the process seems to have been weakened in recent years, considerable progress was made in "mainstreaming" accessibility into transport planning.[85] Lessons to be learned from accessibility planning in the United Kingdom are discussed in more detail in the next section.

However, transportation engineers have also applied accessibility as a normative concept in a completely different way. During the 1930s and 1940s, concerns with increasing congestion and safety problems on higher-speed roadways led highway engineers in the United States to adopt the concept of the limited access highway, based on the boulevards of the late 19th century and the parkways of the early 20th century. In the years following World War II, limited access arterials and freeways became widespread as a means of accommodating traffic growth in urban areas, and site access design concepts for major shopping centers were developed throughout the United States. In recent years systematic statewide access management policies and official guidelines were developed, such as the Transportation Research Board's Access Management Manual (AMM);[86] similar guidelines have been adopted in other countries.[87]

The point of departure of road access management is that a fundamental conflict exists between the mobility (i.e., facilitating movement) and accessibility (providing access to surrounding land uses) functions of roads. Thus, road design is approached as a trade-off between mobility and accessibility: highways designed for higher-speed mobility have limited accessibility to adjacent properties (e.g., few and widely spaced

intersections, limited direct access to driveways, continuous medians), while high-access roadways such as central business district or residential streets are designed for low speeds. This dichotomy has given rise to the notion of the road hierarchy, which implies that high-mobility roads such as freeways are seen as more important than access roads. Figure 3 illustrates this trade-off in terms of a continuous gradation between the access and mobility functions in the hierarchy. The road access classification is linked to a set of normative design standards prescribing elements like design speeds, intersection spacing, and restrictions on use by pedestrian and bicycle users.

Figure 3: Relationship between access and mobility in road access management

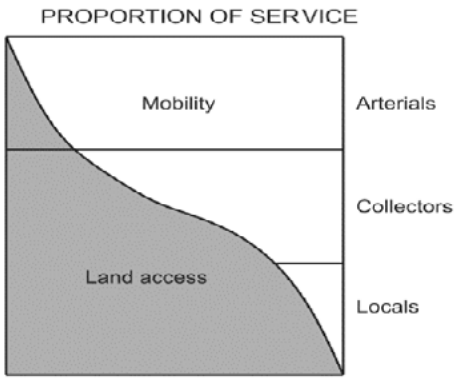


Figure 3.4: Relationship of functional road classes

Source: COTO 2004.

The key criticism that has been leveled against road access management concepts is that they define the function and standards of roadways largely with reference to the needs of car users. The AMM describes the purpose of access management as providing "vehicular access to land development in a manner that preserves the safety and efficiency of the transportation system." The emphasis on efficiency (i.e., movement speeds and volumes) is consistent with the mobility-based paradigm of transport, and tends to discourage multimodal, mixed-use street designs serving a variety of purposes.[88] It defines accessibility solely in terms of the interface between the roadway and the property, from the point of view of the car user, which (as discussed above) is a very incomplete definition of the accessibility experienced by all users.

Some recognition is emerging from within the transport engineering profession of the wider functional role of roads in a community. For instance, the draft Guidelines for Road Access Management in South Africa acknowledge the need for accommodating within the provision of roads social interaction, walking, cycling, and playing,[89] especially in communities where car ownership and use is low. Concepts such a complete street, universal design, and road diets reflect this shift. However, much work remains to be done to link design standards and road management approaches with a wider understanding of the accessibility function of the road network.

4. Experiences with planning for accessibility

In the last 15 years, the application of accessibility within formal transport planning and assessment processes has been growing worldwide, spurred by a recognition of its relevance to policy agendas for sustainable development and social inclusion. However, progress has varied widely between countries, as shown in the brief overview of some of these experiences presented in this section. The accessibility planning process of the United Kingdom is discussed as an example of formal adoption of the concept. More ad hoc approaches are evident in the United States, although some movement toward standardization of performance indicators is underway. Finally, we discuss the situation in the Global South.

4.1 Formal accessibility planning in the United Kingdom

Accessibility planning in the United Kingdom is framed in the context of social exclusion within transport planning, focusing on the ability of people to participate fully in society. Kenyon et al. defined transport-related social exclusion as:

> The process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities, services and social networks, due in whole or part to insufficient mobility in a society and environment built around the assumption of high mobility.[90]

The notion that some individuals or communities (non-drivers) become "accessibility deprived" in the context of a land use/transport system built around the car as the dominant mode has become embedded in analyses of transport equity. Discourses around transport equity have become quite sophisticated in recent years, with accessibility analysis becoming an important tool to examine the links between transport deprivation and social exclusion.[91] This was exemplified in the 2003 report, "Making the Connections," published by the U.K. Social Exclusion Unit,[92] which identified poor accessibility as a significant contributor to exclusion. The report was influential in the development of transport policy guidance that embedded accessibility planning practice within measurement and management activity in local authorities in England.[93] Since 2004 the process, now commonly referred to as accessibility planning, required local transport authorities (LTAs) to undertake strategic and local accessibility assessments as part of their statutory five yearly local transport plans. The process is supported by central government, which identifies strategic national priorities, and develops requirements for subsequent, more systematic local-level assessments. Within local authorities, transport departments are supposed to facilitate coordination between transport and other government departments and agencies, such as housing, health, and education, to reach common accessibility goals.

The accessibility planning framework incorporates accessibility assessments using standardized core and local indicators of accessibility. Core indicators, developed at the national level, inform the development of local indicators applicable to each LTA's region. Each LTA must select its own local indicators, to provide a picture of the current situation and keep track of changes, and sets targets with respect to how the indicators are to change (i.e., an increase, decrease, or no change) and by how much. An accessibility strategy and action plan is then developed and implemented to ensure targets are met.[94] These indicators are mostly of the cumulative opportunity or contour type, and are based mostly on journey time by car, public transport, cycling, and walking to a range of activities including work, education, medical care, and shopping. Indicators are calculated for the general population and for specific risk categories, such as households without car access. The set of Core National Accessibility Indicators evolved between 2004 and 2009 and are now published as Accessibility Statistics.[95] For purposes of illustration, some of the accessibility indicators published for neighborhoods are shown in Table 1.

Table 1: Accessibility indicators published for neighborhoods in EnglandSource: Abley and Halden 2013.

Destination	Population group	Travel time indicator from each residence to each destination	Indicator showing number of people within defined travel time of destination, and choice of opportunities within defined travel time of each residential location		Modes		
			Lower threshold (mins)	Upper threshold (mins)	Public transport/ walk	Cycle	Car
Primary school	School-age children (5-10 years)	√	15	30	√		√
	Children (5-10 years) getting free school meals		15	30	√		√
Secondary school	School-age children (11-15 years)	√	20	40	√	√	√
	Children (11-15 years) getting free school meals		20	40	√	√	√
Hospitals with an outpatient department	Households	√	30	60	√		√
	Households without access to a car		30	60	√		√
Employees in each Census Output Area (COA)	Population of working age (16-74)	√	20	40	√	√	√
	Population receiving job-seekers' allowance		20	40	√	√	√
Supermarket	Households	√	15	30	√	√	√
	Households without access to a car		15	30	√	√	√

Source: Abley and Halden 2013.

Studies assessing the development of and experience with accessibility planning in the United Kingdom to date suggest that, although significant variation exists across local authorities, it is generally viewed positively by practitioners involved in its implementation.[96] A significant impact is reported on some socially excluded groups, especially where local competence exists in "key personnel who understood both the value of the process and have the skills to develop multi-stakeholder agreement."[97] Enhancements to bus services in deprived areas appear to be among the most popular interventions stemming from the accessibility approach; these have reportedly delivered significant improvements in bus patronage, as well as having knock-on benefits in terms of the take-up of new employment, educational opportunities, and health care visits.[98]

An examination of the way in which local transport planners have used accessibility indicators during accessibility planning suggests some mismatch between the indicators and the actions that are needed to improve accessibility on the ground. Curl et al. report that many practitioners felt that often the only way to improve against aggregate-level targets was seen to be through bus service enhancements, while these were not seen to be "the things that would make a real difference," such as adding another service point in an underserved area.[99] Preston and Rajé caution that simply pursuing improvements against accessibility targets will lead to implementing mobility-related solutions such as more bus services, which may not best meet the needs of local populations but will show improvement in measured accessibility.[100] Nevertheless, indicators are seen as important in raising the profile of access goals at the strategic policy level; without it being formally measured, accessibility tends to drop off the agenda.[101]

However, the situation has changed somewhat in the last few years. Austerity in the United Kingdom has led to the cutting of bus subsidies, causing many social services to be discontinued. These reductions are also in line with a de-emphasis of social welfare policy goals under the Conservative Party government: social exclusion itself, and by extension also accessibility, is no longer seen as a key priority. Both the Social Exclusion Unit and the Mobility and Inclusion Unit have been disbanded within central government.[102] Accessibility planning remains a requirement during appraisal for all *new* developments and major transport infrastructure, as part of the assessment of the distributional impacts of transport, especially on vulnerable groups.[103] A quantitative assessment of accessibility impacts (e.g., on travel times) is combined with an accessibility audit, a more qualitative assessment of each component of the door-to-door journey including pre-journey information and access, and on-vehicle usability. However, the requirement for including accessibility planning within the ongoing local transport planning process no longer exists.

What has been learned so far from the accessibility planning experience in the United Kingdom? Reflecting on this question, Abley and Halden see among the main benefits the ability of accessibility planning to establish a shared language between passenger transport service providers, transport planners, and non-transport service providers.[104] It was demonstrated that accessibility planning can indeed be a prompt for encouraging coordination between transport and other public policy objectives, such as housing, health, and education.

However, true coordination will require more integrated policies and measures that position accessibility as more than just a transport issue. Abley and Halden note that non-transport departments do not generally have well-developed policies and mechanisms for improving accessibility, and responsibility for targeted action is generally assumed to lie with transport. In order to contain costs, service organizations like post offices or banks could choose to service the population from fewer sites, since transport

costs are generally external to their operations. This can seriously affect users' accessibility to such services, given the fact that destination location changes tend to have a much greater impact on accessibility than does public transport investment. The extra costs involved in compensating users via enhancing passenger transport services might exceed the savings made by the non-transport service provider, leading to either a net loss to the system or to denied service.[105] Demonstrating the benefits of improved accessibility in terms of targets in non-transport sectors (such as improved health or school attendance) would therefore be a useful step in making accessibility a shared responsibility and being able to impact non-transport agendas.[106]

Demonstrating these benefits requires leadership from within the transport sector. It also requires innovative approaches to setting shared performance targets, especially if they are linked to funding streams. Abley and Halden note that cross-sector indicators are not wholly within the control of any one policy-making department; e.g., a health department might set a target that 90 percent of the population should be within 30 minutes of a health center, but experience shows that if growth in traffic congestion makes the target unachievable, then the target tends to be abandoned rather than cross-sector action being pursued to deliver change.[107] Such action becomes even more difficult if targets are linked to funding streams, as there will likely be significant resistance to exposing funding to another department's performance.

What is required to solve the sectoral problem, apart from effective intergovernmental coordination, is supportive accessibility policy at the national level. The United Kingdom's national accessibility planning framework (now dormant) is considered a good example: it was delivered across all policy departments, and underpinned by audits of accessibility-related policies in health, education, regeneration, land use planning, and other policy areas.[108] Other examples include Germany, where the national government uses accessibility indicators to help direct national resources to local authorities with greater accessibility needs, and the Netherlands, which uses strong land use management to encourage transport-intensive development in accessible locations. In all countries with well-developed accessibility policies, the national government analyzes accessibility changes over time. This is because without clear measuring techniques accessibility goals are unclear.[109]

4.2 Ad hoc accessibility assessment

4.2.1 United States

In the United States, accessibility is only rarely incorporated into performance measures used to evaluate the success of metropolitan and regional transportation plans, leading Proffitt et al. to conclude that "ideas about accessibility generated in academia are, by and large, not translating into practice."[110]

The approach toward accessibility measurement is an ad hoc one, although the level of application varies widely. The most common applications of accessibility in planning practice appear to be for transit service planning,[111] as discussed above in the section about access to transport, and for assessing the equity impacts of transport projects.[112] There is no real coordination or monitoring of accessibility at the federal level. However, federal policies implemented over the last two decades have encouraged transport planning agencies to take account of accessibility; these include the 1998 Transportation Equity Act for the 21st Century (TEA-21), as well as "environmental justice" initiatives that date from the mid-1990s but relate to Title VI of the Civil Rights Act of 1964.[113] Thus, there appears to be some experience with the use of accessibility as a social indicator, as advocated by Wachs and Kumagai and others, that could provide the foundation for a more systematic application of the concept in the future.[114]

A recent analysis shows evidence that the concept of accessibility is starting to make limited inroads into the practice of transportation planning. Proffitt et al. analyze 42 recent long-range transportation plans from metropolitan planning organizations (MPOs) across the United States, and find a limited understanding of the concept of accessibility. The vast majority of the plans that do use the term employ it in the limited sense of "access to mobility," especially access to transit. As congestion relief is the overwhelming priority for MPOs, accessibility is largely seen as a way of mitigating traffic congestion, rather than as a broader means of delivering more sustainable land use and multimodal transport systems. Accordingly, the use of true accessibility-to-opportunity performance measures is very limited. Less than a quarter of the plans surveyed define the success of interventions in terms of increasing the number of jobs or other destinations available to residents within a given travel time.[115]

The use of accessibility measures is more common in larger metropolitan areas with a longer track record of integrated planning. Proffitt et al. see this as a "harbinger of a change in planning practice, much in the way that the use of land use-transportation scenario planning techniques began in the larger metro areas and eventually became accepted planning practice."[116] Such a change might be supported by the move toward wider adoption of a performance-based approach to planning that seeks to link transportation investments with achieving goal-based targets in federal policy, such as via the Moving Ahead for Progress in the 21st Century Act.

4.2.2 The Global South

Although few examples exist of the systematic application of accessibility planning within developing and middle-income countries, the literature is slowly growing. Several academic studies have demonstrated the usefulness of accessibility analysis for examining the spatial distribution of benefits and costs of both transport/land use interventions and operational changes, especially in the context of highly unequal societies where inequalities in income and quality of life are highly correlated to unequal access and mobility enjoyed by different socio-economic groups.[117] Thus, accessibility concerns have mostly been driven by concerns with equity and sustainable development, spurred no doubt by developments in the United Kingdom-based social exclusion literature and the involvement of researchers from the developed world in studies in the Global South.

In fact, the terms access and accessibility have found their way into many national and local transport policies, often under encouragement from international lending and development agencies. For instance, the U.N. Sustainable Development Goals include access to safe, affordable, accessible, and sustainable transport systems for all by 2030. While this reflects a too-limited understanding of the notion of accessibility as merely access-to-transport, this goal has at least inserted accessibility into the policy agenda. In Brazil, the 2000 "Statute of Cities" made it mandatory for cities with over 20,000 inhabitants to develop a master plan considering the interaction between land use, the economy, and mobility. Most cities did not comply, especially the smaller ones, either for political reasons or for lack of human and economic resources to pay for the plan.[118] In the larger cities in South America, Africa, and India, large investments in public transport often include improved access to employment, health care, and other services among their stated goals. However, studies have shown that the accessibility benefits of such investments often do not extend to poor and marginalized populations, showing that equitable accessibility concerns are in practice not central to the way in which most cities are planned and managed in the developing world.

For example, a few studies have looked at the distribution of access to new transport systems across different communities. Teunissen et al. map travel

times and distances toward Bogotá's TransMilenio BRT (Bus Rapid Transit) system, Cicloruta (bicycle network), and Ciclovía (car-free events) systems. They find access to the BRT system equitably distributed across socio-economic strata, but not access to the cycle network and car-free events. Jaramillo et al.'s study of the MIO BRT system of Santiago de Cali (Colombia) finds that it fails to improve access to transport for many of the city's isolated and peripheral districts—especially those located on hillsides where buses cannot operate—which are also districts with higher levels of illiteracy, unemployment, and poverty. [120] Delmelle and Casas came to a similar conclusion after measuring access to opportunities using a gravity-type index that incorporated both door-to-door travel time and the locations of activities. [121] However, lower-strata populations have good access to some types of amenities (such as recreation sites), due to an even spread of these sites across the city, highlighting again the importance of activity location as a driver of accessibility.

Other authors have estimated the contribution of BRT systems to enhancing accessibility to employment in Delhi[122] and Ahmedabad[123] in India; Johannesburg, South Africa;[124] Bogotá, Columbia;[125] and Santiago, Chile.[126] Most common is to measure access to job opportunities, economic access being a key issue for poor populations, but access to schools and government services has also been considered.[127] The general finding is that, while new public transport investment may raise overall accessibility levels in many cities, the benefits are often skewed toward middle-income rather than poor households due to the choice of corridor locations.[128]

Most recently, the multilateral development banks (MDBs) have been incorporating accessibility effects, particularly for low-income areas, into their analyses of urban transport investments. In the Lima (Peru) Metro Line 2 project, for instance, the World Bank's Appraisal Report supplemented the traditional economic appraisal with a "structured" accessibility distribution review. It examined three dimensions of accessibility: regional access to jobs and amenities, local access to social amenities within project impact area, and a universal accessibility assessment to improve the physical design of the system such as to accommodate the elderly and the handicapped. With the increased availability of GIS tools, common data standards for public transport services, city-level data, and efforts to measure accessibility have been extended across developing-country cities. These nascent efforts, however, are still limited and left up to the initiative of individual staff rather than being an institutional requirement.

In conclusion, despite a considerable amount of rhetoric around the accessibility needs and goals of many governments in the Global South, the reality is that practical application is still in its infancy. We simply do not know enough yet of the specific access needs of different groups in developing communities—women, informal traders, job seekers—nor how these needs are affected by transport. Some of the institutional, conceptual, and methodological reasons for this are discussed in the next section, together with promising approaches for moving toward a more integrated and effective application of accessibility within the national and local planning and management spheres.

5. Constraints, barriers to adoption, and emerging approaches

Based on the foregoing discussion, we identify constraints and barriers to the adoption of accessibility-based planning and management under three headings: political/institutional, conceptual, and methodological. The discussion is informed by the available literature as well as personal input from experts in the field.

5.1 Political/institutional barriers

5.1.1 Policy bias

The experience with accessibility planning in the United Kingdom, including its recent weakening under the current government, suggests that its acceptance and adoption is closely tied to the dominant political paradigm of the day. Concerns with economic recovery have overtaken social issues on the English policy agenda, leading to a de-emphasis of accessibility goals and problems within transport planning processes. Karen Lucas notes that "nobody talks about social exclusion anymore in the U.K."[129]

The lack of political awareness is evident in other parts of the world. Eduardo Vasconcellos concludes that in South America, despite progressive policy statements, political bias toward the interests of elites perpetuates urban development patterns based on the automobile, and that any attempts to change this pattern face strong opposition. The result is that the accessibility needs of people who rely on walking, cycling, and public transport are largely ignored, a situation perpetuated by weak education, democracy, and citizenship practices among the poor.[130] The few exceptions (such as movements toward integrated transport systems and coordinated land use planning in Curitiba and some Colombian cities) prove the rule.

In India a similar situation seems to be unfolding. Since the Bharatiya Janata government came to power in 2014, the central government's approach to urban development has shifted away from the more progressive transport policies espoused by the Urban Transport Policy and toward a more neoconservative agenda under the party's Smart City initiative.[131] The focus of the initiative is to promote competitive, modern cities through improved infrastructure, including transport. However, the projects submitted by cities that have been approved for funding seem to emphasise car mobility, and the public transport projects are not meant to signal a reallocation of road space away from the car. The Smart City narrative appears to leave little room for addressing poverty and poverty-related exclusion. So the potential for moving toward improved overall accessibility in Indian cities seems to be decreasing.

This raises the issue of whether accessibility should be positioned first and foremost as an equity issue or aligned with broader city efficiency, sustainability, and liveability goals. An example of the latter is found in the Netherlands, where the new Mobility Policy (2004) and Mobility Approach (2008) saw one of their main goals as improving the economic situation in the Netherlands by improving accessibility, while at the same time reducing the impact on the environment. The recently formed Ministry of Transport and the Environment (a merger between the ministries for infrastructure and spatial planning) has adopted accessibility—in addition to competitiveness, liveability, and safety—as one of the four central themes in new Dutch transport and spatial planning policy.[132] The impacts of this convergence of policy goals are yet to be established.

A broader understanding of the benefits of integrated and balanced planning for the economy and for people would help move toward entrenching accessibility awareness within policy and planning processes and perhaps make it less vulnerable to changing political frameworks.

5.1.2 Weak institutional cooperation

In most countries insufficient institutional frameworks and mechanisms exist for making linkages and trade-offs across transport, spatial planning, and social services like housing, health, and education sectors. The strength and promise of accessibility-based planning—its ability to generate a cross-sectoral view of problems and actions to improve urban governance—will not be realized unless such coordination can take place. The U.K. experience discussed above highlights the importance of

strong national guidance and procedures, including the establishment of common measurement and monitoring systems across departments and mechanisms for managing the sectoral budget implications of working together.

It must be understood that new governance models are needed to move toward fuller adoption of accessibility within an integrated planning framework. For as long as transport problems are defined purely with reference to the transport domain, from within the transport sector, and by classically trained transport professionals, strategies and investments are likely to be driven by mobility rather than accessibility goals. The reason is that, generally speaking, the training and professional orientation of transportation engineers remains focused on infrastructure—its provision and optimal operation. Mobility objectives can be understood, measured, and designed for within existing infrastructure engineering and evaluation tools. Therefore, institutions whose purpose is defined in terms of the delivery of transportation are likely to resist wider definitions of their scope of work. Given that accessibility depends on the interaction between infrastructure, transportation services, land use, and individual capabilities, adopting an accessibility-oriented agenda will mean relinquishing some control over the achievement of their goals (even though many transport professionals may recognize the need for planning for accessibility). This reorientation might negatively affect budget allocations as well, since planning for accessibility might mean redirecting spending away from transport activities toward alternatives like housing support.

If the classical transportation department is disincentivized to deliver accessibility—what society really needs—then a new institutional model is needed that can better align goals, competencies, and rewards within either the current or a reformed organizational framework. A starting point for further work might be to critically examine the experiences with, approaches toward, and barriers to institutional innovation in the area of integrated transport planning, land use planning, and infrastructure finance.

Unfortunately, the prospects for moving toward such new institutional models are particularly bleak in parts of the world with already weak public sectors. For example, a recent World Bank review of progress toward sustainable mobility and accessibility in African cities concluded that weak governance, ineffective regulatory and planning mechanisms, and unclear intergovernmental roles and relationships are significant barriers to more accessible cities in Africa.[133] While sustainable urban mobility policies exist that strongly promote public transport, the reality is that car-based mobility is the de facto mode of choice, partly due to an inability to regulate or improve paratransit and bus systems. In addition, the authors state that "integration of land use and transport planning often fails at all spatial levels, from city-wide strategic planning to street design."[134] Clearly, strengthening public-sector capability and systems is the long-term prerequisite for moving toward more integrated planning.

5.2 Conceptual barriers

5.2.1 Lack of definitional clarity

Problems with unclear definitions and conflation of terms around mobility and accessibility have been highlighted throughout this report. In particular, conventional transport engineering practice tends to use access or accessibility in a very limited fashion, often only to refer to attributes of mobility, access to transport (e.g., proximity to roads, public transport stops), or access to land uses (a function of roadways), rather than the full access-to-opportunities sense of the term. A consensus around definitions and terminology might arise as a consequence of wider development of measurement tools and practices, but it might also be a worthwhile short-term goal for the Moving to Access project.

Apart from the positive (descriptive) use of the

terms, further clarification is also needed around the relationship between accessibility and mobility as a normative planning goal. Despite both concepts having been in use for decades in transport and urban planning, some amount of confusion still exists around questions such as what the role of mobility is in promoting accessibility, what kinds of mobility approaches are not desirable from a sustainability point of view, and how both relate to other goals such as equity and liveability. Some recent work in this regard might provide a useful starting point for this discussion.[135]

More critical thinking and research is needed around the potential limits of accessibility planning. The use of an accessibility framework is often uncritically associated with outcomes such as reduced vehicle travel, improved social inclusion, and reduced societal and personal costs. However, there is evidence that the accessibility gains secured through efforts to pursue a greater jobs-housing balance are not necessarily permanent—due to the balancing effect of generated traffic and co-location of employers and workers—and can often fight against the benefits of economies of agglomeration.[136] Furthermore, actions that enhance accessibility might create winners and losers. Consider neighborhood gentrification and related property value increases after accessibility-enhancing public transport investment, which might displace low-income households to less-accessible locations and produce an accompanying net loss in welfare. Not everybody needs the same amount (and type) of accessibility, so how much accessibility is enough? Clearer theoretical frameworks and empirical work are needed around these issues, based on engagement with different communities.

5.2.2 Linkages to non-transport outcomes

To date a majority of accessibility research has been directed at technical (e.g., measurement) issues. Only recently has the focus started to shift toward obtaining a better understanding of the *meaning* of accessibility within people's lives. In this context, a clearer understanding is needed of the links between access and social outcomes. Referring to the U.K. experience, Halden notes that "there is evidence that poor health patient attendance, restrictions on employment opportunities, take up of education opportunities, and many other mechanisms for social and economic progress, can be related to levels of access, but the relationships are not yet as well defined as they could be, and there is considerable scope for further work."[137] Only once such evidence has been examined can cross-sectoral partnerships be established for addressing accessibility as more than just a transport problem. This is particularly important in developing countries, given the considerable social exclusion problems and barriers to cross-sectoral cooperation that exist. A detailed understanding needs to be formed of what exactly keeps people in different locations from participating in various activities or accessing various services, and of what the contributions of transport and service providers are to such barriers, before exclusion can effectively be addressed.

There is a role, in particular, for qualitative research in examining people's perceptions of access and the process of using access to meet their daily needs.[138] States Karen Lucas, "accessibility planning isn't just about land and transport, it's about detailed population analysis as well."[139]

5.2.3 Linkages to new mobility solutions

Traditional mobility solutions will never be able to fully address transport-related social exclusion.[140] At the same time, the demographics and preferences of people in cities are changing, as evidenced by phenomena such as the leveling off of car ownership and use levels in some Western cities.[141] Indeed, people's experience with new ways of interacting might change the very nature of the demand for accessibility. It is possible, then, that new mobility solutions and information and communications

technology (ICT) solutions will provide alternative ways of satisfying accessibility needs outside the conventional transport and land use space.

New mobility solutions provide new ways of supplying such accessibility by applying shared ownership models to transport and connecting users and mobility service suppliers more efficiently. Examples include e-hailing taxi services like Uber, Lyft, and Didi; car and bicycle sharing schemes; and online brokerage services such as the Dutch Marketplace for Mobility ("De Verkeersonderneming"), a virtual marketplace to connect companies offering mobility services with users seeking alternatives to driving during rush hour. The advent of driverless vehicles might have far-reaching impacts on urban mobility. Overall, the shape of mobility and social interchange might change dramatically in coming decades in ways that we cannot yet anticipate. Accessibility is a flexible concept that is very suitable for analyzing such issues. Yet given the uncertainties about the future, further thinking is required about how accessibility interfaces with dimensions like robustness to uncertainty and adaptability.

5.3 Methodological issues

5.3.1 Linkages to transport and urban planning tools

Apart from an insufficient conceptual understanding of accessibility, there is also a lack of practical tools to effectively incorporate accessibility analysis within transport and land use planning. The multiformity of indicators that have been developed for measuring accessibility is partly to blame, although some consensus is starting to emerge around best practice measures that strike a reasonable balance between theoretical rigor, data requirements, and ease of communicating results. Location-based (e.g., contour and gravity-type) measures seem to be preferable for descriptive and diagnostic purposes. A good example of emerging best practice is the new accessibility assessment tool developed by the New Zealand Transport Agency to assist with formalized accessibility planning.[142] It is sufficiently sophisticated to take into account different modes of travel (walk, cycle, private motor vehicle, public transport), travel behavior (ideally using logistic decay functions), destinations (origin or destination based), activities (consumed or supplied), and multiple opportunities (saturations or competition effects). The measure can be applied at the local authority level or the suburb, city, or regional level, and has been successfully piloted in Christchurch.

Nevertheless, some researchers have pointed out that one of the reasons accessibility has not replaced mobility as the dominant paradigm in transport planning is the lack of a clear link between observed accessibility and the underlying causes or contributing factors.[143] The key strength of accessibility—its ability to integrate several aspects of the transport and land use system into one indicator—is also a limitation, as accessibility indicators do not to allow transportation or urban planners to identify *why* accessibility levels are low or high in a particular area. It is difficult to decompose accessibility into its land use and transport components.[144] As a result, accessibility tends to fall short of providing clear and systematic direction for action.[145] However, scenario tests allow the analyst to determine the contribution of land use changes vs. network changes to the change in accessibility over time.

Regarding the identification of accessibility problems or deficiencies, various approaches have been tried to identify these in relation to revealed or stated expectations,[146] objectively determined transport deprivation, or relative "accessibility poverty lines."[147] Some work is being done on linking accessibility to policy action by using accessibility indices in combination with indicators of mobility[148] and the minimum level and standards of public transport that are necessary for social inclusion under given circumstances.[149] More work is needed along these

lines to develop tools for the systematic practice of accessibility planning.

Given that quantitative appraisal is deeply embedded within engineering practice and decision making, another clear priority for further research is on how accessibility gains should be incorporated into project appraisal. Whether accessibility benefits should replace the traditional valuation of travel cost savings in cost-benefit analyses, or be incorporated through cost-effectiveness analyses, or considered as a supplementary issue via some other multicriteria analysis methodology is still being debated.[150] How to monetize accessibility is an important element of this debate.

5.3.2 Linkages to financial and fiscal issues

More work needs to be done to locate issues of accessibility within the fiscal and financial space. The questions in this regard fall into at least three broad areas, namely, the financial implications (to households and government) of poor accessibility, the costs and fiscal benefits of enhancing accessibility by various means, and potential financial mechanisms by which this can be achieved.

Numerous studies have examined the trade-offs households make between commute costs and housing accessibility. Housing location in areas of lower accessibility (such as peripheral suburbs) is typically associated with higher transport costs, both as a result of the longer travel distances incurred and the likely need, for those living in transit-poor suburbs, to own and operate a car.[151] The Center for Housing Policy finds the combined cost of housing and transportation (as a percentage of household incomes) in the United States typically rises up to a distance of about 15 miles from major employment centers, after which it declines very slightly, though it should be noted that household structure also varies with distance from centers, and many household and transport expenses are by choice rather than necessity.[152] In developing countries, it is common for poorly located low-income populations to bear high transport costs, both in terms of travel time (using slow modes such as walking or inefficient public transport) and cost.[153] In addition, long travel distances may also contribute to unsustainably high subsidy burdens on the state.[154] All of these studies start to point to the costs of poor accessibility, both to households and to the state. More work is needed to expand the evidence base on these costs as well as other costs such as environmental and social externalities.

Strategies to improve accessibility in cities may arise from a range of activities, including changing housing or land use zoning policy, improving transport systems (of various types), and changing the locations of services and employment. The costs of implementing such strategies—both monetarily and politically—vary greatly from place to place. Nevertheless, a comprehensive database of the evidence regarding both the costs and the potential effectiveness, in terms of measurably enhancing accessibility, of such interventions would be helpful in informing the accessibility planning agenda. Particularly helpful would be a better understanding of the circumstances under which transport interventions, purely land use interventions, or a combination of both would be more optimal in terms of delivering incremental or long-term accessibility gains. The challenge here would be to consistently measure the accessibility benefits of such interventions ex post.

Further work is also required to link accessibility benefits to improved government revenue, enhanced property values and property tax income, and overall productivity and tax revenue. The literature on property valuation and value capture might be useful starting points, and it might be possible to start linking such results to accessibility measures that are consistent with economics, such as utility-based measures (see the section above on evaluative applications of accessibility).

A better evidence base on the benefits of enhanced accessibility to households and governments is likely to lead to innovation in terms of products and policies that capitalize on monetizing such benefits. A few examples exist already. One is the use of semi-market mechanisms such as housing or transport vouchers, which give recipients the spatial and economic flexibility to optimize their housing-commute trade-offs.[155] Another is the "location efficient mortgage,"[156] an innovative private-sector product that, by taking into account in income the potential savings on transport costs, allows households to qualify for higher mortgages to buy property in transit-accessible locations. Finally, an example of a government intervention that pro-actively absorbs the cost of (future) higher accessibility for the benefit of low-income households is the city of Bogotá's land banking initiative called Metrovivienda. The municipality buys land located close to future TransMilenio Bus Rapid Transit trunk routes before land values start rising, and then regulates the development and reselling of these properties to be affordable to the poor.[157] Price reductions of 25 percent below market rates have been reported.[158]

5.3.3 Relevance of accessibility measures for analyzing pricing issues

An area of growing policy relevance is the pricing of infrastructure through congestion charging, mileage-based fees, tolling, and so forth. A key question is how such schemes, meant to achieve sustainable transport goals or to finance transport infrastructure, affect the accessibility enjoyed by those affected by the schemes. The question has received surprisingly limited attention in the literature to date.

A key limitation of conventional accessibility analysis in dealing with pricing issues is its frequent disregard for travel costs. Although the monetary cost of travel is acknowledged by many as central to accessibility,[159] by far the majority of applications have considered only travel time as the metric for travel disutility, leading to an overestimation of the accessibility users actually experience. Some researchers have started to explore how travel cost can be introduced in deterrence functions.[160] This is especially relevant to poor user populations, where it makes little sense to examine time-based accessibility to a set of activities while disregarding the fact that many people simply cannot afford to travel there. Further work is required in this respect.

Regarding the question of how road pricing affects communities' accessibility, the key concern is that people for whom paying congestion charges or tolls is a financial hardship may find their access to employment, places of worship, shopping, and socialization curtailed.[161] Some work has been done on the spatial welfare effects of toll roads. Kalmanje and Kockelman investigate welfare changes due to toll roads in Texas by evaluating logsum measures from a destination-mode choice model. The results can be interpreted as a measure of accessibility. They find, as can be expected, that welfare impacts are strongly differentiated across space, with the largest impacts occurring in areas closest to the tolled roads.[162] This pattern suggests that the spatial equity impacts of pricing are very sensitive to the relative locations of different population groups and their destination opportunities relative to the tolled facilities. This finding was confirmed by Van Dijk et al., who, looking at Cape Town, South Africa, found that in the aggregate (i.e., for the population as a whole) gravity and cumulative opportunity accessibility measures are not very sensitive to tolling scenarios.[163] It is likely, however, that the incremental impact on individual communities (e.g., those living next to toll roads) could be considerable. It makes sense, therefore, to measure accessibility more finely disaggregated across space and population groups when investigating road pricing impacts.

While a fair number of studies have examined the equity effects of congestion pricing,[164] these have

tended to focus largely on direct impacts (i.e., the distribution of tolls and charges, and of traffic impacts), rather than on the indirect impacts on accessibility. The few studies that have employed accessibility measurement techniques to assess these spatial effects indicate that the ultimate distribution of impacts is very sensitive to how the scheme is conceived and how revenues are spent. Fridstrøm et al. test road pricing scenarios in Edinburgh, Scotland; Helsinki, Finland; and Oslo, Norway and find that pricing diminishes accessibility by car but increases accessibility by public transit if revenues are used to improve its services.[165] Safirova et al. model cordon tolls in Washington DC and find that industry may leave the central core, and thus pricing might have a decentralizing effect; these industry moves might improve job accessibility for suburban communities, but not for central cities.[166] This finding mirrors an earlier argument by Levine and Garb that "traditional congestion pricing policies may lead to spatial deconcentration as prices discourage driving to congested areas."[167] The authors suggest that tolls be redistributed to mitigate the ensuing negative effects on regional accessibility. Other studies of the accessibility impacts of congestion pricing schemes have been done in Spain[168] and the Netherlands.[169] As the popularity of road pricing grows in the future, both as an alternative funding mechanism and as a means of managing travel demand, much more work is needed on how it affects the distribution of opportunities that can be accessed by different groups.

5.3.4 Data availability

The data required for accessibility assessment have been and remain an important constraint. Even in the United Kingdom, the selection of indicators to support formal accessibility planning was significantly limited by data that were readily available or could easily be collected.[170] The situation is much worse in developing countries, where the quality, availability, and geo-location characteristics of transport and land use data are highly variable. This is an area where the involvement of international agencies acting as data collators, collectors, curators, and disseminators could be very useful, as already illustrated by efforts such as the Millennium Cities Database compiled by UITP, the international public transport association. .[171] In addition, the convergence of new technologies and open data movements could provide new opportunities for data collection (see also the discussion under emerging approaches below).

5.3.5 Modeling and analysis software tools

The availability and performance of integrated land use/transport models are key for the accurate assessment of long-term accessibility impacts of land use/transport policies and plans. The quality and availability of such models are growing, but they remain in limited use,[172] especially in developing countries due to data and technical deficiencies. The traditional transport demand models that are in more widespread use, both in developed and emerging economies, do not in general have strong enough land use modeling components, nor are they set up to produce the right kind of outputs needed for accessibility analyses. As a result, analysts more easily default to mobility-based performance indicators that can be provided by their current tools.

Some exceptions occur, such as Omnitrans (Netherlands) and Cube (United Kingdom), and GIS-based platforms including Caliper TransCAD, which have the capability of generating isochrones and accessibility measures.[173] Several other stand-alone accessibility mapping platforms have been developed, such as TRACC, a multimodal travel-time mapping tool that has been widely used in formal accessibility planning in the United Kingdom.[174] It is also important to note that standard urban transportation planning system-type models can produce accessibility outputs without a land use component, and have done so for decades. Experience suggests that the availability of an easy-to-use, adaptable software platform that can be integrated with multiple data sources could be useful

in advancing the adoption of accessibility analyses across jurisdictions and countries.

5.4 Promising emerging approaches

Recent developments that hold promise for supporting accessibility planning internationally include the following.

5.4.1 Open data and open software

Freely available volunteered geographic information (VGI) offers significant opportunities for overcoming data scarcity issues. Sources like OpenStreetMap[175] are increasingly becoming a worldwide standard for geospatial data (including both road network and facility location data) that might significantly bring down the costs of implementing accessibility mapping.[176] Several efforts are underway to experiment with the use of crowdsourcing to source VGI data to, for instance, map public transport routes,[177] or to gather user data[178] using mobile technologies such as smart phones.

At the same time the development of common data standards for public transport information such as GTFS (general transit feed specification) is making the calculation of public transport accessibility easier and more portable between cities. GTFS is becoming the de facto standard for transit service and route information worldwide. Many transit operators in the United States and elsewhere provide detailed route, schedule, stop, and other information in the GTFS standard via a direct website link. Users can also access GTFS datasets from a crowdsourced archive of datasets from around the world. The chief benefit is that the information enables detailed schedule-based calculation of public transport accessibility for any hour of the day based on actual headways and schedules,[179] rather than estimated or average headways and vehicle speeds.

Both data formats can be used by OpenTripPlanner, an open-source tool, to estimate origin-destination travel times in a city and, in combination with location data for employment (or other) opportunities, to calculate point-specific accessibility values. OpenStreetMap and GTFS data have been used to calculate accessibility by public transport in the United States[180] and Argentina.[181]

5.4.2 Community engagement tools

A few efforts are underway at connecting the concept of accessibility to narratives more easily and intuitively understood by community stakeholders. One such example is the Urban Poor Accessibility Assessment Tool developed by UN-Habitat to help researchers better understand the meaning and use of accessibility within unfamiliar contexts. Turner and Adzigbey describe the application of this tool within a participatory planning approach in Africa that combines the use of GPS to track and map individual travel patterns and qualitative participatory data "to ground this mapping data in experience."[182]

Other approaches are using web-based technology to calculate and visualize accessibility. Researchers at the Massachusetts Institute of Technology have been developing a web-based mapping and visualization tool, called CoAXs, that can be used in planning workshops to evaluate and communicate the accessibility benefits of transit projects.[183] An online accessibility calculator has been developed in Montreal that allows members of the public, developers, or planners/policymakers to measure the level of accessibility for a specific address.[184] Transport for London's web-based connectivity assessment toolkit WebCAT is another well-known example of an online accessibility visualization tool that is readily available to the public.[185] Other interactive accessibility visualization tools (not web-based) for use during stakeholder engagement have been developed in the United Kingdom[186] and the Netherlands.[187]

5.4.3 Agent-based modeling approaches

Agent-based approaches to transport modeling simulate the movements of synthetic populations,

given a set of transport options, the spatial distribution of homes and activities, and desired activity chains. While still largely in a developmental phase, these models are now starting to move toward becoming a viable alternative to conventional four-step transport models for modeling the impacts of transport scenarios. Some researchers have now started to explore how these models can be used to measure accessibility.[188]

Agent-based models hold promise in three respects. First, by simulating the movements of individuals, it becomes possible to achieve a significant degree of disaggregation of accessibility measurement across the population by socio-economic characteristics, travel behavior, or location; results can then be aggregated up to any level of interest. This makes it possible to achieve individual-specific measures, given that differences between individuals can have vast impacts on their personal accessibility.[189]

Second, as agent-based models typically simulate travel and activities over periods of 24 hours or longer, it becomes possible to include individual or household activity scheduling effects on accessibility. Time geography researchers, whose accessibility measures explicitly acknowledge the constraints placed on accessibility by personal time constraints and time budgets, have shown these measures to be important. For instance, the requirement to be at work by 9 am reduces the range of opportunities a worker can access after leaving home in the morning. Thus, it becomes possible to enrich accessibility measurement with more individual constraints and behaviors of the kind advocated by Kwan.[190] Potential downsides are rather onerous data requirements (e.g., the need for population descriptors, such as from a census) and sufficiently calibrated behavioral models.

Third, by introducing greater spatial disaggregation, agent-based models can measure the walking part of a trip much more accurately than can traditional zone-based models. It has been shown that accessibility indices are sensitive to the zoning system used.[191] Recent work has shown the value of moving away from transport zones altogether and using local pedestrian networks to measure fine-grained accessibility (so-called *micro-accessibility*) using door-to-door travel times.[192] These advances are particularly relevant for low-income populations in the Global South, where walking remains a major mode of transport.

5.4.4 Accessibility benchmarking

The University of Minnesota has established an Accessibility Observatory, which aims to provide data and maps of accessibility to employment via various modes of transportation in major metropolitan areas across the United States. So far accessibility maps and figures have been calculated for about 50 of the largest metropolitan areas by car, transit, and walking modes.[193] A key deliverable was to develop a common baseline accessibility metric using travel times by mode, estimated from detailed GTFS transit schedules, road network data, and job data from the U.S. Census Bureau, at the census block level.

The value of this ongoing initiative is that it provides transportation agencies with a standardized metric to be used during implementation of accessibility-based methods in their own planning processes. It also provides a benchmark against which cities can be compared and allows changes in accessibility to be monitored over time. Lastly, it can provide researchers a frame of reference against which new developments in accessibility evaluation can be evaluated.[194] Similar benchmarking and standardization exercises might be valuable for cities seeking to implement an accessibility-oriented approach toward planning.

6 Conclusion

While accessibility has captured the imagination of researchers and theorists since at least the 1950s, its conceptual definition and broader application have only recently gained traction. Over the past decade, in particular, a number of developed and developing cities, along with their national peers, have begun to formally implement accessibility policies into their transportation, land use, and fiscal frameworks. From national evaluation schemes in the United Kingdom to new bus rapid transit lines in Santiago, there is now an emerging volume of knowledge and precedent about how an accessibility approach to transportation planning, investment, and operation can improve economic and social outcomes across urban areas.

Accelerating the pace of practical application, however, will require a concerted effort to address some significant hurdles. In many cases, planners and finance professionals may not be actively involved in accessibility conversations with their transportation peers, leading to less-integrated policies and greater difficulty in generating sustained political support. Likewise, the lack of formal accessibility measurements—plus uncertainty around the data and software requirements to generate those metrics—makes it difficult for relevant leadership to show other practitioners and the public how accessibility policies can change transportation-related outcomes.

Yet there is an opportunity for a new vanguard of cities, regions, and nations to lead in the adoption and practical application of accessibility concepts. Addressing the barriers discussed in this paper will only serve to expand the places beginning to experiment with an accessibility-approach to urban transportation.

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About Moving to Access

The Moving to Access Initiative aims to inform and promote a more socially focused, access-first approach to urban transportation policy, planning, investment, and services. Facing a number of economic, demographic, fiscal, and environmental challenges, cities and metropolitan areas globally are looking to adopt new, actionable metrics to guide more purposeful initiatives to improve accessibility for people of all incomes. The Initiative looks to move beyond theory and accelerate the adoption of these innovative efforts, exploring new tools, techniques, and performance measures across the developing and developed world.

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