MOVING TO ACCESS
BROOKINGS

DELIVERING INCLUSIVE ACCESS

A Framework to Guide Researchers, Policymakers, and Practitioners Working in Urban Transport

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Executive Summary

Across the world, rapid urban growth offers enormous opportunity to those living in cities and suburbs. Urban residents tend to earn higher incomes than their rural peers, and enjoy the benefits of living in closer proximity to vital services and commerce. However, the same influx of people and economic activity also places enormous pressure on the built environment, straining existing transportation systems across the developed and developing world. In turn, residents and businesses increasingly struggle to reach one another, and they often place a premium on locating in neighborhoods with the greatest urban access. In other words, people want to live where it is easy to reach key destinations. This can drive up the price of land and contributes to a toxic mix of income inequality and spatial inequity.

In response, urban leaders need to plan, design, and deliver transportation services and develop land in a way that prioritizes inclusive access. Striving for greater and more inclusive access requires a new vision for urban areas in the years to come and should inform longer-term strategies and policy decisions. This new framework should aim to optimize access for all people regardless of demographic characteristics, ensure the built environment is responsive to their needs, and promote development of a transportation system in line with an urban area's long-term fiscal and financial health.

Developing such a new framework will not be easy. Given the variety of concerns and geographic contexts to consider, approaching accessibility through the lens of all relevant disciplines is still a difficult exercise for researchers, even after decades of academic inquiry. Among policymakers, current frameworks—at national and local levels—too often do not coordinate across agencies and neighboring jurisdictions. Meanwhile, practitioners continue to disagree on how to even measure and quantify accessibility in planning efforts and other activities.

By identifying major barriers in accessibility research and practice and offering a new path forward, this report outlines a framework that can speak to each of the major actors responsible for designing and implementing policies related to inclusive urban access:

- **Researchers** must integrate fiscal/financial tools more clearly in future studies. Building off the vast body of literature discussing the merits of accessibility in terms of transportation and land use, researchers need to better understand how regions can incentivize and pay for access-promoting infrastructure and service improvements in years to come.

- **Practitioners** must begin to more consistently test new accessibility measures and develop new data inputs. Rather than pursuing a single perfect measure, they should focus on developing a broader suite of measures and support a shift toward greater experimentation and widespread policy adoption.

- **Policymakers** across the developing and developed world must create stronger, more transparent governance strategies that explicitly emphasize accessibility. This should include built environment policies that require cross-disciplinary input, especially as it relates to fiscal budgeting, funding and project financing, and greater horizontal, inter-jurisdictional coordination.

Fortunately, several practical innovations are emerging and blazing a new path forward. Multiple urban areas and international finance institutions now score future capital projects and operational adjustments based on accessibility impacts. New transport pricing strategies consider riders' incomes. New public corporations and other governmental bodies attempt to consolidate approaches from multiple disciplines in pursuit of inclusive economic development. The challenges may be large, but innovation is possible.

Based on research by The Brookings Institution and other collaborators during the first year of the Moving to Access (M2A) project, this report unpacks the complexities involved in defining and addressing accessibility needs worldwide. It first identifies the major urban development challenges many areas face and the need for greater accessibility. It then sets forth the key elements of a new accessibility framework and the challenges in implementing it. Doing so, of course, depends on a clear understanding of research gaps in this space, which the report traces through a

bibliometric analysis and literature review. To create a new cross-disciplinary approach, the report looks at the issue of measurement in greater depth and establishes a clear set of criteria to guide future measurement efforts. It concludes with a discussion of future applications and research, informed by practical innovations already under way.

As a concept, accessibility continues to attract attention from researchers, policymakers, and practitioners worldwide, but its practical implementation remains a work in progress. The steps described above will not come easily or quickly, but they are crucial to testing new ideas and creating the feedback loops necessary to guide future actions. This report attempts to provide a starting point in that respect, emphasizing the high level of discernment and persistence needed to unpack such a complex topic—and some initial steps to advance system-wide shifts at a global scale.

I. A call to action

The drive for proximity is a major force behind the planet's rapid urbanization. As households and firms demand to locate closer to one another, urban activities become more concentrated, and as they concentrate, the economic benefits of agglomeration are coming into clearer focus.[1] Households are able to reach a greater variety of employment opportunities, schools, health clinics, and retail destinations. Businesses and firms can connect to bigger pools of labor and groups of consumers, innovate faster, and drive an increase in global freight flows.

But agglomeration is not the same as accessibility. As the sheer number of people and businesses rise in urban areas all across the world, accessibility—or the ease of reaching key opportunities—grows ever more important. Yet even as urban accessibility gains greater interest and momentum globally, accessibility continues to be an ill-defined objective for many policymakers and practitioners.

By default, many professionals tend to focus their attention on the functioning of the transport system and easily measured parameters of congestion and speed.[2] Accessibility, however, requires a broader view that incorporates land use, transport, and related fiscal, funding, and financing elements in designing and delivering different infrastructure systems. In addition to this focus on infrastructure supply, the accessibility concept must also recognize in greater detail what users demand from these systems. This includes understanding the importance of accessibility for all types of users—across all income levels, demographics, and other characteristics—that can help promote inclusive urban development. Policymakers and practitioners cannot expect to achieve equitable growth in urban areas without addressing spatial inequities related to the built environment.

Without a common understanding across key stakeholders in light of these diverse needs, the concept of urban accessibility will struggle to gain political legitimacy and interest, even as some places continue to test out new ideas. In short, urban accessibility's extensive and multi-pronged reach must come into greater focus for a wide range of researchers, policymakers, and practitioners globally. And the moment is ripe for additional attention and action. Right now, urban accessibility represents a key connective tissue across three global trends: growing urbanization, worsening inequality, and inefficient infrastructure.

Facing growing urbanization

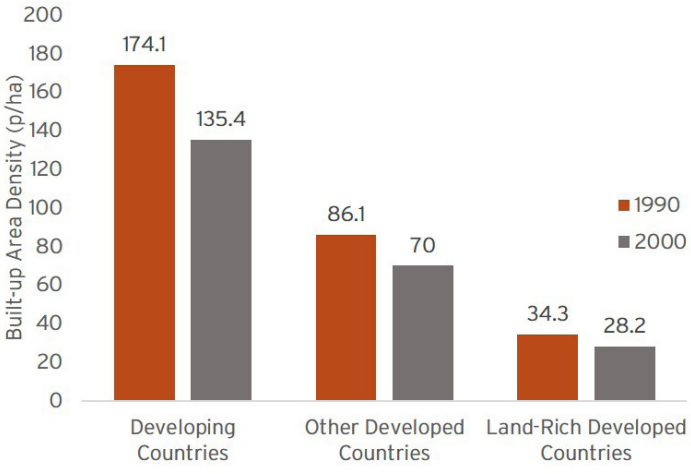
The growing concentration of people in urban areas is leading to a number of economic, social and environmental implications globally, which is raising awareness of accessibility and driving the creation of several new initiatives related to it.

Despite years of research promoting the virtues of densification and avoiding sprawl, urban land coverage keeps extending. As the world population doubles over the next 43 years, urban land cover will double in 19 years.[3] For developing countries, in particular, the projections are even more ominous, with urban populations expected to double between 2000 and 2030 and overall levels of urban land development expected to triple.[4] While Latin America is already highly urbanized and China continues its rapid urban growth, Africa and the rest of Asia are also beginning to confront an urbanization wave. The impacts will likely be far-reaching given the comparatively low-

income levels and weak institutions present in most of these countries' urban areas. Indeed, these types of development patterns are spreading people and opportunities farther apart, resulting in significant spatial mismatch, economic inefficiency, more environmental pollution, and greater social inequity. In turn, the need to encourage greater urban accessibility is that much clearer.

The Habitat III conference in 2016 underscored the urban challenge and the need to advance accessibility-related practices. Serving as the biggest global urban convening every twenty years, over 30,000 attendees from 140 countries attended Habitat III in Quito, Ecuador, to adopt the New Urban Agenda.[5] As part of the broader agenda, countries formally shifted their support behind "inclusive, safe, resilient and sustainable" urban development, one of the seventeen U.N. Sustainable Development Goals.[6] Delivering progress on this goal—whether it's more sustainable mode choice, boosting affordable housing, or limiting land consumption—would benefit from a more developed, practical framework for urban access.

Figure 1: Density differences among cities in three regional sub-groups



Source: Angel, Shlomo, Jason Parent, Daniel L. Civco, and Alejandro Blei. 2010. "The Persistent Decline in Urban Densities: Global and Historical Evidence of 'Sprawl.'" Lincoln Institute of Land Policy.

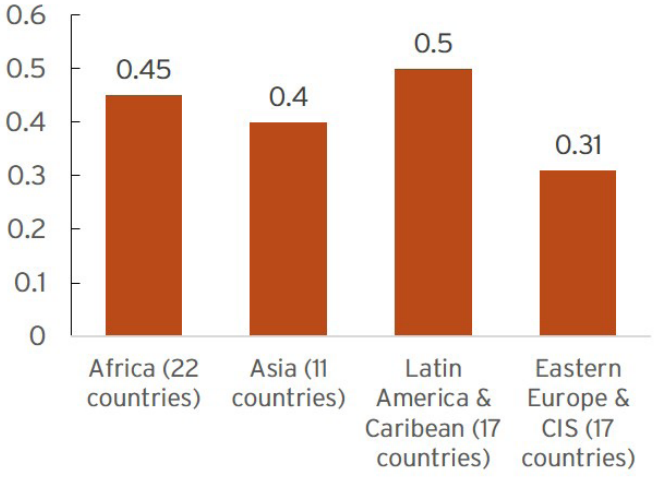
Addressing worsening inequality

With rising levels of urban development, another challenge emerges that further elevates the importance of accessibility: inequality.

Increasing inequality, both among and within nations, has sounded alarm bells worldwide. Developing countries are confronting the most drastic challenges in this respect, with 75 percent of their populations facing higher levels of income inequality today than they did in the 1990s.[7] In many developed countries, the gap between rich and poor is also at its highest level in 30 years; for instance, among OECD countries, the richest 10 percent of the population earn 9.6 times the income of the poorest 10 percent.[8]

At a sub-national level, urban areas are confronting some of the most extreme levels of income inequality, especially in the so-called BRICS countries.[9] Income inequality tends to lead to spatial inequities, where low-income households are often located in entirely separate neighborhoods from higher-income households. A combination of land markets, restrictive or inefficient zoning, and regulatory practices, as well as discrimination, have exacerbated this inequity.[10] In general, neighborhoods with greater urban access

Figure 2: Average urban Gini coefficient by developing regions



Source: United Nations Human Settlement Programme (UN-Habitat), Global Urban Indicators Database 2015. Data from UN-ECLAC, UN-ESCAP, UNU and other sources.

tend to have higher land values, which themselves push lower income households to lower access areas in search of affordable housing.

Although it is difficult to measure and assess these trends across different urban areas—primarily due to a lack of consistent data—slums represent one of the more visible forms of increasing inequality, particularly in the developing world. Today, one in eight people around the world live in slums, or nearly a billion people, according to the U.N.[11] In Africa, over 60 percent of the urban population lives in slums.[12] The U.N. definition of a slum, however, mainly focuses on inadequate access to essential services, such as water and housing, but excludes concerns for spatial isolation. The French Development Agency (AFD), in contrast, provides a more precise measure—"insecure settlements"—that incorporates broader forms of exclusion, including households disconnected from employment opportunities.

While access certainly can exacerbate urban inequality, it also can offer solutions. Many land use policies, such as supporting affordable housing in access-rich neighborhoods or promoting job growth in well-served locations, can all support greater opportunity for the economically disadvantaged. Pricing policies can promote travel for those most in need, while other transportation policies that promote sprawl and expensive, private vehicular travel can be downplayed. In general, how local policymakers approach access will have far-reaching effects on local populations.

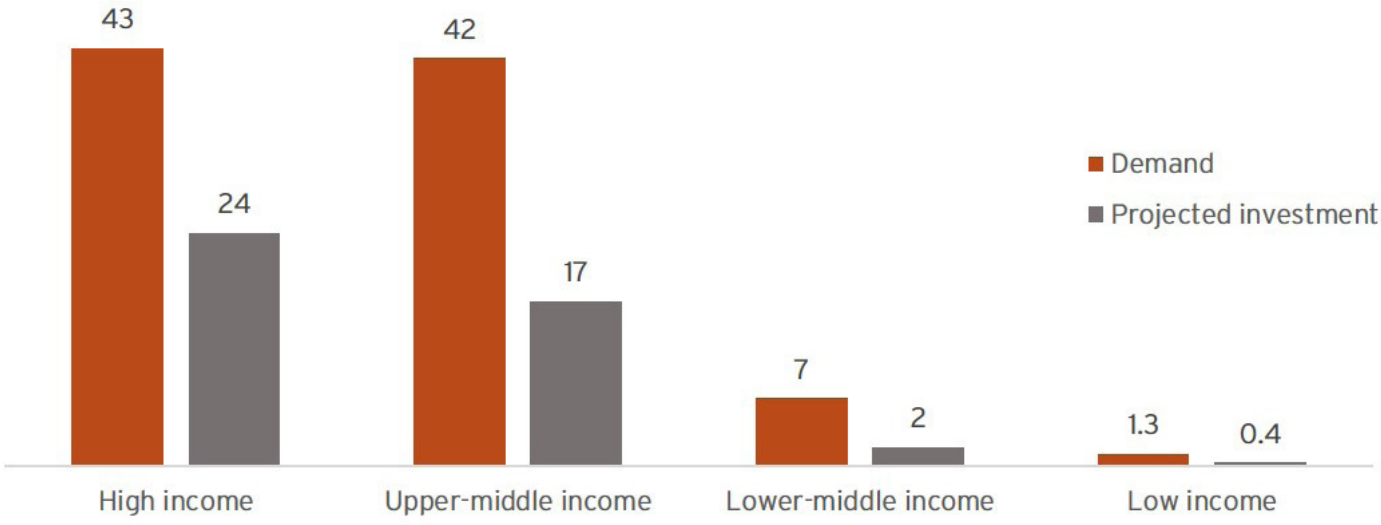
Filling the infrastructure gap

The lack of infrastructure to channel urban growth and serve all individuals is a third piece of the accessibility puzzle. Whether it is the Juncker Plan in Europe, China's "One Belt One Road" initiative, the Trump Administration's trillion dollar infrastructure declarations in the United States, or the G20 Global Infrastructure Initiative, there is mounting interest in new approaches to plan and finance infrastructure.

Urban transport is one of the most significant of all existing infrastructure gaps.

Compared with other infrastructure sectors, estimating a reasonable level of investment in urban transport is fraught with complexities. While it is easy to interpret measures of access to electricity or water or telecommunications, access via transport is challenging to pin down. For example, planners and other practitioners may find it hard to determine the demand for transport across different types of trips,

Figure 3: Infrastructure demand by country type (2015-2030); in trillions, constant 2010 USD



Source: Bielenberg, Aaron., Kerlin, Mike., Roberts, Melissa., & Oppenheim, Jeremy. (2016). Financing Change: Mobilizing Private Sector Financing for Sustainable Infrastructure. McKinsey and Company.
Note: Extrapolated from historical spending and assuming a continuation of real investment growth (assumes conservative investment-growth scenario). Figures may not sum, because of rounding.

among different households, at different times of day, across different modes of transport. Moreover, residents have varying preferences and face a range of tradeoffs when making their housing selections, particularly when it comes to the distance to jobs and other services.

Given this, transport planners tend to focus on more straightforward measures regarding the level of service—such as speed and congestion—of existing infrastructure. While this is a practical, reliable indicator of "mobility"—namely the flow of vehicles and people—it mainly represents the quality of the infrastructure. It is not a robust measure of the level of access of a given household or neighborhood to a range of crucial destinations, including jobs and other services. Nor does the level of service speak to what drives demand.

Troublingly, mobility measures only exacerbate challenges around economic inequality, fiscal sustainability, and environmental resilience. Promoting speed and aggressively targeting congestion tends to promote road construction, which benefits individuals who own vehicles. Roads for vehicles are also expensive to maintain, increase long-run cost burdens, and induce driving and land consumption. This leads to higher emissions, greater loss of undeveloped land, and longer travel times.

Instead, policymakers and practitioners need new measures.

Discussion of accessibility measures goes back decades in the academic literature, as discussed in greater detail later in this report. In more recent years, as criticisms of a singular focus on mobility have increased, researchers have targeted their efforts to more clearly define and measure this broader concept of accessibility. This change in emphasis among researchers, however, would require a change in how policymakers and practitioners plan, appraise, finance, and operate transport infrastructure and services.

Structuring the discussion

This paper aims to make urban access and, in particular, inclusive urban access, "visible" in a global context. It aims to develop an approach that addresses the cross-disciplinary nature of urban accessibility, including a common understanding of its measurement and potential paths forward. As such, the paper's primary audience is applied researchers, policymakers, and practitioners involved in urban land use, transport, and fiscal and financial affairs. It attempts to bridge the gap between theory and practice, points to the key gaps that warrant renewed attention among these key actors, and develops a case for how to better integrate the key governing sectors that relate to urban access. By focusing on the practice of accessibility, it supports the idea that advancing more applied innovation can create feedback loops to inform future research.

Based on research by The Brookings Institution with collaborators during the first year of the Moving to Access project, the paper seeks to untangle the complexities involved in defining and addressing accessibility needs worldwide. To begin, Section 2 sets forth the key elements of a new accessibility framework and the challenges in implementing it. For additional context, Section 3 traces the academic literature on accessibility across the transport, land use and fiscal/financing disciplines to understand the linkages and gaps in formulating a cross-disciplinary approach. Section 4 looks at the measurement and the need for a suite of measures to address the range of issues and urban contexts involved. Sections 5 and 6 discuss future applications and research, informed by practical innovations already under way.

II: Framing inclusive access

As researchers, policymakers, and practitioners struggle to address accessibility needs worldwide, the lack of a common set of objectives makes it difficult to mobilize action and strive for practical implementation. In other words, the failure to develop a "common framework" has led to inconsistent, haphazard discussions on conceptualizing and tracking accessibility in addition to elevating its role in existing institutions, policies, and plans.

Too often, applied research assumes the development of a new accessibility metric will lead to practical change across the world. Yet adopting new measures are just one of many dimensions that currently hold back the paradigm shift from mobility to access as the

driving force in transportation and land use planning worldwide. Instead, developing a new accessibility approach to building inclusive and fiscally healthy urban areas will require a framework that addresses: definition and measurement; cross-disciplinary governance; fiscal and finance policy; jurisdictional coordination; and global contextual flexibility.

Defining and measuring access

It is hard to create and evaluate accessibility if its very definition is unclear, especially among researchers. Likewise, if policymakers and practitioners struggle to define accessibility, instituting performance measures to better understand and monitor it will be difficult. Efforts among all these leaders requires determining "access for what, for whom, and how," based on individual household decisions, the needs of firms, and changes in behavior and market characteristics over time.[13]

With this perspective in mind, several questions emerge when thinking about future directions for research and application. Is it possible to define a benchmark for accessibility? How much is too much and how much is too little? What is the minimum social requirement for access? Is an hour commute too long? Is a 10-minute walk to elementary school too far? Is a 15 percent share of income for commuting too unaffordable? How should one manage the potential tradeoffs between the cost of housing versus transport cost and distance? If one can successfully define a measure and establish a benchmark for accessibility, can it be calculated beyond a limited number of data-rich urban areas?

As evident in the U.N.'s sustainable development goals (SDGs), the issue of definition and measurement is critical, including around Goal 11, which focuses on sustainable cities and communities and has eleven targets. Although spelling out Goal 11 is an important step toward action, much more work remains to drive the widespread adoption and implementation of certain key metrics. One takeaway is clear from previous Moving to Access work: there may not be a singular measure, but a suite of measures depending on the type of issue assessed and the specific urban context worldwide. Moreover, it is clear that such measures should be easy to communicate to elected officials and to a range of other community leaders and residents.

Applying a cross-disciplinary approach to governance

There is strong agreement among researchers, policymakers, and practitioners that transport and urban land use affect one another. For example, the ways in which planners view land use in their urban areas can have profound effects on the need for transport, and the provision of transport can have profound effects on land use decisions. Crucially, it is important to look at transport affordability alongside housing considerations.[14] Whether higher income households opt for cheaper suburban land with higher transport costs or inner-city slum dwellers sacrifice quality of housing in order to minimize transport costs, accessibility requires consideration of land use, transport, as well as the implications of alternative fiscal and financing policies and instruments

What is missing in many policies and plans, however, is a truly cross-disciplinary approach, namely one that cuts across the transport and land use sectors as well as fiscal and financing expertise. Simply put, too many agencies that deal with these issues—including fiscal considerations—do not always address concerns collectively. While this idea sounds logical, in practice it raises a substantive challenge. What does a cross-disciplinary approach mean? Is it a theoretical gap or a practical one? Does it require special expertise or simply better coordination? Which are the key disciplines?

Developing greater integration among related governmental authorities—whether transportation and land use, or the budgeting agencies implicated in the next subsection—is fundamental to implementing accessibility policies that can address spatial challenges related to urban form.

Appendix C describes this cross-disciplinary approach in greater depth.

Placing an accessibility lens on fiscal/financing instruments

Fiscal/financing instruments, in particular, play an important role in enhancing accessibility, but researchers, policymakers, and practitioners often fail to address it, which makes it difficult to develop a truly cross-disciplinary approach. As a third leg of the proverbial stool, along with transport and land use, how investments and services are priced, funded, and financed have serious implications for who benefits and who does not, while touching issues of affordability.

Indeed, several challenges exist on this front. When deciding how transport services are ultimately funded, for instance, pricing approaches that might promote inclusive accessibility often face competition from other important objectives, such as network efficiency (congestion) and environmental sustainability. Likewise, researchers have criticized transport service subsidies for lower income households because they may not always adequately reach those who need it most—or they may actually benefit riders who do not need such subsidies.[15] Other funding options such as pricing non-user beneficiaries through value-capture schemes—or using land value increases due to greater access to fund related transportation services and projects—have also not been discussed in terms of their distributional implications.

The criteria used to assess investments matter too. Multiple researchers from Robert Cervero to Sylvie Fol to Eduardo Vasconcellos all criticized the traditional methods for economic appraisal of transport investments.[16] The focus on level of service and value of time has serious limitations when one looks more broadly at the issue of accessibility. And, in particular, traditional cost-benefit methods generally

remain neutral as to who benefits from the improved access of the project. Various countries and financing institutions such as the multilateral development banks are developing new, complementary approaches, such as multi-criteria analysis (MCA) and the application of accessibility models. Nonetheless, there is still a significant gap in analyzing and applying these types of investment tools.

Lastly, the financing structure of projects can also affect accessibility. The extensive discussions among policymakers, infrastructure experts, and the finance community worldwide regarding infrastructure financing seldom, if ever, address the implications for income inequality, let alone spatial inequality. Recent discussions on how to mobilize private finance and explore other financing mechanisms, meanwhile, may ignore or hinder inclusive access. With increasing attention on public private partnerships (P3s) to help finance new investments and operations, incorporating targeted pricing for low-income households under P3 schemes may complicate already lengthy contracting agreements. Whether or not the public sector maintains its control regarding pricing and social policies and how related responsibilities and risks are allocated between the public and private sector will determine how effectively social issues of spatial inequity can be addressed.

Without examining these types of fiscal and financing approaches when addressing inclusive access, any planning and economic development strategies will come up short.

Fostering accountable institutions across urban geographies

Incorporating accessibility into transport plans, land use strategies, and pricing and investment decisions requires policymakers to foster institutional arrangements in support of these objectives. Indeed, as the World Bank's 2009 World Development Report emphasized, "spatially blind institutions" reaffirm the all-important issue of governance and its role in urban accessibility. Conceptually, "spatially blind institutions" are crucial in developing policies to address issues that cross municipal boundaries, such as spatial inequality. This is especially true when considering transport services, which sometimes do not universally cover all urban jurisdictions, leading to numerous network inefficiencies and limited economies of scale.

In practice, municipal boundaries generally are drawn early in the history of an urban area and are difficult to change over time. As a result, most global urban areas include a multitude of local municipalities with varying incentives or disincentives to work collaboratively. Income and spatial inequality between municipalities further discourage collaboration. The potential for collaboration, however, differs between national government schemes, ranging from strong local empowerment in land use and taxation as in the U.S.,

to more centralized government in France.

Fostering cross-border municipal collaboration is not easy for several reasons, especially when it comes to addressing a central tension: the promotion of local engagement and empowerment on the one hand, and scale efficiencies from a metropolitan approach on the other. As the pendulum moves increasingly towards greater delegation of functions and fiscal responsibilities, how does one establish an appropriate balance? This has led to a search for the appropriate form of horizontal governance and cooperation between contiguous municipalities. Many versions of metropolitan transport authorities have been established in various countries. Yet, there is still a concern this has only heightened the siloed approach to urban accessibility. Without incorporating land use and revenue and expenditure (i.e. fiscal) authority, planners and other practitioners may find it challenging to adopt a more cross-disciplinary approach.

Distinguishing country context characteristics

The last challenge for researchers, policymakers, and practitioners to developing a common framework is the ability to adapt to different country and urban contexts.

Without question, inflexible policy frameworks lead to inflexible solution design. The level of service system is an obvious example, especially as it relates to highway construction. Since so many countries and global financing institutions prioritized congestion mitigation—through high-speed freeway (or toll road) capacity and other means—several costs emerged over time, including faster land consumption, greater spatial mismatch, and higher long-term maintenance expenses. Boosting accessibility should not aim for the same solution in every urban context, but instead develop a process to tailor solutions.

At the same time, it is helpful to avoid overly simplistic categorization schemes. For example, the dichotomy between developed and developing country urban areas is inappropriate, if not, counterproductive to such a process. The term "developing country" covers too broad a set of countries from Brazil to Sudan or urban areas from New Delhi to Tegucigalpa. The term "developing country" covers upper and lower middle income, lower income, and fragile states.

To that end, designing a practical accessibility framework in this developmental era must respect modern information channels. Simply put, the entire world tends to know what others are doing. In practice, that means there are good south-north lessons as much as north-south lessons to draw upon in addressing urban accessibility. In the end, if policymakers and practitioners search for constructive policies to address different aspects of urban access, they should not constrain the potential sources and should more precisely define contextual differences that affect alternative policy prescriptions.

Dividing the work

Given the enormous variety of contexts and concerns to consider in developing a common accessibility framework, a broad collection of efforts among researchers, practitioners, and policymakers is necessary to accelerate action. No single actor is going to usher-in such a framework, of course. Instead, leaders in each of these groups must build off their specialties and focus their attention on topics, tools, and approaches in line with their unique skillsets. The following sections describe specific ways in which these three groups can overcome current gaps in theory and practice, offering a new path forward to elevate accessibility's reach worldwide.

III. Finding and addressing gaps in accessibility research

Researchers represent one of the most important groups to establish a clearer accessibility framework, and they have made great strides on this front over many years. Decades of published, peer-reviewed research—judging urban transportation through the lens of reachable destinations—has helped reposition how individuals observe urban connectivity and its economic potential.

But researchers' work is not yet complete. Despite several advancements in accessibility theory, especially in pursuit of new forms of measurement, similar

advancements in practice have not occurred.

As researchers of all disciplines and global regions advance their next stage of accessibility research, advancing accessibility practice is a valuable pursuit. To do this, researchers need to address the gaps listed above, which can better inform practitioners and policymakers responsible for changing formal practice. Ultimately, the goal is for theory to transform practice, but also for practice to provide feedback and guide further development of robust theory.

Through a combination of advanced bibliometric techniques and a traditional literature review, this section illustrates where these research gaps exist and identifies potential avenues for action. (See Box A for more detail). By mapping how researchers approached the accessibility concept over multiple decades and examining specific measures, metrics, and indicators[17] of accessibility, this approach empirically situates where the fields of transportation, land use and fiscal/finance converged around shared accessibility goals. This clustering technique confirms long-held concerns about past research gaps and suggests how to fill those gaps with new, applied research.

In order to capture the breadth of relevant literature on accessibility, this report uses an online scientific citation indexing service called Web of Science.[18] Through Web of Science, access to a range of literary databases that reference cross-disciplinary research allows in-depth exploration of specialized sub-fields within an academic or scientific discipline. It also provides metadata and citation connections, which are crucial to understanding the evolution of a certain field over time and clearly identifying gaps that the research community has yet to address. Additional background on this methodological approach is available in Appendix A.

Several takeaways emerge from this bibliometric analysis, discussed in greater depth below. Chronologically, in particular, it becomes easier to spot key years and trends in the evolution of accessibility research. This clear timeline, in turn, helps identify the seminal works—and most influential authors—that advanced the field. Finally, highlighting certain keywords and mapping their relationships to one another helps

Box A. What bibliometric analysis is and how it can trace accessibility's evolution

Beginning with Walter Hansen's foundational thesis[19] in 1959, academic approaches to accessibility continue to evolve. Since accessibility straddles multiple fields, this evolution led to a particularly diverse set of definitions and corresponding measures, metrics and indicators. This prompted several researchers to periodically review the abundant literature on this complex topic, particularly on what it means and how to operationalize it.[20][21][22] Some recent literature also investigates accessibility in practice, although they acknowledge the dearth of many tangible examples.[23][24][25]

These more traditional forms of literature review offer collective overviews and critical summaries of different aspects of research on accessibility. However, they have certain key limitations. They often are subjective, since reviewers are "vulnerable to bias in the selection, interpretation and organization of content."[26] They also tend to focus on access through specific disciplines. This can make the review non-comprehensive and siloed within areas of expertise, which introduces real obstacles to identifying opportunities for cross-disciplinary work.

To overcome the above limitations and fully consider the universe of prior research as it relates to accessibility, this report relies on more empirical forms of review. Bibliometric methods offer clear advantages and can thoroughly supplement a traditional literature review. They can empirically map major areas of prior research, identifying different communities of articles, key papers and authors.[27] They offer convenient tools to study the extent of collaboration among researchers[28], earmarking the gaps that need to be addressed through current and future work. From a practical perspective, such analysis can guide future research that intentionally targets current gaps. Given this report's focus on identifying gaps in cross-disciplinary collaboration and setting the tone for future work on accessibility, a bibliometric review lends itself well to such an analysis.

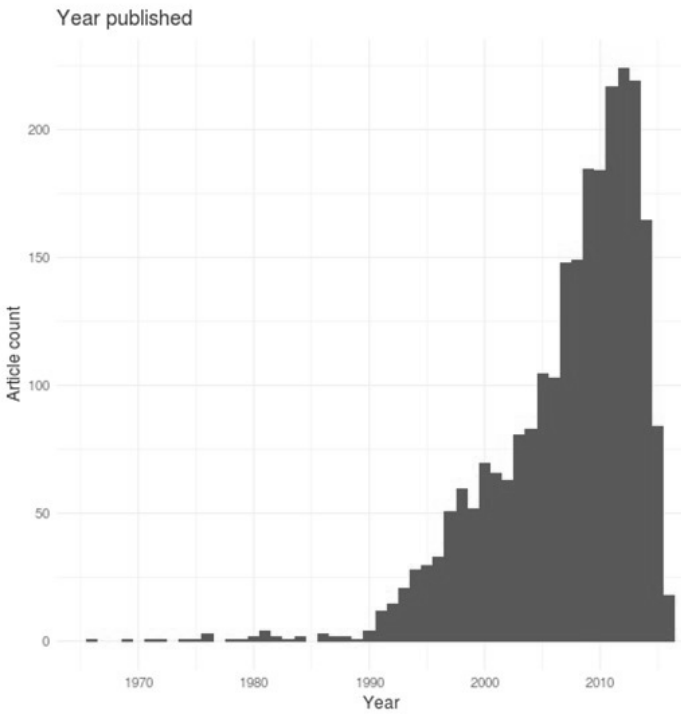
expose why accessibility lacks certain connections across different disciplines. The immense challenges defining and applying accessibility over time come into sharper focus as a result, and point to specific steps that researchers can take in strengthening its future growth and use in years to come.

Accessibility is still a growing field of research, much younger than many researchers may believe and relatively limited in its topical breadth.

It has been well over half a century since Walter Hansen published his seminal work on accessibility. Such a lengthy period can elicit a sense that more progress should be made in terms of practical implementation. But this singular time comparison masks the pursuits of researchers during this period. A scan of published work in major journals over a century reveals a story of accessibility's impressive academic growth—but a growth that is still very much in its early stages.

Figure 4 visualizes this evolution in detail, based on the volume of accessibility literature produced over time. Accessibility first appears in published journals during the late 1950s, including Hansen's 1959 article.[29] However, research in the field is relatively sporadic and limited through the 1980s, with literature only beginning to grow at a rapid pace in the 1990s. This pattern also confirms that, while the concept appears to have universal popularity in the early 21st century, accessibility is effectively a product of the digital age. Given its relatively short history, many challenges still exist in taking accessibility from conceptual definitions to practical implementation in all types of urban areas worldwide.

Figure 4: Year of publication of literature



Source: Brookings analysis of academic journals.

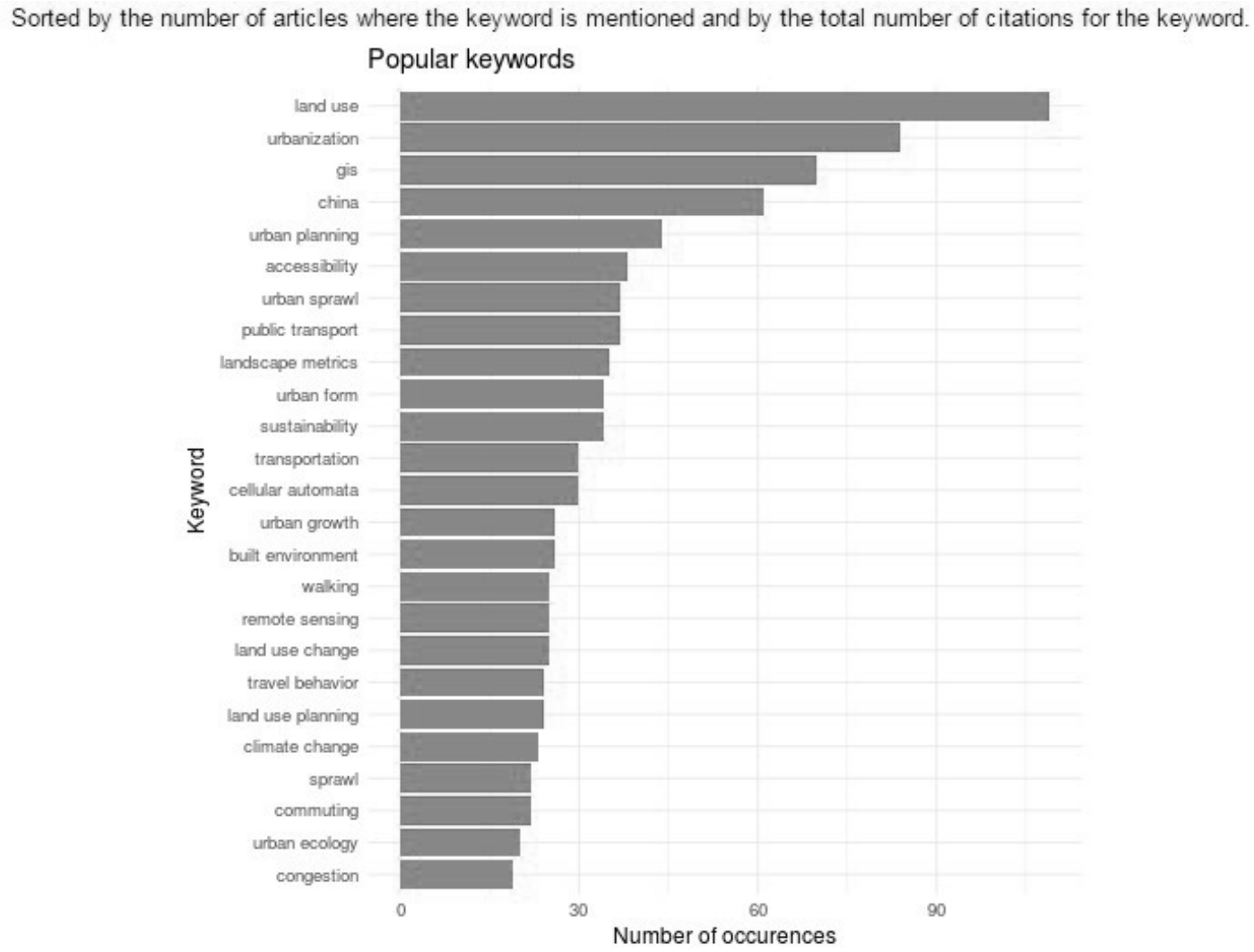
Likewise, the relatively narrow set of topics covered in these articles is also a sign that more research is needed across a greater range of disciplines. Figure 5 shows a set of keywords that most commonly co-occur with accessibility in the literature.[30] Some of the most popular keywords are 'land use', 'urbanization', 'urban planning', and 'transportation', with no finance-related terms evident. This hints at a concentration of accessibility literature in the fields of land use and transportation, a key insight explored in more depth throughout this section.

Landmark accessibility researchers primarily focused on conceptual measurement

Despite accessibility's relatively short history, researchers have emphasized—and made more progress on—measuring urban transportation needs. The most influential authors, in particular, have led the way on this area of research. This is a sensible pursuit: for researchers willing to explore a new topic, defining the concept clearly is a priority, and to do so in a manner that is replicable.

Bibliometric analysis makes it easier to reconstruct the history and evolution of accessibility within various research topics. The "family tree" approach in Figure 6 represents the 50 most frequently cited publications using the accessibility keyword, labeled by the last name of the first author.[31] The vertical location of a publication denotes its publication year, while its horizontal location and proximity to other works depends on its shared citations with other publications. Overall, this approach helps to group clusters of research near one another by time and similarity. The curved connecting

Figure 5: Popular keywords in accessibility literature



Source: Brookings analysis of academic journals.

lines represents who cites whom, and functions as a useful indicator of the most influential authors.

Hansen continues to serve as the conceptual genesis,[32] first defining accessibility in his 1959 thesis as the "potential of opportunities for interaction." He remains one of the most influential researchers in the field today. Moreover, as reflected here and signaled in Figure 4 earlier, the limited amount of literature stretching from 1959 to 1994 also led to the release of few landmark pieces. Instead, researchers in this period focused on developing foundational theory and an abstract generalizable understanding of accessibility. For instance, William Alonso's[33] 1964 paper laid out a theory of land rent and location, and in 1976, Swedish economist Jorgen Weibull[34] derived a general mathematical form of an accessibility measure satisfying specific postulated axioms.

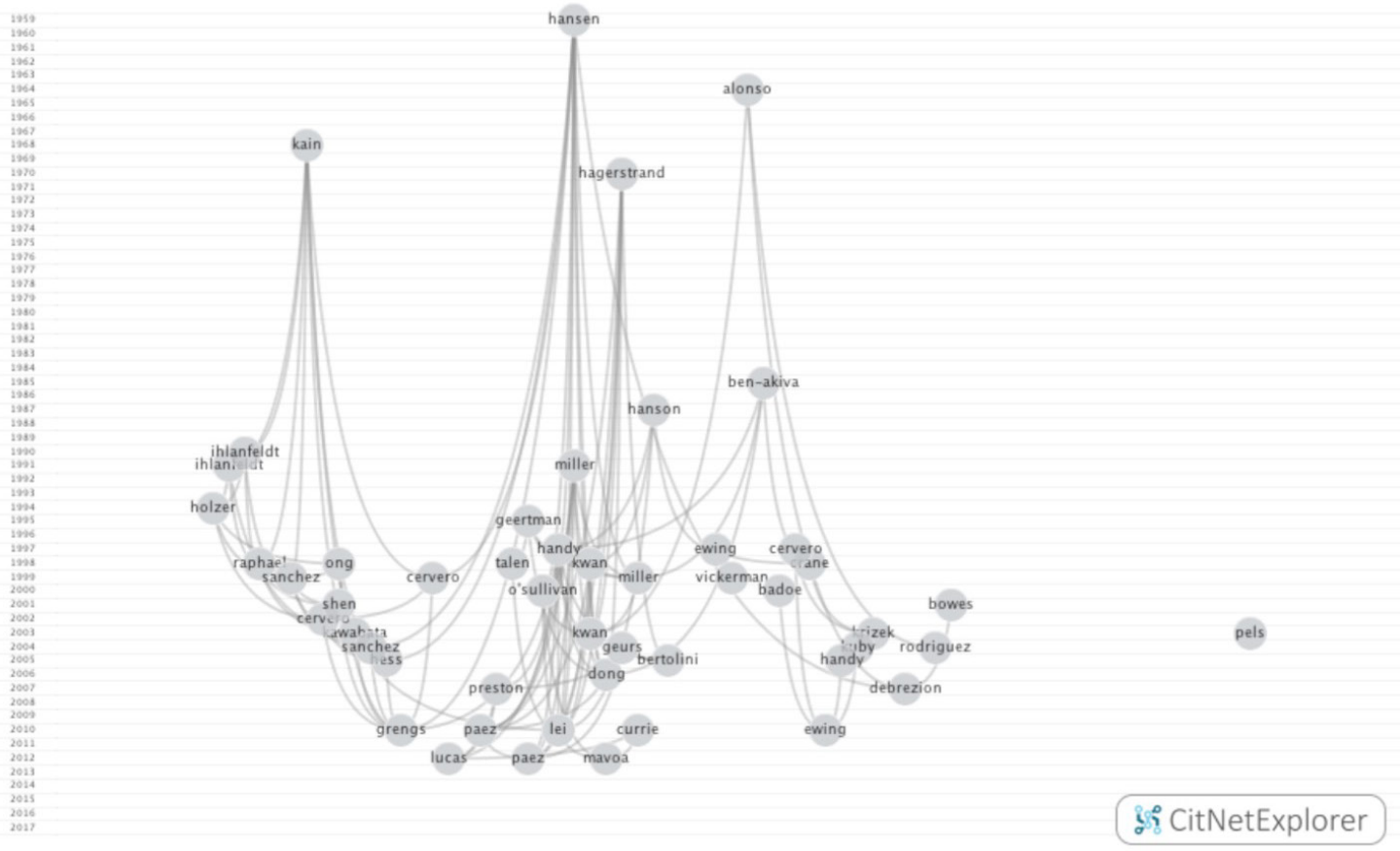
The leftmost branch of research originates from John. F Kain, who was among the first to propose the concept of spatial mismatch (a moniker he disclaimed) in his influential 1968 article, "Housing Segregation, Negro Employment, and Metropolitan Decentralization." Many academics view Kain as among the first in a series of researchers to examine the cross-linkages between land use and transportation. Garrison[35] was another influential researcher to set much of the groundwork

for deeper analysis of the interaction of land use and transport. Generations of researchers continued to explore the relationship in greater depth. For example, Robert Cervero investigated connections between travel and the built environment[36] [37], Keith Ihlanfeldt explored job accessibility by race,[38,39,40] and Thomas Sanchez's looked into the connections between transit and employment, especially for minorities.[41] [42] [43] Moving further down the left of Figure 6, it is perhaps fitting that one of Cervero's most-cited publications nestles between Kain and Hansen.

On branches farther right in Figure 6, Moshe Ben-Akiva's Discrete Choice Analysis model in 1985 helped initiate a broader body of research focused on developing models and evaluating them, including Vickerman, Ewing, Badoe, and Handy. While Rodriguez, Pels, and Debrezion are still in this same cluster, they deviate from other authors given their focus on various applications of accessibility modeling techniques to tangent topics such as residential and commercial property value. This in part explains why this branch is less interconnected.

Though a wide variety of access models and metrics exist, the "family tree" also confirms two other key ingredients that drive measurement-based research: data inputs and computational tools. Researchers have repeatedly pointed to the deficiencies in the data inputs that would help test their theoretical models. For instance, already in 1979, J.M. Morris[44] highlighted how household travel surveys—the primary data source of the time—offered no longitudinal data. There are also several missing data components, such as indicating trip purpose. Further, transportation data has often been limited to the supply side, and Morris acknowledges the need for working models of activity linkage in travel demand. He also recommends

Figure 6: Relationships among most-cited accessibility publications; 1959-2016



Source: Brookings analysis of academic journals; software courtesy of CitNetExplorer.

descriptive analyses of journey making to improve understanding of travel behavior.

Incomplete and limited data inputs can affect the potency of even the most comprehensive and robust models. For instance, in Ben-Akiva's Discrete Choice model[45], each individual in the sample must have related data on their socio-economic characteristics, the complete set of available travel alternatives and their attributes (like travel time across different modal choices), and the demonstrated modal choice of the individual. Until recently, such real-time micro-level data simply did not exist, nor did the storage and analytics capacity to make computations based on such data. Only recently, big data-driven applications like Transit App are beginning to generate and analyze such datasets, but the field is still in its nascence.[46]

In the same vein, several researchers acknowledged computational difficulties as a deterrent to better analysis. For instance, Dalvi and Martin[47] work with a smaller sample size on the London Travel Survey citing computational limits. This is an indication of the need for software tools and applications that could help test accessibility models, which Geertman's crucial work on GIS modeling for accessibility applications addressed in 1994.[48] The continuous evolution of better computational and analytical tools marks a step forward in practical implementations of earlier theoretical models of accessibility. It also explains why so much research emerged alongside the profusion of high-power computing and geospatial software[49]

Past research reveals the lack of a cross-disciplinary perspective

Although a number of landmark papers have come out covering accessibility measurement in recent years, research is still lacking on the multiple economic dimensions of accessibility. Here, too, bibliometric techniques help confirm these gaps in the research, and reveal more clues as to why the accessibility concept is often not found in practice.

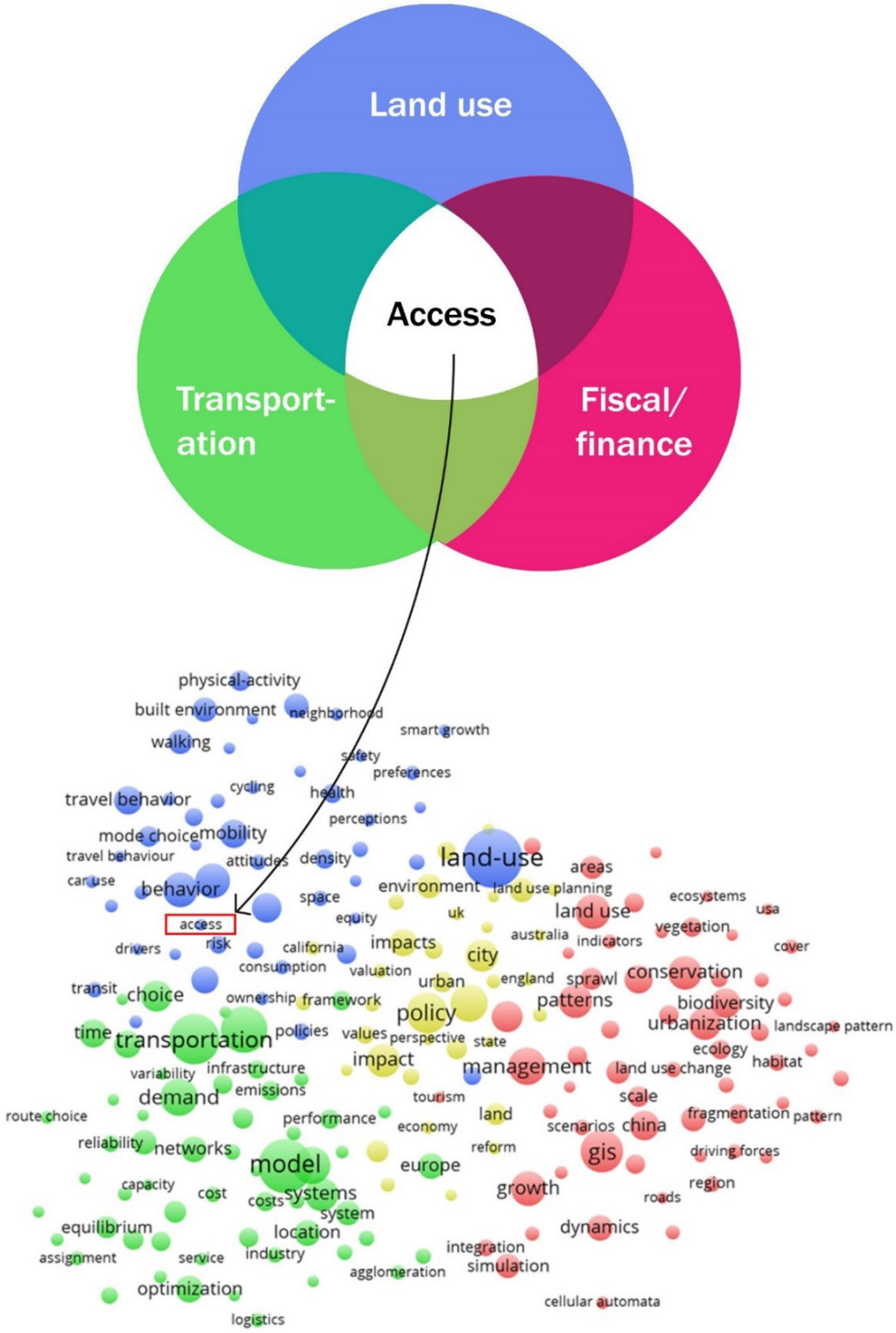
As displayed in Figures 8 and 9, using co-occurrence networks to map relationships among major keywords in existing literature is helpful in this respect. By using a tool called VOSviewer, it is possible to mine different texts of academic articles to find important key words mentioned in the literature, and map a "visualization of similarities."[50] VOSviewer maps the distance between two nodes (keywords) based upon their indicated relatedness. So for instance, if the keyword "transportation" is one of the major nodes of a cluster, VOSviewer's algorithm will map other keywords often mentioned in tandem with "transportation." Only the nodes are displayed in these distance-based bibliometric analyses.[51] Closely-related nodes are further aggregated into colored clusters. By clustering high-impact keywords together, this map offers a glimpse into the topics of literature that occur most frequently, and that are coupled most often.

Three crucial shortcomings reveal how fractured accessibility research remains.

First, as a keyword, access is closest to land use and transportation. Ideally, the keyword co-occurrence map for accessibility literature would look like Figure 7, where accessibility forms the connective tissue between keywords related to the fields of transportation, land use, and fiscal/finance. In other words, accessibility would represent the point of cross-disciplinary convergence, reinforcing the promise of a cross-disciplinary accessibility-based approach in delivering a more equitable, sustainable, and resource efficient urban environment.[52] Governance would form an overarching theme that permeates all three fields. In reality, the actual mapping in Figure 8 presents a marked contrast to the ideal distribution in Figure 7. Figure 6 presents a density view of Figure 8, similar to a heat map where the areas in red show the centers of major clusters.

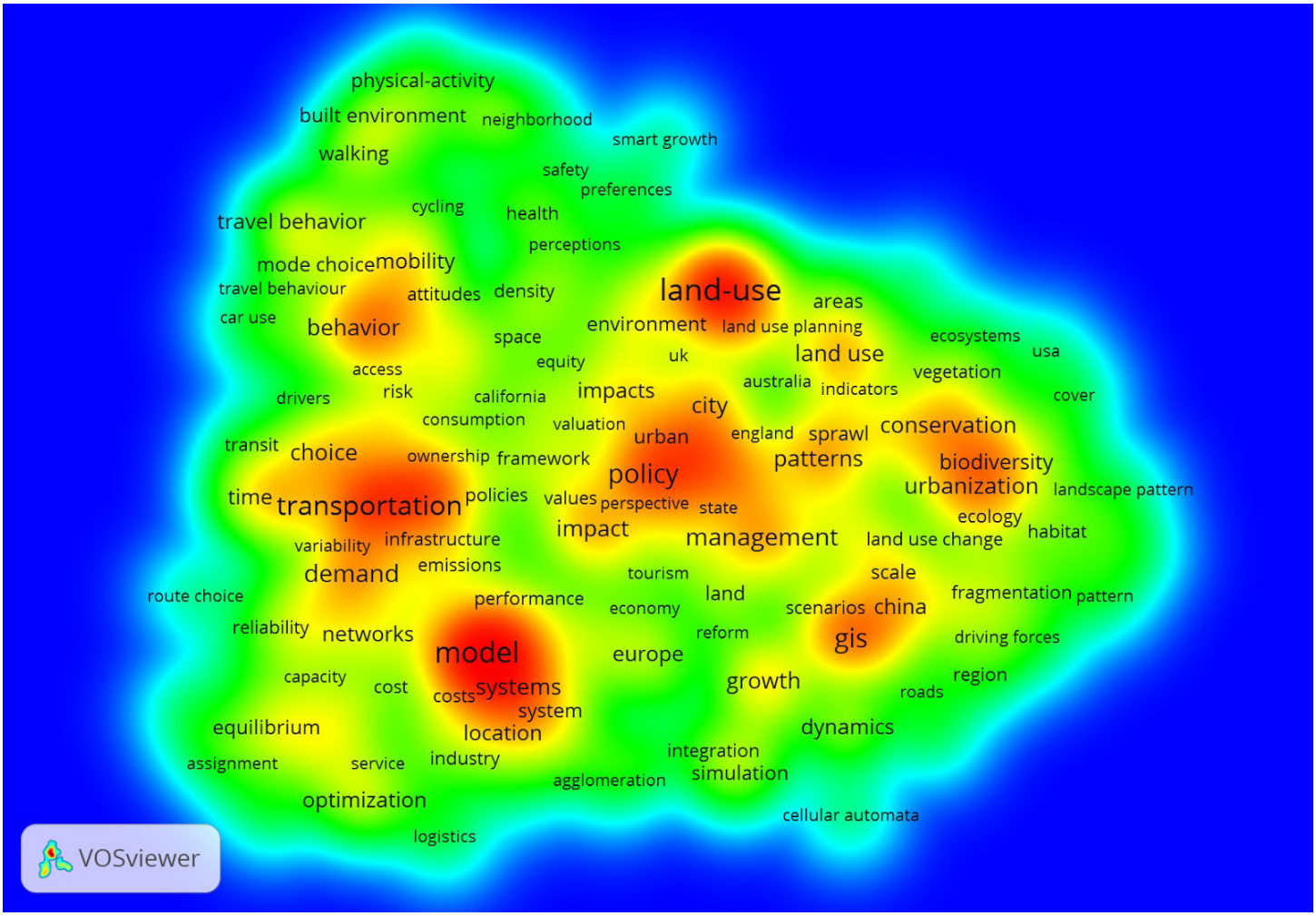
Figures 7 and 8 show how 'land use' (in blue), 'transportation' (in green), and 'policy' (in yellow) are keywords that anchor major clusters of other keywords. In contrast, the fourth cluster (in red) does not have any major anchor keywords. Access is closer to transportation in terms of distance, showing the successful efforts of researchers like Cervero who have strongly advocated for greater use of accessibility indicators in long-range transportation and land use planning.[53] It is also a positive sign that research has started to highlight a fundamental disconnect among researchers: on the one hand, transportation experts

Figure 7: Ideal distribution of literature (top); actual keyword co-occurrence (bottom)



Source: Brookings analysis of academic journals.

Figure 8: Actual keyword co-occurrence; density view



Source: Brookings analysis of academic journals; software courtesy of VOSViewer.

focus too much on mobility provisions, and on the other, urban management experts overlook transportation impacts in terms of the costs of residential and commercial land use policies.[54] Not surprisingly, as shown earlier in Figure 5, access is also part of the land-use cluster. Research thus sees that crucial nexus between transportation and land use planning as a central component of accessibility in theory.[55] Gallez et al state there is greater acceptance among researchers that "coordinating transportation and urban planning is a necessary condition for setting sustainable urban development into motion".[56]

Second, finance-related keywords are barely present. While transportation and land use connect strongly to accessibility, there is little meaningful literature pertaining to fiscal/finance tools, despite the inclusion of a significant number of finance journals in the database. Admittedly, several researchers have looked at transport pricing in the literature. Researchers like Gwilliams[57] and Jansson[58] have contributed to our understanding of pricing strategies. Scholars like Carruthers et al[59], Serebriskey,[60] Gomez-Lobo[61], Litman[62], and Mitric and Carruthers[63] have paid special attention to transport affordability for the poor. For instance, Carruthers et al[64] construct an "affordability index," which measures the proportion of monthly income required to make 60 single journeys to work per month. So, while researchers explored transport pricing, broader funding and finance considerations beyond pricing are simply not yet a part of mainstream accessibility research, and vice versa.

Simply put, there is a missing cluster of research activity focused on this crucial dimension to accessibility.

Funding sources and financial instruments can truly determine what public infrastructure is built, which in turn influences how people access different services in an urban area. Sclar et al[65] have repeatedly emphasized that approaching fiscal/finance policy through an accessibility lens presents a real opportunity for both theory and practice. Even in practice, though, few places consciously pursue access as an objective when making financial decisions or setting fiscal policies.[66] This is a key gap: there is an urgent need to consider funding and finance beyond just pricing as the third leg of the stool in addition to transportation and land use.

Third, policy-related keywords form a centrally-located cluster, reinforcing the centrality of governance. Transitioning access from theory into practice will require formal changes to governance designs and policy. As such, it is encouraging to see governance-related keywords land in between the major transportation and land use anchors. Since the clustering technique aims to minimize the distance between included papers, this is evidence of policy's central role in the literature.

Fourth, the strong linkage with model-related terms demonstrates the preoccupation of prior research with measures, metrics and models. Measurement and metrics for access have received ample consideration in the literature in the past. Looking again at the network maps above, there are two large clusters around the keywords "model" and "GIS," which are the basis of using modern tools to evaluate accessibility. Still, the evaluation of accessibility and picking a measure is still a challenge.[67] In their reviews of access measures, Geurs and van Wee[68] and Boisjoly and El-Geneidy[69] identify five primary methods to measuring accessibility: gravity based measures, cumulative opportunities measure, utility-based measures, constraints based measures, and composite indicator based measures.[70] This focus on finding the ideal measure of access comes even as other researchers have rightfully identified that there "probably is no ideal accessibility measure,"[71] because the choice of measure depends on "the type of problem being studied and the resources available".[72]

Building a new research approach

Accessibility researchers are true intellectual innovators. They are developing a new approach to urban development and actively questioning the existence of one that is outdated, inefficient, and inequitable—where private vehicle use and low-cost construction have focused narrowly on faster movement and low density development. By emphasizing access to key destinations and new ways to measure it, researchers are inspiring new models and geospatial analyses that are just beginning to bear fruit.

Now is an ideal time to expand these research efforts. As more practitioners and policymakers aim to design policies that reflect this new line of thinking, researchers can support their efforts through a broader, more integrated focus on barriers to adoption.

One priority for researchers is to integrate fiscal/financial tools more clearly in future studies. In doing so, there are useful examples of cross-disciplinary research that assess the impacts of accessibility on other factors. For instance, Wachs and Kumagai[73] developed an approach to use accessibility as a measure of the quality of urban living, linking it to socio-economic outcomes for citizens. Jones et al look examine how different social groups perceive access to the built environment, looking at both "strategic-level accessibility (e.g. access to employment opportunities) and micro-level accessibility".[74] Stretching this coordination to fiscal/finance techniques may be difficult, but it is essential to integrating professionals from those disciplines. In particular, we recommend that current accessibility experts network with fellow researchers in financial affairs, explaining the importance of the accessibility approach and brainstorm new research topics to integrate their expertise.

Another priority is to continue leveraging big data and emerging software tools to test existing theoretical accessibility models. Specifically, accessibility theory must move away from a limited focus on supply side assessments and integrate new data sources that speak to urban travel demand. Myriad sources of real-time, hyper-local data on the movement of people now exists, some public and some private.[75] GPS and navigation data can track the movement of people at a level of detail not possible before, while improved data

infrastructure for storage and analysis is opening up new frontiers to derive insights for practice. Recent research has only scratched the surface of utilizing emerging data and methods to promote accessibility, be it Jiang et al's[76] work on geometric accessibility, or the design of GIS systems to promote access[77] from the perspective of the disabled.

Finally, using existing measures and metrics, research should document and highlight innovative practical applications of accessibility. Combined, the above two key factors can help explain the lack of practical examples that many in the literature repeatedly mention—the relative nascence of the field and the more recent emergence of technology and modeling tools that can help put it into practice. Efforts to examine specific contextual applications include Ganning's work on accessibility applications to shrinking urban areas[78] and Aljoufi's work on land use-transport in Jeddah[79]. More deliberate engagement with lessons learned from practice, as well as the sharing of best practices can help guide future work.

To extend this final implication a bit further, it may be time for researchers to focus less on theoretical growth—especially in terms of more mathematically-advanced metrics—and instead focus more on evaluating the concepts to which most published authors all seem to subscribe. Landmark theorists like Hansen established a core theory that has acted as a useful guide for decades to promote more inclusive and efficient urban economies; however, confirming the power of that thought in both academic research and practical application is of the utmost importance moving forward. In short, researchers must respond to practice, using the lessons from practice to inform evolved accessibility theory.

IV. Designing a practical measurement suite

For accessibility to achieve uptake in practice, it must resonate with practitioners and policymakers, including those without deep expertise in transportation concepts. Leaders from housing and real estate, public budgeting and private equity, and any other discipline concerned with the built environment must fundamentally understand how an accessibility-focused approach to transportation and the built environment will lead to improved economic outcomes for all populations.
Delivering on this promise will require a practical approach to measurement: a new language to express how regional transportation networks are functioning and can achieve collective goals in years to come.

As it stands, current performance measures are often too narrow in scope, disconnected from one another, and fail to target shared objectives. Level of Service measures related to transportation network performance—which are used in every corner of the globe and tend to speak to asset capacity—inherently focus only on system conditions, completely ignoring why people may be traveling or related spatial conditions. Financial and economic investment evaluations like cost-benefit analysis too often look strictly at asset usage, failing to consider the distribution of those benefits. Affordable housing policies can exacerbate economic and social disconnect when they do not consider regional disconnect, of which the 2005 Parisian banlieue riots made clear.[80]

Yet for all the limitations of transportation mobility, financial evaluation, and land use metrics, many accessibility measures are a work in progress. As researchers continue to refine existing methods and push the intellectual frontier, they often do so at the expense of clearly accounting for—and communicating with—cross-disciplinary practitioners. There is a broad consensus among those who cataloged accessibility measures, from Geurs and van Wee to Venter, about this specific communication challenge.[81]

Just as importantly, leaders in urban areas worldwide face a blank slate measuring accessibility—a measurement tabula rasa. Boisjoly and El-Geneidy show that most developed urban areas do not currently use accessibility measures in their approach to planning and evaluation.[82] For those places looking to implement accessibility measures, there are no established global standards to follow. And per other published research detailed in the prior section, there is no single measure that could capture all the dimensions related to accessibility. Each urban area has a unique opportunity to chart its own way forward.

Now is the ideal time for practitioners to begin testing what combination of performance measures will advance an accessibility paradigm. Researchers have done an excellent job creating libraries of sample measures to use; there is little need for practitioners to build new measures from the ground up. Instead, the opportunity is to find the right suite of measures that will reflect the growth ambitions of a region, expose their spatial economic challenges, respect local fiscal capacity and fixed inputs—and to do all this in a way that promotes greater collaboration between officials in multiple governing agencies.

This section presents a flexible approach to develop locally tailored measurement suites. Since it is hard to prescribe the exact measures every urban area should use, this outline attempts to make clear suggestions without dictating answers.

Setting measurement goals: measurement's foundation

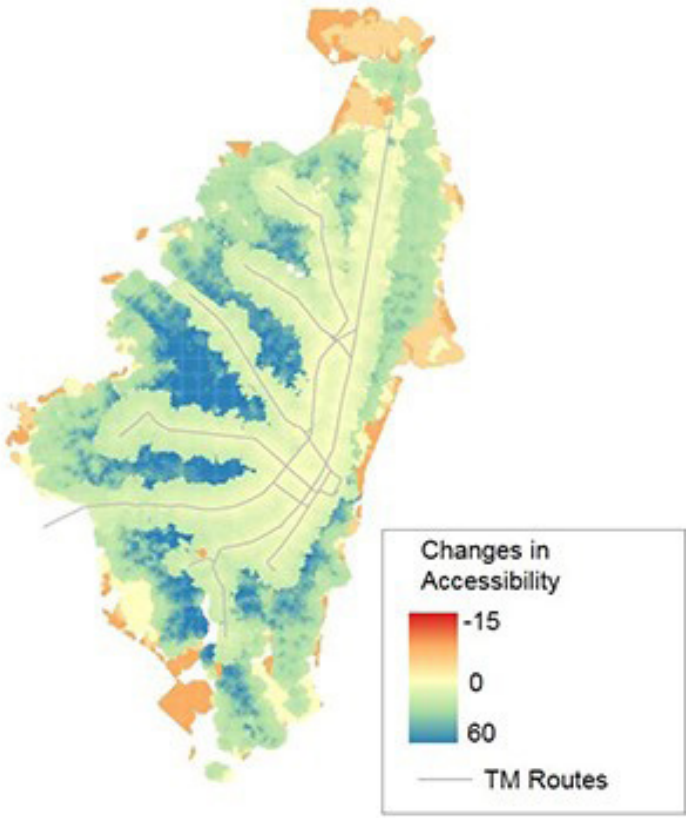
While accessibility is an inherently flexible concept with many potential applications, there are certain elements that any measurement suite should consider.

First, measures must **include all relevant disciplines.** The prior section detailed the deep symbiosis that already exists among transportation and land use researchers when it comes to the topic of accessibility. This disciplinary connection can be seen in practice, too, through the many applied applications—such as "distance to job" measures—that capture both land uses and transportation systems.[83] Yet the same multi-decade, scientifically controlled literature review confirmed fiscal and finance disciplines' absence from such accessibility conversations. Any accessibility framework must include measures that cover transportation, land use, and fiscal perspectives; otherwise, it is incomplete. Moreover, deploying a cross-disciplinary approach to measurement should incentivize greater interagency collaboration.

Second, practitioners must choose measures that place people at the center and aim to **maximize inclusive access to opportunities.** Many accessibility measures, including those from applied research, use specific demographic components to delineate results by specific populations and/or neighborhood types. For example, the World Bank's work in Bogota represents how mapping access based on income and transportation prices can demonstrate different results.[84] As in Figure 9, access drops when considering levels of transportation spending. This decision should not be a luxury, but a requirement of an accessibility measurement suite. Measures should cover all populations based on income, race and ethnicity, education levels, age, and other demographic characteristics.

This inclusive focus applies especially to infrastructure and real estate financing. If left in a geographic and user vacuum, projects aiming to recoup costs will

Figure 9: Change in access to jobs based on income committed to public transportation, lowest income cohort, Bogota



Source: World Bank.

naturally gravitate to a higher-income user base, either by being built where such users already travel and live or offering new benefits to attract them to new corners of a metropolitan area. When this is the case, it can exacerbate social exclusion. Requiring socially inclusive measures alongside traditional funding and financing models will be fundamental to address this natural spillover.

Third, practitioners should use measures that **enable multiyear analysis.** Infrastructure investments and policy reforms can take years to implement, while market-based indicators—such as new travel patterns, changing real estate demand, and improved economic performance like higher employment levels—can take years to surface in ways that can be quantified. As urban areas look to design new policies related to the built environment and then evaluate them, a multiyear timeframe is necessary. In practice, practitioners should use measures where there is reasonable confidence that data will be available.

Finally, the selected measures must be **communicable to a range of stakeholders.** All accessibility measures require a relatively sophisticated level of mathematics and geospatial data, meaning there is always a role for quantitative experts and data scientists to manage measurement data collection and computation. Yet for elected leaders and more generalist practitioners, they will need to understand how measurements relate to broader goals such as higher household disposable income, improved labor market outcomes, sustainable fiscal balance sheets, or even general economic efficiency.
Communication is especially important with respect to cross-disciplinary ambitions: if the measurement suite will represent a minimum of three different disciplines, there is naturally a language barrier among common terms and formulae. Purposely addressing this barrier is fundamental.

Box B. Limitations of a Single Accessibility Measure: A Simple Qualitative Proof

There is no single formula to exhaustively measure cross-disciplinary access in a given place. This limitation can be demonstrated by analyzing one popular approach to measure accessibility, but could apply to other commonly-researched measures collected in Appendix B.

Based on a scan of 32 global metropolitan areas, the most popular accessibility measurement type are location-based measures, or those that measure access to destinations between specific origins and destinations. These measures typically count the number of opportunities that are reachable within a given amount of time and/or distance, and are flexible enough to consider multiple transportation modes, fare or cost structures, and subdivide results by target demographics or other geolocated features. The generalized formula for the cumulative opportunity version of a location-based measure is: [85]

$$A_i = \sum_{j=1}^{j} B_j a_j$$

where references accessibility measured at point i to potential activity in zone j, measures opportunities in zone j, and is a binary value equal to 1 if zone j is within the predetermined distance or time threshold and 0 otherwise.

The cumulative opportunity measure is popular because it is powerful. It elegantly captures the fundamental question individuals tend to ask of their regional transportation networks: can I get there from here? It is a powerful way to benchmark different neighborhoods against one another, to understand the impact of specific transportation projects and new real estate developments against current access levels, and to focus on specific demographic groups. It would be hard to imagine an applied measurement suite that does not include a cumulative opportunity measure.

Yet even for the most popular formula, it has at least two major shortcomings:

- The formula does not speak to user demand; it only approaches accessibility from a supply-side perspective. There is no method within that formula to test how individuals make different transportation choices based on accessibility levels. To many that is a feature of these formulas, not a limitation. But it does mean additional measures must be used to compare cumulative opportunities against actual travel habits.
- The standard formula omits fiscal affairs outside user pricing, although fares or gas prices are receiving more attention.[86] There is no clear ability to include project financing or aggregate budgetary impacts within the formula. This formula simply cannot tell a practitioner or policymaker what it will cost to boost reachable opportunities for specific groups or neighborhoods.

The formula's limitations prove that even the clearest approaches to accessibility measurement should be part of a broader suite. Rather than try to make this effective formula serve all disciplines, practitioners should find other metrics to complement it.

Similarly, accessibility measures should also resonate with all types of residents. If boosting accessibility requires reformed transportation operations, new housing units, or higher taxes, for example, clearly communicating accessibility benefits to the public will be critical to achieving broad-based support.

As such, any local measurement suite must address the tension between complexity and communication. Consider the relative strength of the Level of Service system. While it relies on calculus and an enormous set of data points to determine if transportation corridors have ample capacity to meet current usage demand, the measurement system evolved to report basic scores—and even letter grades in some national systems—to help policymakers and the public understand the

final results. An accessibility measurement suite must solve the accessibility language problem, enabling complex measures to operate in the background and communicate essential results to the end consumer.

Quantifying objectives: setting goals to measure

Maximizing performance from the transportation system and the surrounding built environment requires a clear understanding of broader economic, social, and environmental objectives, particularly from a local perspective. Transportation is usually just the means to other ends. This subsection details what objectives practitioners should consider and how to translate them into formal goals. Such quantitative information is instrumental to selecting appropriate measures.

That begins with a clear focus on **socioeconomic** conditions. The mobility model is criticized for its socioeconomic agnosticism: by viewing vehicles, bicycles, or pedestrians without broader context, it opens up measurement to ignore how the built environment either restricts equitable access to opportunity or prioritizes mobility for advantaged individuals.[87] Accessibility's ability to consider demographic groups is an enormous advantage over a strict mobility approach, but practitioners much choose to look at such conditions to accelerate practical application.

To boost access for all residents, practitioners should choose which demographic groups they want to better understand from a spatial perspective. In most markets, that will involve some version of maximizing all individuals' affordable and time-limited access to valued destinations. For markets where physical access varies significantly by neighborhood and housing is a relatively high share of median household income, it will likely also include a goal to maximize affordable housing in high-access neighborhoods. These ambitions are very much focused on the origin-side of accessibility: who can benefit from broadly defined access. Yet the focus on destinations is much wider ranging, requiring a clearer focus on specific outcomes. Other places may minimize their focus on employment access—since private market actors manage real estate decisions—but prioritize education and healthcare since they are public sector driven. Others may want to measure all kinds of key destinations, including job access.

Even with the proposed transition to an accessibility framework, **mobility** goals are still important. One of the key lessons from decades of research is to compare accessibility by mode (or modal competitiveness). That means using supply-side access indicators, such as the share of jobs reachable by private vehicle versus bicycling, to understand why individuals choose certain modes. For markets concerned with entrenched vehicular congestion, sprawling development patterns, or environmental sustainability, for example, accessibility's mobility dimensions are crucial. In particular, creating higher access targets for travel by foot, bicycle, and public transit is one way to deliver on such promise.

Quantified **land use** objectives are also fundamental. As detailed in Section I, governments from the local to national levels confront major challenges and opportunities related to their land uses, whether it is promoting more affordable housing, addressing spatial mismatch between housing and destinations, or confronting higher per capita maintenance costs related to lower-density urban development. Ideally, urban areas already formalize these objectives in long-range planning documents or through long-range land policies. For example, urban growth boundaries are effectively a stated objective to constrain land consumption. However, in those places where land use goals are not yet clear, there is a political consensus building-exercise that must take place before any goals can be quantified.

Developing a clear connection between transportation accessibility and an urban area's **fiscal and financial** objectives will likely be the most difficult to achieve. Every government aims to generate a healthy long-term fiscal balance sheet, but local leaders and their staffs will need to decide where they stand on philosophical issues of who pays for what services and in what places. This includes how taxation impacts real estate and transportation behavior. Similar issues around environmental impact pricing—especially carbon fees that can be locally administered—should feed into decisions for how access is judged.[88] Finally, willingness to take on debt to finance capital and operational projects is in itself a normative judgment for each place, especially as it relates to other policy sectors and their long-term commitments.

Of course, not every urban area will even have established objectives within all of these categories. Due to jurisdictional boundaries or governance models, fragmentation can mean some actors simply have no control over certain levers related to transportation, land use, certain social services, or specific fiscal and finance instruments. But it is essential that practitioners take the time to bundle the objectives where they do have authority into formal aims for the built environment.

Selecting measures

Assuming objectives are clearly defined and can serve as the foundation for a measurement suite, local authorities should select the accessibility measures that best enable them to judge progress against those objectives. Those measures should be self-selected based on local conditions: the objectives the urban area hopes to achieve, the capacity to conduct analysis, and the communication channels preferred by local practitioners and the public.

Ideally, local practitioners should have access to a master list of applied accessibility measures, which other urban areas have successfully implemented or have proven to be well suited to test in the future. Unfortunately, there is not yet such a list targeted at practitioners.[89] The research under the Moving to Access Initiative at Brookings, the Financing Urban Access Road Map by the Volvo Research and Education Foundations, and additional applied journal articles all confirm that accessibility measurements remain underused among practitioners.[90] As such, there is no field manual or even obvious place to compare best practices. This is a major research need for the next step of the Moving to Access initiative or another practitioner-centric research effort: developing a curated list of potential access measures, targeted at practitioners. This should complement the step-by-step procedures and software review by Enrica Papa and António Ferreira, published under the Moving to Access Initative.[91]

To compare, there are multiple engineering-centric

guides that clearly explain how to deploy various Level of Service measures and street designs.[92] These attempts to standardize a mobility-centric evaluation is fundamental to both creating consistent measurement across global geographies and to proselytizing the approaches within the guidebooks. Accessibility as a concept would benefit greatly from similar, practitioner-driven documentation.

When practitioners do begin to assemble the access measures best matching their local objectives, minimizing the number of measures is a worthy goal. For example, some urban areas may find the cumulative opportunity measure discussed in Box B may adequately judge certain socioeconomic and land use objectives at the same time.

Local capacity can also steer local measurement selection. Data quality is far from consistent in all global regions, and even from urban area to urban area within the same country.[93] This makes it difficult to apply any accessibility measure universally. Practitioner skills also vary, meaning some places could operate the most advanced data collection, database management, and analytical systems, while others may struggle to conduct even the most basic accessibility analyses. Each urban area also has different financial resources available, affecting their ability to make small-scale investments like licensed software to enormous ones like new transportation capital. Based on those financial resources, each place must tailor accessibility measures to their unique investment capabilities.

Finally, the lack of certainty concerning fiscal and financial measures leaves plenty of room for clarification. Because researchers covering fiscal and financial topics have not yet demonstratively pursued accessibility concepts, there is no past research to evaluate potential measures. As such, it is especially important to recognize the measurement experimentation that must take place. Yet there is also an incredible opportunity to deploy fiscal and financial measures—regardless of the global region or other local context—to support empirical examination of how a mix of transportation, land use, pricing, and other fiscal and financing policies impacts urban form. Just as importantly, regularly tracking accessibility measures alongside fiscal measurement techniques can create a new information loop about how accessibility interrelates with capital investment, operational costs, and tax policies.

Translating Performance Measures

Rather than directly delivering measurement results to top-level decision-makers and the public, practitioners should experiment with a set of quantitative adjustments to enhance communication.

First, proportions are often easy to understand contextually than raw numbers. As already mentioned, raw numbers—such as jobs reachable within a certain

timeframe—can be difficult to judge in isolation. Instead, proportions help confer relativity. For example, the share of all metropolitan jobs reachable in 30 minutes is more intuitive than reporting the raw number. And when joined with specific performance targets, proportions can easily point to urban accessibility gaps. Critically, public sector officials from all sectors have deep experience working with proportions. Converting performance measures to proportions also "hides" the complex computations many accessibility measures require, which could reduce the intimidation factor some policymakers and elected officials may feel when consuming any new performance measure.

Second, benchmarks and standard scores can be especially helpful when evaluating multiple local geographies such as neighborhoods. With multiple statistical observations, positive and negative outliers are often the most important tool to motivate political change. In particular, the general public and elected leaders are often inspired to support low-performing neighborhoods. Standard scores help flag outliers by using standard deviations. Practitioners can also easily convert standard scores into percentages, further enhancing the use of proportions.

Third, practitioners should prioritize visualizing measurement results. Arguably, visual presentation is accessibility's most valuable asset in terms of creating resonance with non-experts—isochrones of different travel times to and from key destinations are the accessibility indicator now found in applications found throughout daily life. Yet those isochrones are not exhaustive, as evidenced by the criticisms in Box B. Practitioners should explore ways to visually represent results from measures focused on fiscal and financial concerns, too. Since these measures are not yet in existence, this is another area ripe for further research.

Challenges and innovations

None of these efforts will be easy. The measurement approach described in this section demands multiple steps to move from concept to reality. It requires local policymakers, elected officials, and other concerned stakeholders such as citizen advocates and anchor institutions agreeing on objectives for the entire urban area when it comes to inclusive economic growth. It requires a mix of financial professionals—from academia and elsewhere—to invent measures that can relate clearly to access measures focused on transportation and land use. It requires an enormous range of public sector inputs to conduct measurement, including geospatial and longitudinal data, trained data scientists, and budgets for a mix of hardware, software, and cloud-based subscriptions. Finally, once all those requirements are met, practitioners will need to convince officials in management positions to allow measurement to commence and formally integrate the results within high-visibility policy schemes like local zoning and infrastructure project selection.

This list is not meant to dissuade practitioners; it is meant to emphasize the scale of the challenge.

But in the face of all these obstacles, measurement innovation is underway all across the world. While these innovations may be isolated, they demonstrate the potential to install a new measurement system:

- **Expanding resource capacity:** Nonprofit, civic organizations like Humanitarian Open Street Map Team collaborate with local partners—including interested private citizens—to help create digital maps of urban areas in lower-income economies.[94] Of course, many of these efforts are not focused on transportation accessibility but motivated by broader humanitarian concerns. Yet their results enable future accessibility analyses, creating new open-source maps and reducing future costs to run spatial analyses. More transportation-focused efforts are underway in many global regions who rely on more informal transportation (or paratransit) services, such as the Global Network Mapping Transit project under MIT's Civic Design Data Lab.[95]

- **Creating new techniques:** The rapid adoption of smartphones and other devices with location-based services make new analytical techniques available, many of which can have clear impact on how practitioners judge urban accessibility. A fascinating study of urban areas in Italy using mobile phone records, socioeconomic data, and open source street data was able to confirm theories posited by Jane Jacobs half a

century earlier—and speak to how urban design, access, and amenities impact demand for space in a manner impossible to reproduce just ten years prior.[96] While local governments do struggle to manage data at this scale, research like this serve as practical evidence of data and accessibility metrics potential.[97]

- **Establishing replicable benchmarks:** In 2017, the International Transport Forum released an international benchmarking of access to destinations in global cities between the populations of 3 to 5 million inhabitants.[98] Such efforts provide important proof-of-concept evidence to practitioners and policymakers around the world, demonstrating the power of access measures. In the United States, the multiyear Access Across America series out of the University of Minnesota—which receives funding from multiple states—produces access benchmarks for the whole country.[99] In each case, the benchmarks offer an important opportunity to compare performance against peer cities, a benefit of more historically established measurement systems. However, their work also underscores the challenges ahead: the measures do not include fiscal and finance components, nor are they sensitive to local socioeconomic conditions (including income).

- **Adopting formal measures:** The U.S. state of Virginia recently adopted an accessibility score as a component within its Smart Scale system, a formal evaluation system for capacity and operational improvements in the state.[100] The accessibility metrics include a mix of access to jobs, priorities for disadvantaged individuals, and fixed multimodal access. Using access measures to influence actual project selection is an enormous accomplishment—similar to past efforts in the United Kingdom and the Netherlands—and proves such measures can be put into practice worldwide.

These innovations—plus many others not listed here—form the foundation of a new approach to accessibility measures. As those innovations continue to evolve, they will provide invaluable tools to further some of the approaches detailed in the next section.

V. Accessibility in practice

Beyond the measurement innovations mentioned above, there are an increasing number of innovative applications that policymakers and practitioners are undertaking to address key challenges in **cross-disciplinary planning, fiscal and financial approaches, and horizontal governance.** While there is no one place that does it all, it is important to see how urban areas under different political, social, and economic contexts are trying to address specific issues and challenges through a variety of innovative approaches.

This section focuses on these three areas of innovation. Under each area, relevant issues are highlighted, innovative practices are described, and gaps for future work are explained. Since most of the examples described here are anecdotal, they represent opportunities for deeper analysis among researchers; additional exploration of these and other cases can help achieve several objectives, including the creation of a menu of "good" practices, the identification of more sources for empirical verification, and a new way to adapt evolving theoretical constructs.

Cross-disciplinary approaches

The issue. Conceptually, as illustrated in Section 3, there has always been an acknowledgment of the interrelationship between land use and transport.[101] The difficulty comes in executing this dynamic relationship within formal policy.[102] As a result, land use and transport practitioners have retreated to their sectoral silos rather than working across disciplines. The lack of engagement of fiscal and financing disciplines creates further obstacles to cross-disciplinary practice.

As urban areas collect and manage larger amounts of data with clearer connections to urban access, the potential for a cross-disciplinary approach becomes that much more tangible. By observing how practitioners are applying these measures in different places worldwide, it becomes easier to see how new collaborations and shared learning is taking place. The following discussion focuses on the transport and urban

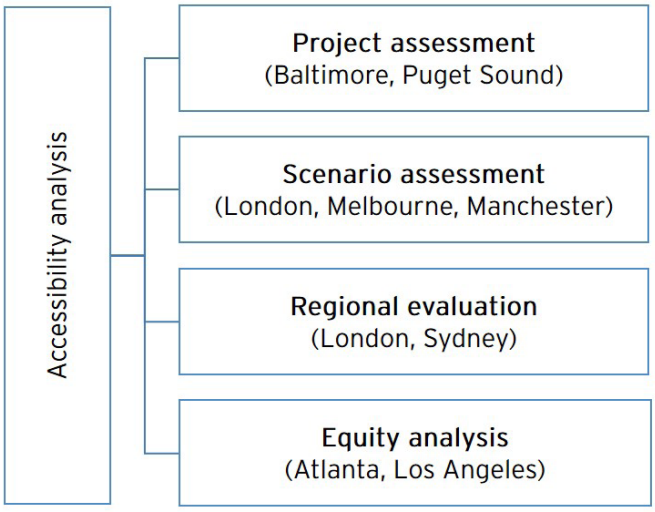
land planning cross-disciplinary efforts. The fiscal and financing element is treated in the next subsection.

For more information on this cross-disciplinary approach as a whole, see Appendix C.

Innovative practices. Boisjoly and El-Geneidy,[103] in their review of a series of urban land use and transport plans, assess how practitioners are applying accessibility indicators in their work and at what stage in the planning process (see figure below). From higher level planning stages that involve regional evaluations to lower level planning stages that assess individual projects, practitioners are beginning to view accessibility in greater detail and are making strides toward additional implementation.

At the regional level, urban areas from London to Toronto to Sydney are emphasizing the objective of accessibility. Typically, practitioners in these areas are mapping access to jobs to assess the impact of transport projects. For instance, using the graphic power of mapping to illustrate the importance of accessibility, the London plan (London T2025) estimates how proposed projects would increase the number of people within 45 minutes of central London by 25 percent.[104] This is a very different message than the traditional mobility focus on congestion, but it is still transport-centric without considering land use options or impacts. Kigali is another example of using accessibility measures in overall urban planning.[105]

Figure 10: Accessibility analysis types



Source: Geneviève Boisjoly and Ahmed M. El-Geneidy.

What is less clear, however, is how often policymakers and practitioners apply accessibility in project assessment and design. Boisjoly and El-Geneidy point to Baltimore and Puget Sound (Seattle) as examples of using specific accessibility parameters in prioritizing investment projects. Both areas aim to improve access to opportunities, especially for lower income households, by scoring and weighting projects accordingly. For the most part, however, accessibility analysis often only judges project impact—and does not yet confirm, deny, or alter a specific investment.

The same applies to how often policymakers and practitioners are using access measures to compare alternative scenarios for specific investments, services, and policies. In London, Melbourne, and Manchester, at least, it appears that leaders are comparing various transport investment scenarios based on accessibility. In London and Manchester, for example, accessibility measures appear in their application of multi-criteria analysis (MCA). In London, two of the eight criteria used to judge investment options relate to accessibility. That includes measuring the percentage of the population in the most deprived areas in terms of income who would be within a 45-minute trip to the center of London under alternative investments.

In the past, some national-level policies supported many of these regional efforts. The United Kingdom established a Social Exclusion Unit in 2003, which addressed barriers in access—to employment, education, healthcare and services in local communities—through a more systematic and integrated approach. The development of an Index of Multiple Deprivation is a major component of these efforts that is helping compare small communities, with a focus on socially and economically disadvantaged populations. In particular, these national efforts have required local governments to prepare accessibility plans when presenting investment programs for financing. Similarly, in the U.S., the Department of Transportation required an environmental justice assessment that led to accessibility and social equity assessments.[106] However, as was the case in both the UK and U.S., changes in national leadership can lead to changes

in priorities and a lack of consistency in addressing access.

In addition, the World Bank increasingly uses a model to measure the accessibility implications of its projects. For the most part, staff applied the model to selected investments to explain the access implications of that investment for specific communities.[107] In other cases, World Bank and client countries used such analyses to offer policy recommendations, such as tariff adjustments, to ensure lower income communities on the periphery share in the accessibility benefits of a particular investment.[108] However, the key investment decision-making criterion remains the economic rate of return based primarily on the value of time and mobility.

Beyond measuring and planning for projects, implementing these cross-disciplinary ideas has often come to fruition via Transit Oriented Development (TOD) projects. By mapping and managing land use around transit stations, planners are able to take clear advantage of transport access principles, including various financing tools, such as value capture. Staying in London, the major Crossrail project includes a de facto land value capture funding technique through direct business rate supplements.[109] The limitation, however, is that value capture requires an ability to manage the consolidation and development of land, which is not always viable based on local land taxation schemes.

Gaps. While the innovative practices in transport and land use planning illustrate the potential for cross-disciplinary efforts, they also reveal serious gaps that researchers, policymakers, and practitioners should address in future practical applications and academic projects:

- These planning initiatives remain transport-centric. While the focus on access rather than mobility better aligns land use and

transport, there is still a lack of focus on the trade-offs between land use policies and transport investments to enhance access when considering transport investment. Land use remains a given. A truly cross-disciplinary approach would bring both areas of expertise together in the modeling, design of alternative solutions, and decision-making as well as incorporating fiscal and financing elements;

- These examples ignore the dynamic nature of land use, including the impact of transport on land use over time. Especially concerning are the expected increases in land value related to urban access improvements, since those increases may price-out lower income households. Gentrification is a hotly debated topic worldwide. It represents a key challenge that requires a cross-disciplinary approach integrating land use, housing, transport, and fiscal policy. Recent efforts to incorporate social equity considerations in TOD are proving very difficult.[110] Addressing this issue is central to inclusive urban development.

Fiscal and financing

The issue. As discussed throughout this paper, researchers often struggle to identify or address fiscal, financing, and funding challenges in accessibility, including a critical analysis of alternative approaches to support urban transport and implications for public sector budgets. While this represents the third leg of the proverbial accessibility stool, the general exclusion from traditional accessibility discussions and the extensive confusion over terminology, especially in distinguishing between funding and financing, warrants a separate discussion.

Funding is the ultimate source paying for transport investment and operations. Funding sources are either the direct user/non-user beneficiaries through specific charges or taxes, or the public through general taxation. These sources can be further distinguished between different users and between local, regional or national taxpayers. Accordingly, finance is the mobilization of capital from different sources, whether it be private equity, private debt, or public debt with the understanding of repayment via the funding sources mentioned. The fiscal dimension combines both, in terms of public sector budgets and debt.

These clarifications are important because the source and design of both funding and financing approaches have implications for inclusive urban access.

Regarding funding, the basic issue is pricing transport infrastructure and services, especially given increasing demand and mounting constraints on public sector budgets. Transport pricing has a long history of academic literature with a major focus on efficiency and increasingly on environmental management. With regard to distributional issues, the use of subsidies has been an important element of these discussions. Whether it is urban roads or urban transit, accessibility has been subject to subsidies worldwide for a combination of reasons including the technical difficulty of charging for road use, or policy arguments in favor of promoting public transport for social or environmental purposes.[111][112]

Inclusive access raises the highly debated question of affordability. Transport planners and economists in the 1980s considered services unaffordable if more than 10 percent of a population spent more than 15 percent of its income on it.[113] Later, based on previous studies by the Urban Markets Initiative of the Brookings Institution, which linked housing and transport costs, transportation was found to be unaffordable if it accounts for more than 20 percent of the household's income.[114] Today, lower income households in many countries often pay above 20 percent of their income for transport[115] [116] and many at the lowest income levels cannot afford to take motorized transport at all.[117] The problem is exacerbated by urban spatial inequities, where low-income households can only afford housing at the urban periphery and must take longer and more expensive trips to reach key destinations. A study of the impact of the Transmilenio BRT in Bogota on lower income neighborhoods found that the potential number of jobs made accessible in terms of distance and speed by the BRT was reduced by 39 percent when affordability measures were considered.[118]

Applying public transport subsidies in response to affordability concerns, however, has been consistently

criticized for being ineffective and inefficient in targeting the appropriate individuals. As outlined by Ken Gwilliam, most public transport subsidy schemes are rated poorly. Some schemes are inadequate in terms of benefiting travelers who should not benefit in terms of income (flat fare schemes) and others leave out many of the potential beneficiaries who should be targeted (subsidy schemes directed through employers that miss the unemployed or informally employed travelers).

Beyond social equity concerns, a number of cities are using pricing policies to address a range of efficiency concerns like congestion and externalities such as environmental issues. It does appear that these other issues have come to dominate the discussion of pricing without exploring their impacts on equity and the accessibility of low-income households.[119]

Financing transportation adds additional complexity. While there have been extensive policy discussions around the world on new financing instruments for infrastructure,[120][121] the implications of alternative financing options on inclusive access, at least in the transport field, are seldom addressed. There are discussions about the division of risks and responsibilities between the public and private sector[122], but not enough attention to social equity considerations. This is particularly evident in the financial and economic decision models used to justify investment projects.[123][124]

Innovative practices. Despite the enormity of the funding/financing challenge worldwide, several urban areas are adopting new models to support accessibility and offer potential lessons to consider for a wide variety of researchers, policymakers, and practitioners.

When it comes to funding, in particular, technology is quickly overcoming late 20th century concerns

about charging road users. In London, Singapore, and Stockholm, congestion pricing technology is changing the ability to charge users.[125] In Bogota, a pilot scheme that combines smartcards with a data driven systematic identification of low-income households was able to identify the route patterns of women and users of informal transport.[126] Similarly, technology has facilitated national cash transfer schemes to low-income households in Mexico, Brazil, and Indonesia.

Various value capture mechanisms are also generating growing interest among transport policymakers and practitioners. While these mechanisms are certainly not new, value capture is still a step in the right direction because of its focus on utilizing the interaction of transport and land use.[127] [128] Value capture is taking hold in many countries across the developing and developed world, particularly in Latin America[129], and is at the center of most TOD schemes. This funding source, however, is subject to the uncertainties of the land markets and other governance related issues in implementation.

In the area of financing, fewer applied examples exist to illustrate how alternative financing instruments or structural design can enhance access. With growing emphasis on P3's, there are a number of risks and opportunities regarding inclusive access that have to be factored into the overall risks and returns analysis between the private and public sectors. It is crucial that policymakers and practitioners carefully consider particular objectives when structuring the contract. For instance, if the public sector is maintaining its control and flexibility over subsidy and pricing objectives, it is key to establish this in the contractual arrangements when looking for private sector participation.

The literature is overflowing with arguments "pro" and "con" regarding P3's.[130] [131] However, P3's are a dynamic and ever-changing area of experimentation. One important design feature that urban areas can use to ensure that government maintains the ability to address social as well as environmental externalities is the use of "availability payments" as a performance-based income to concessionaires to reimburse their investment and pay for the cost of operation and maintenance.[132] Through this method, urban areas can take advantage of the efficiency benefits of private management while maintaining control over pricing and funding options.[133] Some recent examples include the Waterloo Light Rail in Ontario and the Nottingham Tram scheme.

Gaps. Clearly, this abbreviated presentation only scratches the surface of the funding and financing issues affecting accessibility. It underscores, however, the critical nature of future research and policy testing. Among key gaps are the following:

- Although technology is improving the ability of policymakers and practitioners to better target public transport subsidies, it is not clear what is the appropriate subsidy level. As national cash transfer efforts improve targeting of non-sectoral support to low income households, this is a better option where feasible. It allows the household to make the tradeoff between housing and transport. In practice, however, such national schemes are difficult to design and implement, leaving second and third best policy options at the local and sectoral level as the only practical instruments available to address spatial inequities;

- An equally urgent issue regarding pricing is the impact of taxes and subsidies in support of other objectives such as environment and congestion, particularly among researchers. The literature is relatively thin regarding the distributional (including inclusive access) impacts of these interventions. But they are of increasing importance. As value capture schemes are increasingly applied, gentrification concerns are paramount. How can the design of value capture schemes be crafted to not push low-income households out of high-access neighborhoods? While there are caveats in the literature regarding the preconditions for making value capture instruments work,[134] there is very little discussion on the implications for low-income households. There are examples of value capture or related compensation schemes in which the government requires a reserve for lower or moderate-income housing. It is not clear yet, however, what have been the results and whether they are sustainable over

time in avoiding gentrification;

- The lack of a framework to measure the social implications of different financing instruments warrants serious attention. There are a number of critiques regarding the financial and economic evaluation criteria of investment projects.[135] But there is little systematic application and discussion amongst the finance community, especially in terms of accessibility. Efforts mentioned above illustrate the opportunities for incorporating accessibility measures. But there is still a tension on whether they complement or replace traditional cost benefit analysis.

Horizontal governance

The issue. The critical thread that runs through all aspects of the discussion on urban accessibility is the issue of governance. Questions concerning the distribution of functions and fiscal responsibilities among different levels of government are widespread, especially as they relate to promoting inclusive accessibility. Most discussions of governance regarding urban transport have focused on the objective of efficiency; there is a clear need to better understand what frameworks are accounting for network economies and cross-border transport services. Policymakers have responded by establishing metropolitan transportation authorities with varying levels of managerial, technical, and financial capabilities.

Accessibility, however, as expressed in this paper, requires an ability to address both the land use and transport variables. The dependence on a metropolitan transportation authority to ensure inclusive accessibility actually reinforces the sectoral silos rather than promote cross-disciplinary initiatives. Municipalities may be willing to delegate their transport planning and operational functions to a cross-boundary organization but they are less likely to delegate either taxation authority or land use decisions.[136]

For decades, there has been worldwide debate over decentralization and the empowerment of subnational governments with the major argument being the need for local participation and clear accountability[137]. The primary focus has been on the distribution of responsibilities and authority of the "vertical" governance system, between national, state/provincial and local government units. Less attention has been paid until recently to the issue of "horizontal" governance in which governance functions involve multiple adjoining municipalities whose borders don't conform to states or provinces.

The main impetus behind these horizontal governance initiatives appears to be a recognition of the importance of coordinated development and scale economies to promote economic growth and/or redevelopment. To a secondary extent, the desire to effectively address environmental concerns is also driving a broader regional approach.[138]

Social equity concerns and inclusive urban access, however, are generally lower down the list of objectives. Yet, with low-income households segregated into separate neighborhoods, generally in outlying districts, social issues should benefit from a broader governance structure. There is a need to even the playing field between higher and lower income contiguous municipalities. Voith and Wachter in discussing low-income housing illustrate the problem:

> "In many respects, affordable housing is a classic externality problem that needs to be solved at a government level capable of internalizing cross-jurisdictional externalities—which suggests a higher level of government than the local municipality." [139]

Innovative practices. There is a wide range of innovations that attempt to promote horizontal governance, largely determined by historical considerations regarding decentralized authority. The U. S., for example, has a long history of strong municipalities unwilling to relinquish their traditional powers. Countries such as France, on the other hand, have a tradition of a stronger top-down authority that facilitates greater empowerment to a regional authority. The examples below must be seen within this historical context.

Sweden, in 2012, established regional public transport authorities in recognition of the need for more

integrated and coordinated public transport systems across municipalities. Land use planning responsibility, however, remains in the hands of the municipalities.[140] This is a pattern repeated in many countries. According to a recent study, a regional Swedish organization in the Region Skane comprising 33 municipalities supports the benefits of the regional approach to transport and its local acceptance; the study also indicates the unwillingness of local governments to compromise their authority on local land use. Coordination then depends on more informal interactions, such as by councils of municipal representatives and non-governmental organizations, between the Region and the municipalities as well as other stakeholders in order to develop a shared vision. The study also argues that agreement on such a vision is easier to achieve during periods of economic growth.

The second type of innovative approaches to horizontal governance is the establishment of statutory development agencies devoted to land development and related infrastructure for targeted areas. As one example, Ahmedabad in India created the Ahmedabad Municipal Corporation and the Ahmedabad Urban Development Authority to promote and manage development in the periphery of the city through a cooperative agreement with local landowners. It aimed to improve and develop lands and financing the work through the sale of improved lots.[141]

A similar concept appears in several urban areas across Europe, such as Copenhagen and Hamburg, as they attempt to redevelop specific neighborhoods. In Copenhagen, the national and local government, in an effort to redevelop the port area, transferred land to CPH City and Port Development, a hybrid corporation. The local government is rezoning the land to support mixed-use development and the Development organization borrows against the increased value of the land. The funds are used to build supportive

infrastructure, while development efforts come from the private sector or the Corporation itself.[142] These types of efforts help avoid the fragmentation of local governments and "de-politicize" the process. Social equity concerns were not central to the Copenhagen initiative, although by law 25% of the residential units were to be reserved for low-income households. In the case of Hamburg, a similar model has been followed to redevelop its port area. There is a more specific effort at mixed-income housing.

A third innovation to consider involves the creation of a new regional government body. Ideally, this body is elected and has authority over both land and infrastructure development, as apparent in France. In 2014, France's national government established regional governments—or metropoles—with responsibility for planning, economic development, education, transport, and a range of other activities. This led to the formation of the Greater Lyon in 2015 to forge collaboration and coordination among 58 municipalities.[143] Similarly, more recently, the city of Santiago, Chile, is considering empowering its regional government to better coordinate and address economic development, environmental concerns, and social equity issues through coordinated land use, infrastructure, and fiscal strategy.

Gaps. While these examples of innovative practice begin to populate a menu of options for policymakers, there has not been any empirical assessment on the impacts of these initiatives on urban access.

- The concept of metropolitan governance raises a challenge for policymakers and researchers that have pressed for greater localization of decision-making and increased stakeholder participation. It is not clear how to strike the right balance. While one may gain in terms of addressing cross-border externalities and overcoming the most destructive aspects of inter-municipal competition, it is not clear

whether this enhances or diminishes local accountability. The answer will depend on whether metropolitan governance actually leads to better results that are recognized by stakeholders. In the specific case of accessibility, does metropolitan governance result in more equitable access?

- Similarly, effective metropolitan governance could lead to enhanced funding and financing opportunities critical to infrastructure development and related services. This important area has not been substantially explored.

VI. Moving forward

The growing amount of attention by researchers, practitioners and policymakers to the issue of accessibility is an important recognition that past urban development paradigms are not working—and that the accessibility concept can offer a path forward. In particular, improving urban access offers a compelling way to address worldwide challenges around increasing urbanization, worsening inequality, and underfunded and inefficient infrastructure. At the same time, modern information technology makes it easier than ever to test accessibility theories in practice.

Yet this paper and the related Moving to Access initiative confirm the challenges in implementing a new accessibility-focused framework. A number of factors underpin this situation, including the lack of attention particularly to the fiscal and financial implications; the institutional isolation of practitioners; and the cross-disciplinary and horizontal gaps within current governance frameworks.

To respond to these opportunities and challenges, it is important to mobilize research and practice to focus on developing a new accessibility framework. However, the complexity of the concept, the range of issues involved, and the variety of geopolitical, social, and economic contexts suggest the need for a more adaptable approach. It is premature and counter-productive to fix on one key indicator or measure to rally accessibility proponents or to replace current built environment metrics. Instead, what is called for is a targeted effort to identify the key issues and the specific measures that facilitate the analysis and the design of policies and instruments.

This paper argues for a "suite" of indicators—a virtual toolkit—that policymakers and practitioners can use to assess questions of accessibility and monitor progress of different interventions. There are principles that should frame such indicators such as their resonance across disciplines, their ease of understanding, and their data requirements. As researchers and practitioners gather more empirical evidence, the "suite" can adapt and expand. This is the most appropriate and reasonable approach given the nascence of the work.

In identifying the key directions for applying these measures, testing approaches in practice, and encouraging future research, this paper proposes the following:

- **Designing and updating a master list of accessibility-focused performance measures.** What current measures resonate with practitioners, policymakers, and the public? Who is the ideal public agency or civic organization to manage a list of implementable access measures, including tracking specific measures used in specific places? How can the gaps within that list motivate development of new measures, especially among applied researchers?

- **Documenting and evaluating innovative governance models that address vertical and horizontal constraints to improved accessibility.** What do alternative governance arrangements offer in terms of integrating transport, land use and fiscal and financing elements? How can a balance be achieved between a more metropolitan or regional approach to ensure equity and efficiency and the need for more localized, participatory decentralization? How can alternative approaches be measured and assessed?

- **Developing planning and evaluation methods that more adequately consider the dynamic relationship between land use and transport,**

and their implications for inclusive access. How can land use regulations and social housing practices avoid challenges associated with gentrification? How can TOD projects be adapted to foster inclusive access? Do household employment outcomes really improve when they experience increased access?

- **Analyzing the effects of different approaches to pricing and taxation, and how both impact funding.** How can a more comprehensive approach to transport pricing, subsidies, and related taxation be established? What are the efficiency and distributional impacts of accessibility pricing for other externalities such as congestion and environmental sustainability? What are the impacts of funding mechanisms such as value capture on inclusive access and how can they be mitigated?

- **Establishing a framework for assessing and scoring alternative financing structure in terms of accessibility.** How do different financing options affect accessibility? What are the options for addressing accessibility objectives in P3 agreements and contracts? What are the distribution of responsibilities and risks?

- **Incorporating accessibility in upstream transportation decision-making.** How can accessibility concerns be considered not just in terms of project or investment decisions but also in the choice between alternative planning scenarios? What is required to ensure effective cross-disciplinary approaches to planning?

- **Mapping accessibility scenarios based on adoption of new mobility technologies.** The rapid ascent of smartphone-based ride-hailing companies, plus the promise of automated vehicles, have led many to project wildly different scenarios for travel habits, housing demands, and where people choose to live. How do those various scenarios impact net accessibility? Do they exacerbate current spatial inequalities?

As indicated in Section V, there is a range of innovative efforts being undertaken across these various topics over a wide spectrum of countries. These cases offer opportunities for evaluation and testing to inform future initiatives. Among the goals of applied research and practice should be the key considerations in adapting such efforts to the specific political, economic and social context of different cities. Thus, a case study approach that focuses on a set of policies across different cities would be of high value.

This is an ambitious agenda, one that is beyond the capacity of any one actor. Yet the opportunities are enormous. There are clear initiatives for researchers, especially around integrating fiscal and financing measurement techniques with transportation and land use measures. Practitioners should continue to develop cross-disciplinary accessibility measures and explore the opportunity for global benchmarks. Practitioners can also work alongside current policymakers to initiate a series of issue-oriented case studies to test many of these questions in global urban areas. Considering the breadth of future work, there is an enormous need to document "good" practices, aggregate those results in one place, and create feedback loops to design further research.

In contrast, it will take considerable time to execute all this work. And this amount of time rightfully symbolizes how long institutional change of this scale takes. Much like the relative young age of academic research in the accessibility space, local and national governments have only just begun to test accessibility theories in practice. As such, we urge patience and persistence.

Appendix A: Bibliometric methodology

The following section describe the report's methodological approach, including an exploration of the bibliometric techniques utilized. As noted earlier, the report primarily relies on an online scientific citation indexing service called Web of Science to conduct this analysis.

Due to the immense volume of literature in the Web of Science repository, a first step involved putting together a rigorously selected and comprehensive core of journals that are relevant to the fields of transportation, land use and fiscal/finance.[144] The keyword-based search yielded over 20,000 relevant academic articles on the subject matter. This served as a foundation to generate different databases from this set of core journals, which in turn became the primary inputs for the different bibliometric analysis tools used in this report. Table 1 offers a summary of the tools used, namely Hammer,[145]CitNetExplorer,[146] and VOSViewer[147].

Each tool listed offers network analysis algorithms that can mine the sample of academic articles to identify what topics they cover and what gaps still remain. The output is a bibliometric network, which typically consists of edges and nodes. The nodes can be publications, journals, researchers, and keywords, and the edges indicate relations between nodal pairs. Table 2 lists the specific journals used in this multi-decade analysis.

Table 1: Bibliometric analysis tools and use

Tool	Sampling criteria	Sample size	Primary Output in Report
Hammer	Keyword filter 'access*'	Top 5000 most-cited	Bibliometric overview that highlights key trends
CitNetExplorer	Keyword filter 'access*'	All 5317 total results	Citation Network that shows evolution of research over time
VOSViewer	Keyword filters "transport" OR "transportation" OR "land use" OR "land-use"	Top 5000 most-cited	Keyword co-occurrence map that identifies extent of inter-disciplinarity

Table 2: Selected list of journals

Number	Journal Title
1	Case Studies on Transport Policy
2	Economic Development Quarterly
3	Economic Geography
4	Environment and Planning A
5	European Planning Studies
6	Geographical Analysis
7	European Transport Research Review
8	Geoinformatica
9	International Journal of Geographical Information Science
10	International Journal of Transport Economics
11	International Journal of Urban and Regional Research
12	International Regional Science Review
13	Journal of Economic Geography
14	Journal of Geographical Systems
15	Journal of The American Institute of Planners
16	Journal of The American Planning Association
17	Journal of Planning Education and Research
18	Journal of Planning Literature
19	Journal of Real Estate Finance and Economics
20	Journal of Regional Science
21	Journal of Transport and Land Use
22	Journal of Transport Economics and Policy
23	Journal of Transport Geography
24	European Journal of Transport and Infrastructure Research
25	Journal of Urban Affairs
26	Land Use Policy
27	Landscape and Urban Planning
28	Progress in Planning
29	Regional Science and Urban Economics
30	Regional Studies
31	Research in Transportation Economics

Table 2: Selected list of journals (cont.)

32	Transportation Journal
33	Transportation Letters The International Journal of Transportation Research
34	Transportation Quarterly
35	Transportation Research
36	Transportation Research Economics and Policy
37	Transportation Research Part A Policy and Practice
38	Transportation Research Part B Methodological
39	Transportation Research Part C Emerging Technologies
40	Transportation Research Part D Transport and Environment
41	Transportation Research Part E Logistics and Transportation Review
42	Transportation Research Part F Traffic Psychology and Behaviour
43	Transportation Research Record
44	Transportation Research Record Series
45	Transportation Research Procedia
46	Transport Policy
47	Transport Reviews
48	Urban Geography
49	Urban Policy and Research
50	Urban Studies
51	Transport Subsidy
52	Transport Policy
53	Transportation Research A
54	International Social Science Journal
55	American Economic Journal
56	American Economic Review
57	Journal of Transport Economics and Policy
58	Urban Studies Journal
59	Research in Transportation
60	Urban Geography
61	Social Research in Transport
62	Review of Economics and Statistics
63	Journal of Public Economics
64	The American Economic Review - keywords Urban & Transport
65	Public Budgeting and Finance
66	Land Economics
67	Transport Economics and Policy
68	Research in Transportation Economics
69	Research in Transport Economics
70	Urban Studies
71	National Tax Journal
72	American Journal of Economics and Sociology
73	Public Works Management and Policy
74	Municipal Finance
75	Journal of Urban Economics

Appendix B: How is accessibility measured?

Numerous typologies of accessibility measures have been designed, often focusing on different aspects or targeting different academic communities. Considering the one proposed by Geurs and Wee (2004), a review that is relevant for transport planning, three streamlined perspectives can be distinguished:

Infrastructure-based metrics typically analyze the performance of the transport infrastructure or service level. Typical examples include average speeds, number of people living near transit stations, or infrastructure densities. These metrics are not demanding in data but only provide information on the supply side of transport (i.e. do not include information about land-use or transport demand) and thus do not provide a proper measure of accessibility.

Location-based metrics integrate the land-use dimension and assess the level of accessibility for an average user, thus neglecting most of the heterogeneity among users. Person-based and utility-based metrics analyze accessibility on the level of individuals/groups taking into account their characteristics and constraints to derive the level and value of accessibility. Thus they are the more complete and complex metrics.

This appendix briefly summarizes the most common approaches to measure accessibility used in published research.

Cumulative Opportunity Measure[148]

The isochronic or cumulative opportunity measure is one of the basic and early measures discussed in the literature. This approach counts the number of potential opportunities that can be reached within a predetermined travel time (or distance).

$$A_i = \sum_{j=1}^{j} B_j a_j$$

Where:

A_i = Accessibility measured at point i to potential activity in zone j

a_j = Opportunities in zone j

B_j = A binary value equals to 1 if zone *j* is within the predetermined threshold and 0 otherwise

Gravity-Based Measure[149]

The gravity-based measure is still the most widely used general method for measuring accessibility among researchers, although it is more complex in calculations and has some points of weaknesses.

$$A_{im} = \sum_j O_j f(C_{ijm})$$

or

$$A_{im} = \sum_j O_j C_{ijm}^{-2}$$

or

$$A_{im} = \sum_j O_j \exp(\theta C_{ijm})$$

Where:

A_{im} = Accessibility at point i to potential activity at point j using mode m

O_j = The opportunities at point j

$f(C_{ijm})$ = The impedance or cost function to travel between *I* and *j* using mode *m*

$\exp(\theta C_{ijm})$ = Negative exponential function to travel between *I* and *j* using mode *m*

Utility-Based Measure:

The most complex and data intensive is the utility-based measure. Several researchers use this method since it adheres to travel behavior theories (Ben-Akiva & Lermand, 1977; Neuburger, 1971). The general specification of the measure is as follows:

$$A_n^i = ln\left[\sum_{\forall \in C_n} \exp(V_{n(c)})\right]$$

A_n^i = Accessibility measured for individual *n* at location *i*

$V_{n(c)}$ = Observable temporal and spatial component of indirect utility of choice *c* for person *n*

C_n = Choice set of person *n*

Constraints-Based Measure:

High levels of accessibility to various activities in a city can be present, yet the amount of time available in a day that people can spend to reach these activities might not. This leads to the constraints-based measure or people-based measure of accessibility (Wu & Miller, 2002). For example, if a person is at node *i* at time *t1* while at time *t2* the same individual has to return to *i* then the time *t = t2 - t1* constrains the number of *j* destinations available.

Composite Accessibility Measure:

A fifth measure is the composite accessibility measure. A composite measure is suggested by (Harvey Miller, 1999) where he combines space-time and utility-based measures in one measure. This approach introduces a higher level of complexity where time constraints are superimposed. The composite accessibility measure requires more data than utility-based measures and it is even more complex in terms of calculations and accordingly generalizing it for usage is not an easy task.

Place Rank:[150]

Place rank measure take inspiration from a methodology developed by Brin and Page (1998) used in ranking web pages for large scale search engines, such as Google.

$$P_{i,t} = R_{i,t}/O_i$$
$$E_{ij,t} = E_{ij,t} * P_{i,t-1}$$
$$R_{j,t} = \sum_{i=1}^{I} E_{ij,t}$$
$$R_{i,t} = R_{j,t}^T$$
$$If\ R_{i,t} = R_{i,t-1}, stop; else\ first\ equation$$

Where:

$R_{j,t}$ = The place rank (weighted number of people destined) for zone *j* in iteration *t*,

$$R_{j,0} = \sum_i E_{ij,0}$$

$P_{i,t}$ = The power of each person leaving *i* in iteration *t*;

$$P_{i,t} = P_{j,t}^{T}$$

I = The total number of *i* zones

$E_{ij,t}$ = The weighted trip table, the weighted number of people leaving *i* to reach an activity in *j*, is th$E_{ij,0}$inal trip table

O_i = The number of people originating in zone *i*;

$$O_i = \sum_j E_{ij,0}$$

Appendix C: Drawing insights across disciplines to inform a new approach to urban access

As with other papers in the Moving to Access (M2A) project, this report aims to showcase a variety of perspectives on urban access—academically and otherwise—while drawing knowledge from a host of different knowledge sources. It seeks to develop a more comprehensive, common understanding of urban access, as both a theoretical concept and paradigm for action, which naturally requires a closer look into an ever-shifting mix of social and economic factors at play worldwide, from growing urbanization to worsening inequality.

Doing so, of course, is easier said than done. As described in the Financing Urban Access (FUA) Road Map, exploring the evolution of urban access and its future direction is an enormously complex exercise that demands additional investigation among academics across many geographic, socio-economic, and institutional contexts. Ideally, at its core, this process is also informed by ongoing work and dialogue among a wide assortment of urban leaders and constituencies, focused on measurement, financing, and governance, among other activities. Over time, however, there has been a clear disconnect in how different people and places have conceptualized urban access, including a lack of clarity or consistency concerning its potential benefits.

One of the biggest challenges and opportunities in establishing a new approach to urban access, then, is to link together these various perspectives. In other words, identifying commonalities and gaps in how the academic community views urban access is crucial, as is shining more light on the difficulties and innovations underway in actually applying new plans, policies, and tools across the developing and developed world. The key to building more momentum behind urban access as an area of research and practical implementation is to draw inspiration from—and inform efforts among—a multitude of disciplines.

Traditionally, urban access, like other cross-cutting topics, has gained attention from many individual disciplines that can struggle to connect with one another. From transportation engineering and urban planning to economics, political science, and sociology, academics have long explored the need for a more equitable, sustainable built environment, but the increasingly specialized and nuanced perspective within each of these disciplines can make it difficult to coordinate research or define common goals.[152] Multi-disciplinary approaches, for instance, continue to play a lead role in more scientific research efforts, where specialists tend to work independently before combining their findings.[153] Interdisciplinary approaches, on the other hand, encourage specialists to cross their subject boundaries and engage more actively in defining common sets of problems.[154] Likewise, transdisciplinary approaches tend to go one step further, promoting research among specialists in unrelated disciplines and seeking input from practitioners throughout the research process.[155]

Still, as many disciplines continue to become more differentiated over time, it becomes more difficult to develop common definitions, integrate methods, and develop a truly comprehensive approach to topics like urban access.[156] For that reason, this report emphasizes a cross-disciplinary approach, which bundles together elements of many of the approaches described above, but focuses on a clearer articulation of the viewpoints

represented in different disciplines and the potential for increased collaboration.[157] To be sure, describing research that crosses traditional discipline boundaries remains an imperfect exercise in many ways; a number of overlapping and conflicting definitions exist among researchers and practitioners to promote greater interaction and shared learning.[158] However, by moving beyond jargon and exploring more unified directions for research, this report attempts to create a clearer synthesis of ideas and approaches to urban access.

This cross-disciplinary perspective is reflected throughout the report. In Section III, for instance, a new bibliometric analysis reveals how transportation researchers have defined and measured urban access over time, often without considering fiscal/financial dimensions in their work. However, the same analysis also points to the importance of relevant land use and governance considerations, which can help drive practical applications of accessibility. Likewise, Section IV points to the limitations of creating a singular accessibility measure and highlights how a broader measurement suite—informed by all relevant disciplines and greater interagency collaboration—can accelerate innovation and adoption. Finally, Section V points to several practical applications already underway in urban areas worldwide, centered on greater integration and communication across different disciplines; horizontal governance alignment is especially crucial in this respect.

In particular, the report identifies a broad collection of actors—namely researchers, practitioners, and policymakers—engaged across a wide range of disciplines relevant to urban access—including transport, land use, and fiscal/finance. As cautioned in the FUA Road Map, the report does not seek to develop an all-encompassing framework for urban access, which can make it challenging to adopt practical lessons across different global regions and contexts, but rather investigates how actors across these disciplines interact with one another and may face particular barriers to pursue ongoing work in this space. By investigating these three disciplines in greater depth, the report seeks to delineate a set of key topics and actors most directly involved in urban access without stretching the tent too wide. In this way, the report marks a starting point to guide larger cross-disciplinary discussions, research efforts, and innovative approaches focused on creating a more inclusive, accessible built environment worldwide.

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