International Transport Forum

Accessibility in the Seoul Metropolitan Area

Does Transport Serve All Equally?

Mobility Innovation Hub

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The International Transport Forum

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Abbreviations and Acronyms

BRT	Bus Rapid Transit
DMZ	Demilitarized Zone
DRT	demand-responsive transport
EC	European Commission
FUA	functional urban area
ITF	International Transport Forum
OECD	Organisation for Economic Co-operation and Development
PTAL	Public Transport Accessibility Level
SMA	Seoul Metropolitan Area
SOV	single-occupant vehicle
TOD	transit-oriented development

Glossary

Term	Definition
Absolute accessibility	A cumulative count of the opportunities that can be reached within a specified travel time or distance threshold using a given transport mode.
Active modes	Human-powered modes (e.g., on foot, by bicycle).
Core areas	A city or region's most densely inhabited urban areas, in contrast to its less densely populated but contiguously inhabited peripheral (or peri-urban) areas that are still within its administrative boundaries.
Dwell time	The time public transport vehicles spend at stops and stations to facilitate passenger boarding and alighting activity.
Equity	The fairness and appropriateness of the allocation of resources, along with their benefits and impacts. In transport, equity can be classified into horizontal and vertical equity. This study considers the personal and contextual factors that influence transport choices to add an equity lens to the assessment of accessibility.
Functional Urban Area	A densely inhabited local unit (e.g., municipality, city), along with its less densely populated but contiguously inhabited surrounding areas (or commuting zone), which may not be within an administrative boundary but is highly integrated with the city functionally and economically, as defined by the EC-OECD.
Headway-based scheduling	Dynamic scheduling of buses to maintain a consistent interval between buses (headways) along corridors, as opposed to static scheduling of bus arrival times at stops and stations.
Horizontal equity	The distribution of costs and benefits between equal units (individuals and groups).
Leading pedestrian intervals	Signals that allow pedestrians to enter the intersection before corresponding car traffic is given a green light.
Mode	Refers to the method of transport service. For example, road, rail, waterway, air or private car, powered two-wheeler, bus, metro, or urban rail.

Mode share	Percentage of total passenger-kilometres or trips accounted for by a single mode of transport.
Peri-urban areas	Less densely populated but inhabited peripheral areas that are still within the city's boundaries. Peri-urban areas are also more likely to be single-use areas, typically agricultural or industrial, or residential areas that are close to the greenbelt.
Polycentric	For cities and regions, polycentric refers to having more than one urban centre with overlapping commuting zones.
Proximity	The total number of opportunities within a given distance threshold.
Spatial accessibility	The ease with which people can reach the locations of their needs using the transport system.
Spatial structure	The pattern of distribution of land uses and transport networks.
Sub-centres	In this report, urban centres that are within the SMA but are less densely populated than Seoul are referred to as sub-centres.
Time-poverty	Lack of available time for discretionary activities.
Transport performance	The ratio of the number of reachable opportunities within a given time threshold (absolute accessibility) to the total number of opportunities within a distance threshold (proximity).
Urban centre	Per the joint EC-OECD's FUA definition, the urban centre is a cluster of contiguous, high-density grids that can be defined independently from administrative boundaries. For this study, administrative boundaries were taken into consideration based on feedback from stakeholders, so Seoul is considered the main urban centre due to its population density.
Vertical equity	The distribution of costs and benefits between unequal units based on one or several attributes, such as income, ability or demographic characteristics.
Working age	In this report, the age group between 25 and 64 is considered "working age".

Executive summary

What we did

This report outlines the factors that determine equitable access, using the Seoul Metropolitan Area (SMA) as a case study. It recommends a framework for incorporating such an analysis into policy making to better account for the distributional effects of transport policies.

The assessment builds on the International Transport Forum's Urban Access Framework, a tool for measuring spatial accessibility which can be used to compare different cities or regions and can be adapted for an in-depth analysis of a given study area.

For this study, an equity lens was added to the framework. Local expertise was contributed by Korean transport professionals and practitioners in technical and stakeholder workshops. The report also draws on the *Benchmarking Accessibility in Cities* study, and on available literature.

What we found

Measuring accessibility is an intuitive way to show whether the transport system meets its core function (connecting people to the location of their needs). Including accessibility and equity in transport decision making can add social and economic value to communities and improve the quality of life for residents.

Improving accessibility requires consideration for both land use and the transport performance. Absolute accessibility combines two factors: proximity and transport performance. Proximity is influenced by the density and diversity of land uses, meaning dense and mixed-use areas will provide better access to destinations. Transport performance is influenced by the quality of the transport network and depends on the availability of infrastructure and service.

Land use and transport network design that combine to promote car use limit opportunities for people without access to cars if alternatives are not available. In most areas of the SMA, it takes less time to reach work opportunities by car compared to other modes, partly due to the extensive road network and the region's development over time. This increases car dependence, which has negative impacts such as increased congestion, pollution and traffic fatalities, and reinforces inequality of access for users of other modes.

Moreover, complex and interconnected challenges influence access, and the opportunities available to address these challenges vary by demographics and contexts. Personal and contextual factors influence transport and destination choices, and as a result, accessibility. Considering these factors adds an equity lens to measuring accessibility and improves the planning and design of transport systems as well as land-use policies.

In areas of the SMA where local public transport services are more limited, people face longer travel times using the mode. The longer travel times penalise people who rely on public transport, such as women, older adults and those with lower incomes living in peri-urban areas. Conversely, in urban centres where public transport has extensive geographic coverage, frequent service, and longer hours of operation, it provides the same ease of access as cars.

Neighbourhoods that can provide affordable housing near essential services and amenities, as well as infrastructure for active travel, empower older adults and children to be independently mobile. In the SMA, persons over 65 have the highest walking mode share of all groups, which has preventative health benefits and can reduce social isolation. As mobility needs change with age, neighbourhood design plays a role in maintaining accessibility and in allowing ageing in place. On the other end of the age spectrum, fewer children in the region will live within walking distance of middle schools as they grow older, decreasing the likelihood they can walk or cycle to school.

Designing urban environments in ways that make active travel safe and enjoyable for everyone can achieve multiple policy objectives at once. Transport interventions that capitalise on low-cost infrastructure to reallocate urban space from cars to people based on accessibility analysis can improve the connectivity offered by active modes, even where investing in active infrastructure can be costly.

What we recommend

Develop people-focused policies to improve accessibility

Complementary policies that focus on peoples' needs should be the basis for addressing multiple and interdependent accessibility challenges together. Rather than looking to improve the performance of individual modes, decision makers can instead focus on meeting the travel needs of people and improving equity. For example, mixed land-use policies can decrease travel distances, thereby making active modes more viable and investment in public transport improvements more cost-effective. Such a holistic approach can improve integration between modes, provide people with more options for travel, and thereby improve access.

Measure the impacts of policies on access and equity

Measuring accessibility through an equity lens offers a tool to improve policy coherence and co-ordination in transport decision making. Such analyses can be used to identify deficiencies in transport design that impact equity. These people-centric analyses can be used to engage stakeholders across different functions to develop and prioritise targeted and context-sensitive solutions that improve accessibility. Measuring accessibility will require leveraging diverse and disaggregated data from public and private sources.

Enable conditions for people-focused transport policies

Enabling conditions need to be in place to normalise people-focused transport and land-use decision making. Supportive administrative frameworks can make sure the relevant decision makers are empowered to use accessibility analyses to inform policies. Supportive regulations that consider the broader urban policy environment can facilitate collaboration with the private sector to implement innovative solutions. Funding mechanisms can target scarce resources where they can be most beneficial, using accessibility analyses and in alignment with policy priorities. Tools that allow the inclusion of individual lived experiences in transport decision making, such as accessibility dashboards and open data portals, can facilitate more meaningful engagement and participatory planning.

Accessibility: A core function of transport

Successful societies enable access to opportunities, including work, school and healthcare facilities, as well as other activities and people. This access can be provided either through travel or by the proximity of locations. Demand for travel is derived from the need of individuals to access opportunities. As such, the core function of a passenger transport system is connecting people to the locations of their needs. The ease with which people can make these connections, independently of their physical ability, is referred to as spatial accessibility. Spatial accessibility can also be considered a human capability or the freedom to pursue activities that are essential for survival and development (Pereira, Schwanen and Banister, 2017).

Accessibility is influenced by land use and its interaction with transport systems. Land-use policy and practice determine how many opportunities are nearby, whereas transport policy and networks determine how many opportunities can be reached within any given travel time. Crucially, the ability to access opportunities is not evenly distributed within a population. Personal and contextual factors (e.g., age, income, gender, ability) play a role in the distribution of accessibility. They determine transport choices, including destinations, time of travel, and modes used. Considering these factors adds an equity lens. Equitable accessibility is a core policy objective in many societies.

Adding an equity lens requires policy makers to consider the distribution of benefits and costs across different socio-economic and demographic factors. Incorporating equity in the analysis of accessibility can be complex, as it requires understanding barriers to access based on travellers' needs and preferences. However, exploring these challenges is necessary to develop land-use and transport policies that alleviate, rather than reinforce, inequality of access.

This report presents a top-down global framework for measuring spatial accessibility through an equity lens, which can be used to compare different cities or regions. It can also be adapted for a more in-depth analysis of a given study area by local practitioners who have the contextual expertise. It focuses on Korea's capital region, the Seoul Metropolitan Area (SMA), as a case study to illustrate potential applications for such an analysis. Firstly, it outlines the land-use and transport performance factors shaping access in the region. Secondly, it presents specific scenarios, focusing on how personal and contextual factors can affect access. Finally, it recommends a framework for incorporating this approach into policy making to better account for the distributional effects of transport policies and interventions.

Physical accessibility, which is also an important consideration of access, requires additional consideration to remove barriers for individuals with limited mobility (universal access). Although this report focuses on spatial accessibility, connecting people to the location of their needs should also consider universal access.

How land use and transport performance shape access

The Seoul Metropolitan Area (SMA) is the country's economic centre and home to almost half its population (ITF, 2018). The SMA consists of three main administrative territories:

- The Special City of Seoul: the capital and largest city in the Republic of Korea. It has 10 million residents and is the most densely populated area of the region.
- The Metropolitan City of Incheon: the third largest city in Korea (3 million residents), adjacent to Seoul, located downstream of Hangang River. Its shoreline faces the Yellow Sea, and its population density is much lower than Seoul's (15% that of Seoul).
- The province of Gyeonggi: encompasses Seoul and Incheon and has 28 cities and three counties, and a population of 10 million residents (in addition to those of Seoul and Incheon). Further references to Gyeonggi in this report exclude Seoul and Incheon.

Partly due to the complexity and diverse needs of its various jurisdictions, no single transport authority is responsible for the region's transport planning (ITF, 2018). However, local authorities co-operate in delivering public transport services. This study aims to understand accessibility not just based on administrative boundaries, but through the lived experience of residents. As such, the results presented reflect the functional relationships between the three administrative territories in terms of travel behaviour and changes in land use over time.

Despite the administrative boundaries, Seoul, Incheon and Gyeonggi have inextricable links in their land uses and regional travel patterns. Seoul, the region's main urban centre, has a wide range of opportunities due to its density and economic pull. As demand for housing and work pressured the metropolitan area to expand, new developments (termed "New Towns") emerged in the periphery to accommodate population growth. The outward expansion of the region has been characterised by land-use regulations designating growth to New Towns, initially within 30 km of Seoul. Successive phases of New Town developments have reached as far as 50 km from Seoul (Jun, 2020). The New Town developments have had a significant impact on regional travel patterns, as discussed throughout the report.

The research acknowledges administrative boundaries, which inform decision making and delineate roles and responsibilities to provide actionable insights for decision makers. As a result, the study does not look beyond the borders of the province of Gyeonggi, although there may be some functional relationships to destinations and activities that are immediately adjacent to the provincial border. Further details regarding the selection of the study boundaries are found in Box 1.

Box 1. Defining the geographical and administrative boundaries for the study

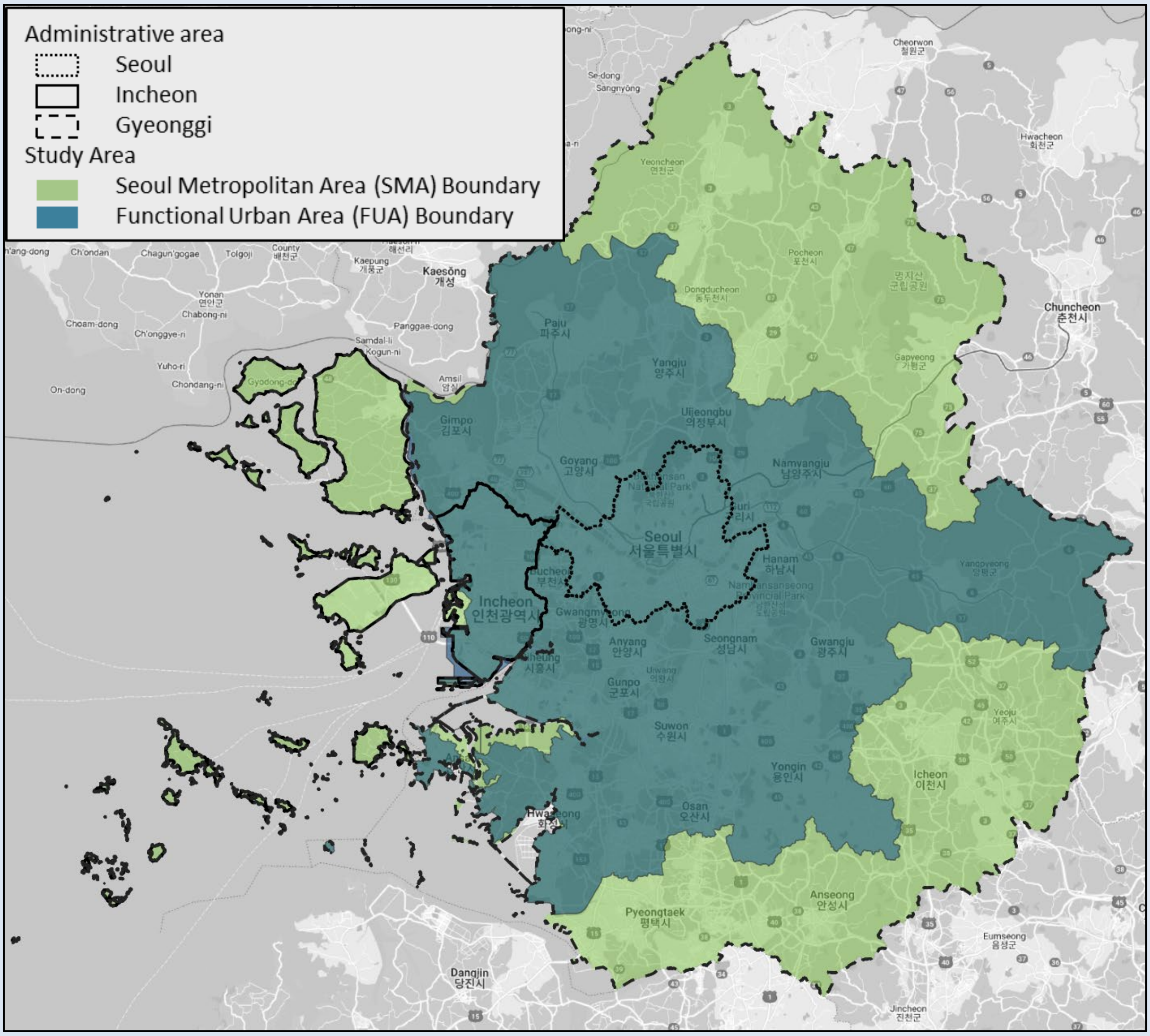
This study focuses on the Seoul Metropolitan Area (SMA), an administrative boundary consisting of the province of Gyeonggi, within which are the cities of Seoul and Incheon. Due to its economic pull, the travel patterns and trip volumes within the SMA have a clear link to the City of Seoul. However, this association is not as strong at the outer boundaries of the SMA, which are often closer to other neighbouring communities.

The extent of the urban region with a strong association with Seoul can be called its Functional Urban Area (FUA). The FUA, as jointly defined by the European Commission (EC) and Organisation for Economic Co-operation and Development (OECD), is a densely inhabited local unit (e.g., municipality, city), along with its less densely populated but contiguously inhabited surrounding areas (or commuting zone), which is highly integrated with the city, functionally and economically (ITF, 2019). The benefit of this consistent definition of FUAs is that it allows for comparison between different cities that might otherwise have administrative boundaries that are too dissimilar for benchmarking. It also allows for a joint or distinct assessment of the urban centre and the commuting zone.

However, from policy implementation and service delivery perspectives, excluding certain areas within an administrative boundary can introduce complexity. On the other hand, considering the results for the entire urban area provides insight into the big picture while still allowing for context-specific exploration. One notable limitation to this approach is that accessibility in areas of the region that are not part of the FUA will be underestimated as their travel behaviour is less associated with the City of Seoul. Figure 1 is a comparison of the SMA boundaries along with the FUA boundaries. For this study, the Seoul FUA was computed using the OECD methodology, so the results can be reproduced to allow for benchmarking across different contexts (OECD, 2013). However, the results presented within this report are at the extent of the administrative boundary, based on feedback received from local stakeholders.

Cities and counties in Korea are further sub-divided into districts (“gu”), and “gus” are divided into smaller neighbourhoods (“dong”). Some demographic data is reported at the “gu” or “dong” level. However, the majority of the data used for analysis in this study is reported at the census block level, typically smaller than a “dong”. For computational purposes, the study area is split up into 500-metre square grid cells. Each cell is associated with the sum of the population and destinations within the cells. Access, transport performance, and proximity are measured between cells.

Figure 1. The Seoul Metropolitan Area in relation to the Functional Urban Area



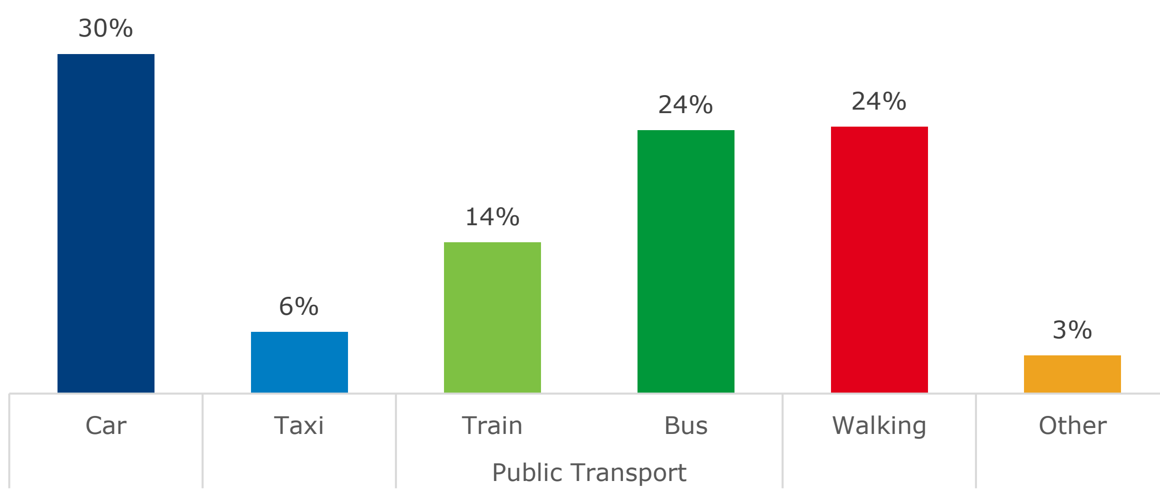
Government policies to industrialise areas southwest of Seoul have led to employment growth in those areas, resulting in a more polycentric spatial structure with new regional sub-centres emerging (Sohn et al., 2010). The development in the region is also skewed southward due to geopolitical factors, namely, the region's proximity to the Korean Demilitarized Zone (DMZ).

Despite the region's polycentric nature, transport connections are still oriented toward Seoul, as are most opportunities, resulting in increasing car dependence in the region's sub-centres and the peri-urban population.

This trend also influences regional travel patterns in the SMA – over a quarter of all trips in the region are destined for Seoul. In terms of the regional mode share, a third of all trips are by car, with the road network structure making driving in the region an efficient way to get around, although congestion in Seoul is significant (Figure 2).

Public transport accounts for 38% of trips: 24% by bus and 14% by train. The region has an integrated public transport network with commuter rail and high-speed rail connections. Despite the compact development patterns, the cycling mode share is negligible, but walking accounts for just under a quarter of trips. (Korea Transport Institute, 2018) The region has a dedicated infrastructure for pedestrians and is continually working on improving the pedestrian experience by increasing pedestrian-priority areas.

Figure 2. Transport mode share for the Seoul Metropolitan Area (2016)



Note: Cycling is included in the "other" category.
Source: (Korea Transport Institute, 2018), *Passenger Travel Status Index Book,* https://english.koti.re.kr/user/bbs/BD_selectBbs.do?q_bbsCode=1017&q_bbscttSn=20190319144504053&q_clCode=6&q_lang=eng.

Understanding how the interaction of land use and transport affects how well people can access opportunities improves the planning and design of transport systems. As such, accessibility analysis is the cornerstone of transport planning. Traditionally, transport analyses are centred on mobility and connectivity (Miller, 2020). Mobility focuses on improving transport performance through efficiency improvement measures, such as reducing congestion and shortening travel time for public transport. Connectivity focuses on the quality of transport options, such as the directness of a bus route, the coverage of a public transport network, and the ease and efficiency of intermodal transfers (Miller, 2020).

Mobility and connectivity enhance accessibility and will continue to play a role in the planning and analysing of transport systems. However, decision making for transport that focuses solely on these factors can lead to inequitable outcomes, as is discussed in this report. Including accessibility through an equity lens in the decision-making process can result in more equitable transport policies that allow people the freedom to pursue activities that meet their needs.

Measuring accessibility

The ITF Urban Access Framework provides one method to measure accessibility. It uses a cumulative count of the opportunities that can be reached within a specified travel time or distance threshold using a given transport mode. The total number of opportunities reachable within a certain time threshold is absolute accessibility. It is a combination of two factors that facilitate the connection between origins and destinations: proximity and transport performance (ITF, 2019).

Proximity is influenced by the density and diversity of land uses, meaning dense and mixed-use areas will have higher access to destinations. Transport performance is influenced by the quality of the transport network and will depend on the availability of infrastructure and service. To improve accessibility, consideration must be made for both the land-use and the transport performance aspects of access.

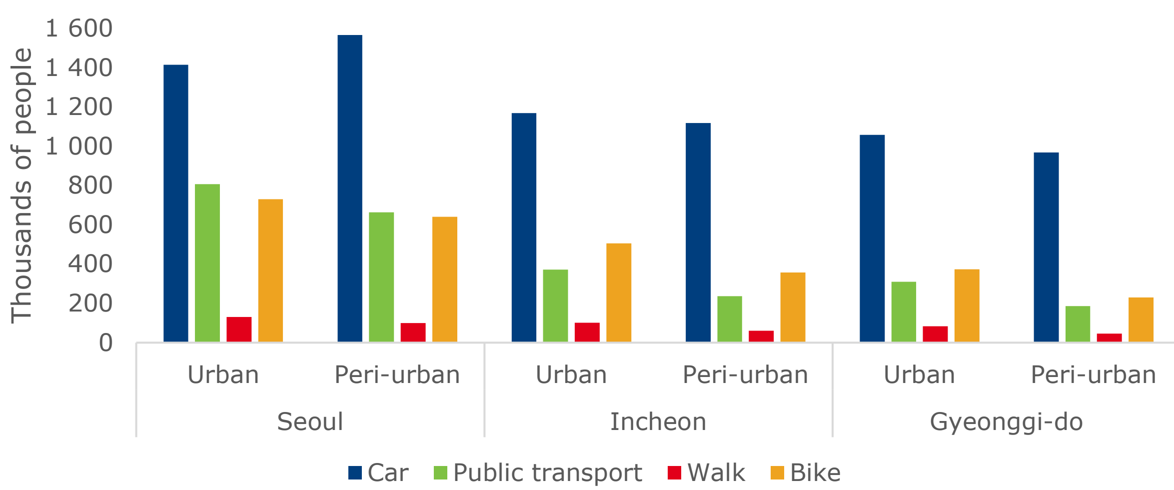
A comparison of absolute accessibility to the population by mode, administrative region and predominant spatial structures (urban, peri-urban) in the SMA shows the importance of the interaction between land use and the transport network (Figure 3).

Population is used as a proxy for opportunities to illustrate the measurement of accessibility because people generate activities. Population gives a snapshot of access for all the inhabited areas of the region, which represent potential trip origins. It also allows for comparison of the three core concepts of the ITF Urban Access Framework (absolute accessibility, proximity and transport performance). However, using population has limitations for in-depth analysis of access, particularly where land-use regulations create large single-use zones within urban areas that may have no inhabitants. Subsequent sections of this report illustrate access to actual destinations for a more complete analysis.

The 30-minute time threshold used for this example can encompass a variety of trip purposes using all available modes of transport. The shorter time also allows for a better comparison with the walking and cycling modes because it is still within a feasible threshold for most active trips.

Absolute accessibility is computed by first measuring the travel time from one origin to all possible destinations within the study area. In this example, the number of people reachable within the time threshold selected (30 minutes) then becomes the absolute accessibility of that origin. This process is repeated for every grid cell in the study area. The accessibility value of an area comprisipng multiple grid cells (e.g., region, city, district) is computed as a population-weighted average of the accessibility scores of individual grid cells within the boundary (ITF, 2019).

Figure 3. Average number of people reachable within 30 minutes in the Seoul Metropolitan Area



Car access in peri-urban areas of Seoul outperforms car access everywhere else. This can be attributed to the performance of the transport network: the higher traffic congestion in the city’s core areas results in lower access levels for cars. Empirical road network data, which uses actual operational speeds, was available for the SMA and improved the quality of the analysis.

For all other modes, the combination of high density in the urban areas and the performance of the transport network results in a clear trend: as density decreases, so does access. In Seoul, on average, twice as many people are reachable using a car compared to public transport or bike. Compared to walking, which is the slowest mode, over ten times more people are reachable by car in the urban areas of the region, and over sixteen times more people are reachable in peri-urban areas.

Public transport's worsening accessibility performance as density decreases is also notable: users of the mode in Seoul's urban areas can reach over twice as many people on average as those in the urban areas of Incheon and Gyeonggi. The difference is greater for public transport users in peri-urban areas of Seoul, who can reach three times as many people as those in the peri-urban areas of Incheon and Gyeonggi.

However, this measure does not account for the quality of travel, which can also affect accessibility. For example, in some core areas of Seoul, high public transport use can cause crowded conditions, particularly during the peak period. Overly crowded buses and subways increase travel times for public transport users, who end up with longer wait times. As an aggregate measure, it also does not account for corridor-specific performance, which can result in higher public transport performance in areas that prioritise public transport.

In Incheon and Gyeonggi, access by bike surpasses access by public transport, largely due to the potential of the mode. Unlike public transport, bikes are not limited by availability and service coverage, but by the availability, quality and safety of infrastructure. Since cycling is allowed on most roads, bikes have the potential for higher access than public transport in areas with less extensive public transport service.

Walking has the lowest access of all the modes due to its speed, but it provides a fairly consistent level of access throughout the region. Similar to cycling, the mode is only limited by the availability, quality and safety of pedestrian space on existing roads, which may differ across road types. This analysis provides a starting point to understand the contextual factors that may limit access, including trends in travel demand, quality of transport, and individual characteristics that can affect transport choices.

Absolute access is an intuitive measure to understand whether the transport system meets its core function and can be easily communicated to different stakeholders. However, it has three main limitations that are worth further discussion:

- Treating all destinations within the same distance or time range as equally accessible assumes that they are all equally attractive to users (see Box 2).
- Selecting time thresholds can be meaningful for several trips that occur within that range. However, it assumes that people are indifferent to all travel times within that range but opposed to anything even slightly longer (see Box 3).
- Measuring accessibility for single-trip purposes and or a single destination does not account for changes in accessibility for trip chains, which include a combination of purposes and destinations (see Box 5).

Addressing these limitations would increase the complexity of measuring accessibility as well as the data required and may not yield a proportional additional benefit in the policy-making process. The benefits of a more complex approach depend on the policy relevance of what is measured and on the context.

For example, fine-tuning the selection of time thresholds may be relevant for policy makers looking to define a minimum standard for access, whereas more detailed location attributes may be relevant for determining the span of a public transport service. However, recognising the limitations of absolute accessibility emphasises the importance of applying an equity lens to the measure to develop context-relevant and equitable policies.

Proximity: Fewer opportunities further from urban centres and sub-centres

Proximity measures the distribution and concentration of nearby destinations, reflecting the land-use patterns and density of an area. Although Seoul and Incheon are primarily urban, some areas within both cities are less dense and can be considered "peri-urban". Peri-urban areas are also more likely to be single-use areas, typically agricultural or industrial, or residential areas that are close to the greenbelt. In Seoul, these areas are mainly on the northern and southern edges of the city. Similarly, in Incheon, the northern edges of the city are considerably less dense. In Gyeonggi, outside of its cities, many areas can be considered peri-urban and suburban, typically in the northern and the eastern areas. These differences can influence accessibility.

As expected, Seoul, the region's main urban centre, has the highest proximity values. Most areas within the city's boundary have over two million people within an 8 km radius (Figure 4). The 8 km distance threshold was selected to correspond to the absolute access analysis in Figure 3. Given the average travel speed for car and public transport in the region, 8 km is the approximate distance reachable within a 30-minute travel time.

In some parts of Incheon and in Gyeonggi (specifically the cities of Bucheon and Gwangmyeong, located between Seoul and Incheon), the proximity value is also very high. Outside of these areas, proximity values decrease gradually south of Seoul and Incheon, and more steeply in the northern and eastern areas of Gyeonggi. In most of the province of Gyeonggi, even by car, only up to 150 000 people are reachable within an 8 km distance – less than a tenth of those reachable in the densest areas.

This difference illustrates the importance of density and diversity of land uses when it comes to access (see Box 2). Land-use policies affect the distances between origins and destinations and, as a result, proximity. Given that absolute accessibility is the product of proximity and transport performance, dense urban centres and sub-centres are typically likely to perform better in accessibility analyses.

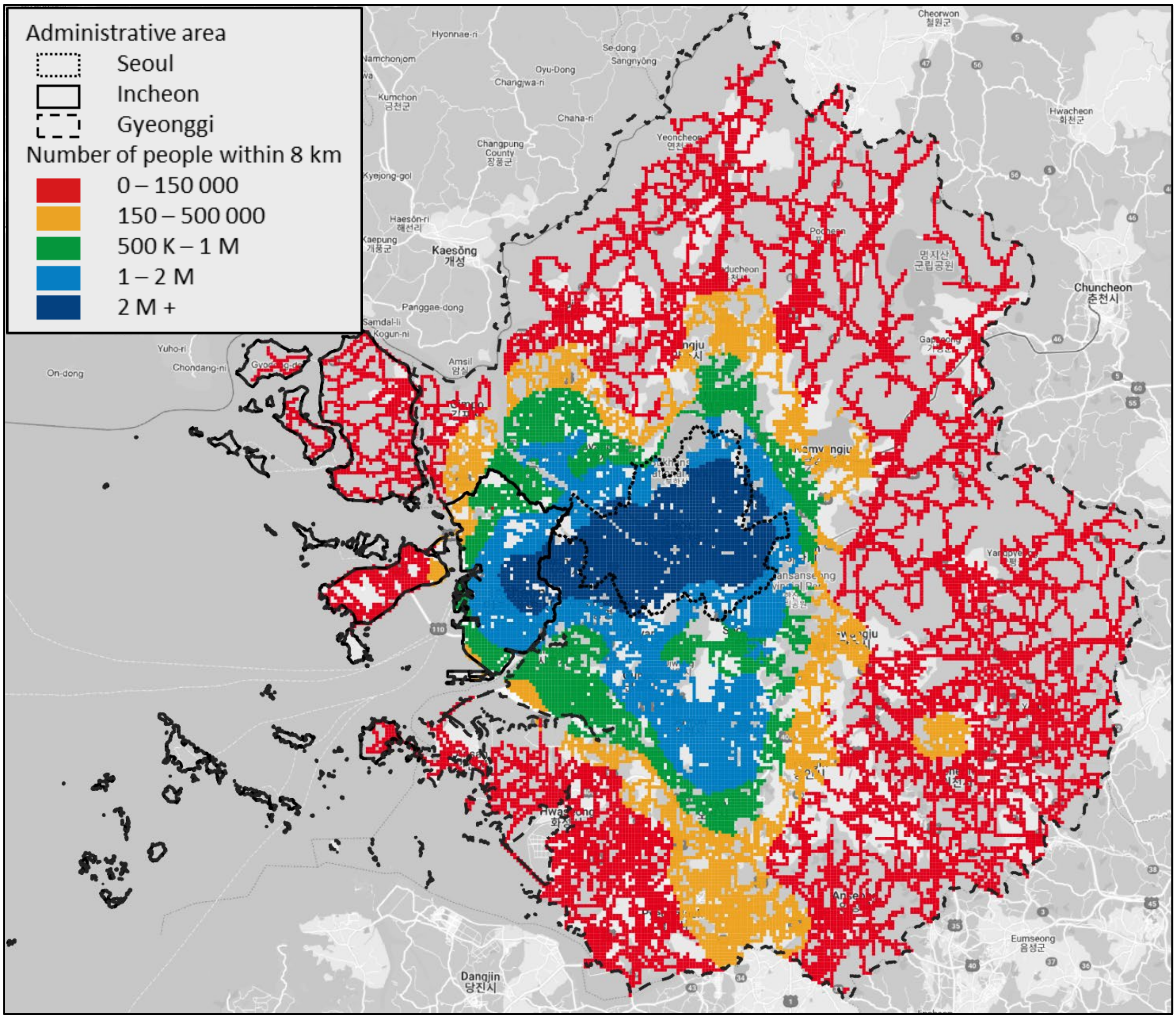
Box 2. Location attributes and their effect on measuring accessibility

Various factors influence whether a person selects a given destination, primarily their ability, needs, preferences and the attributes of the location. These factors are often outside the purview of transport decision making (e.g. education attainment, income level). Considering the attractiveness of a location to an individual would require making many assumptions regarding an individual's abilities, needs and preferences in measuring accessibility. This is challenging given the complexity of individual behaviour and the availability of data. However, including some location attributes that may affect location attractiveness in the measurement of access can be beneficial from a policy maker's perspective. For example, hours of operation when measuring access to retail outlets, or the availability of hospital beds when measuring access to healthcare facilities can influence the attractiveness of these locations.

Not all location attributes may be relevant for improving overall accessibility or equity. Introducing additional factors to measuring accessibility, such as location attributes, should then depend on policy objectives. These can vary based on context and priorities, but considering accessibility as a human capability would require that policies achieve two goals: improve overall accessibility and guarantee a minimum level of access to essential activities. In this sense, a measure such as absolute accessibility has the benefit of capturing the cumulative effect of multiple destinations, which can infer additional choice and thus, a higher likelihood that the choices available may fit individual ability, needs or preferences.

Source: Miller (2020), "Measuring Accessibility: Methods and Issues", https://doi.org/10.1787/8687d1db-en.

Figure 4. Number of people reachable within an 8-km radius in the Seoul Metropolitan Area



Transport performance: Quality of travel varies by mode

Transport performance is the ratio of the number of reachable opportunities within a given time threshold (absolute accessibility) to the total number of opportunities within a distance threshold (proximity). It demonstrates how well a given mode provides access to a given point of interest within the time threshold (see Box 3). The higher the score, the higher the transport performance, with scores that are greater than one illustrating above average mode performance across the study area. Accounting for the actual performance of the modes by considering the availability of infrastructure, quality of service, and the demand results in different accessibility scores between modes.

Building on the measurements of absolute accessibility and proximity presented in the previous sections, Figure 5 shows the transport performance to population ratio for car, public transport, cycling and walking. The difference in transport performance and access between the modes can also affect mode choice, as areas with limited alternatives to driving are more likely to favour car use. Transport policies that improve the availability and quality of all modes provide more choices for residents, and as a result, accessibility.

Box 3. Selecting a travel-time threshold for access analysis

This study uses travel time as the main variable to measure access because it is policy-sensitive: it is influenced by spatial structure, responsive to changes in demand and supply, and can provide decision makers with information to improve the performance of the transport network (Miller, 2018). Travel time also represents a cost for users and tends to be higher for public and active modes, with some exceptions such as higher-order public transport, and bikes and e-bikes in congested areas. This affects the mode share for sustainable transport (Ha, Lee and Ko, 2020). Features of the transport system, including more connected road networks, intelligent traffic management systems, higher coverage, service span and frequency of public transport, along with prioritised or dedicated infrastructure for walking and cycling provide residents with more route choices and can influence travel time, resulting in better accessibility.

Isochrone measures of accessibility are influenced by the time threshold selected for analysis (Xi, Miller and Saxe, 2018). For example, longer time thresholds allow for the inclusion of public transport services with longer access and egress distances. In areas within Gyeonggi, the time threshold selected can mean the inclusion of high-speed rail, significantly improving travel time. If the high-speed rail station is just outside the given time threshold (e.g., 30 minutes), the results will exclude it, but in reality, it is within reason to expect an individual to consider it accessible. In addition, destinations within a selected time threshold can be more or less attractive based on their distance from the origin.

To address some of these nuances and reduce the impact on the policy insights, the time thresholds can be selected based on observed data in the local context (e.g., travel survey data). In this study, time thresholds were selected based on travel survey data where available, to reflect what can be considered a reasonable travel time for the activity and mode. Alternatively, time thresholds can be selected to measure policy objectives such as meeting a minimum standard for access (e.g., number of schools within a 15-minute walk).

On average, car transport performance outperforms all other modes in the 30-minute time threshold, especially outside Seoul (Figure 5). This finding is consistent with other cities evaluated in the Benchmarking Accessibility in European Cities report (ITF, 2019). The car's performance can be attributed to the connectivity and structure of the road network in the SMA and the limited congestion and higher speed limits outside Seoul.

The region's development over time has also resulted in better car access for residents and better quality of travel by car, particularly outside the urban centre and sub-centres. The available empirical road network data for the SMA allowed for actual operational speeds to be used in the measurement of the accessibility indicators, improving the quality of the analysis.

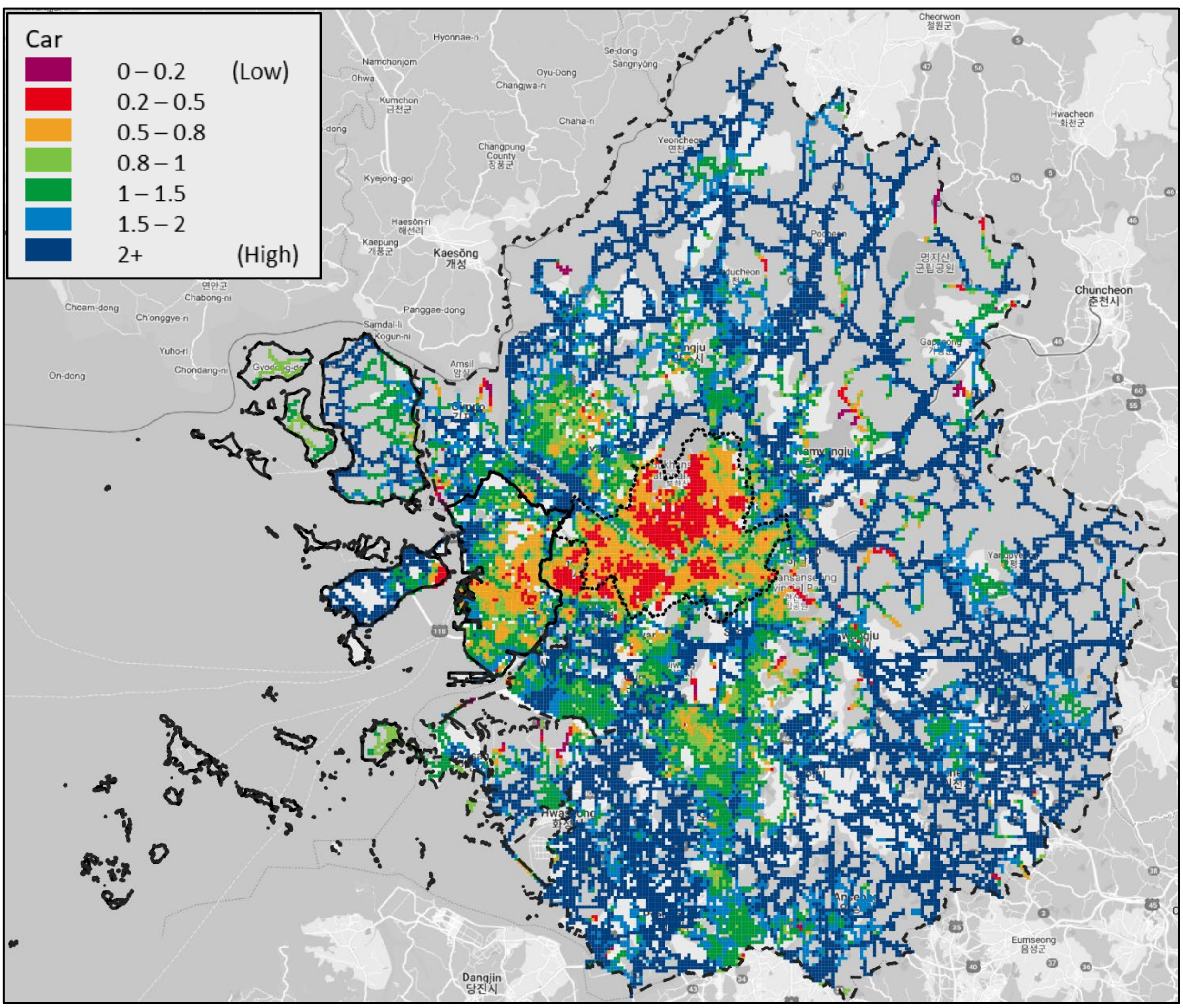
The SMA has an extensive and integrated public transport network. The subway network is denser in the urban centre (Seoul), it is supplemented by a hierarchy of bus services with frequent trunk lines operating on dedicated lanes on major arterial roads. As a result, public transport performance is better in Seoul and the sub-centres. However, as higher-order public transport services (those operating in dedicated rights-of-way, such as rail, metro and bus rapid transit [BRT]) decrease outside Seoul and the sub-centres, public transport performance declines considerably, noticeably in Incheon and the southeast area of Gyeonggi.

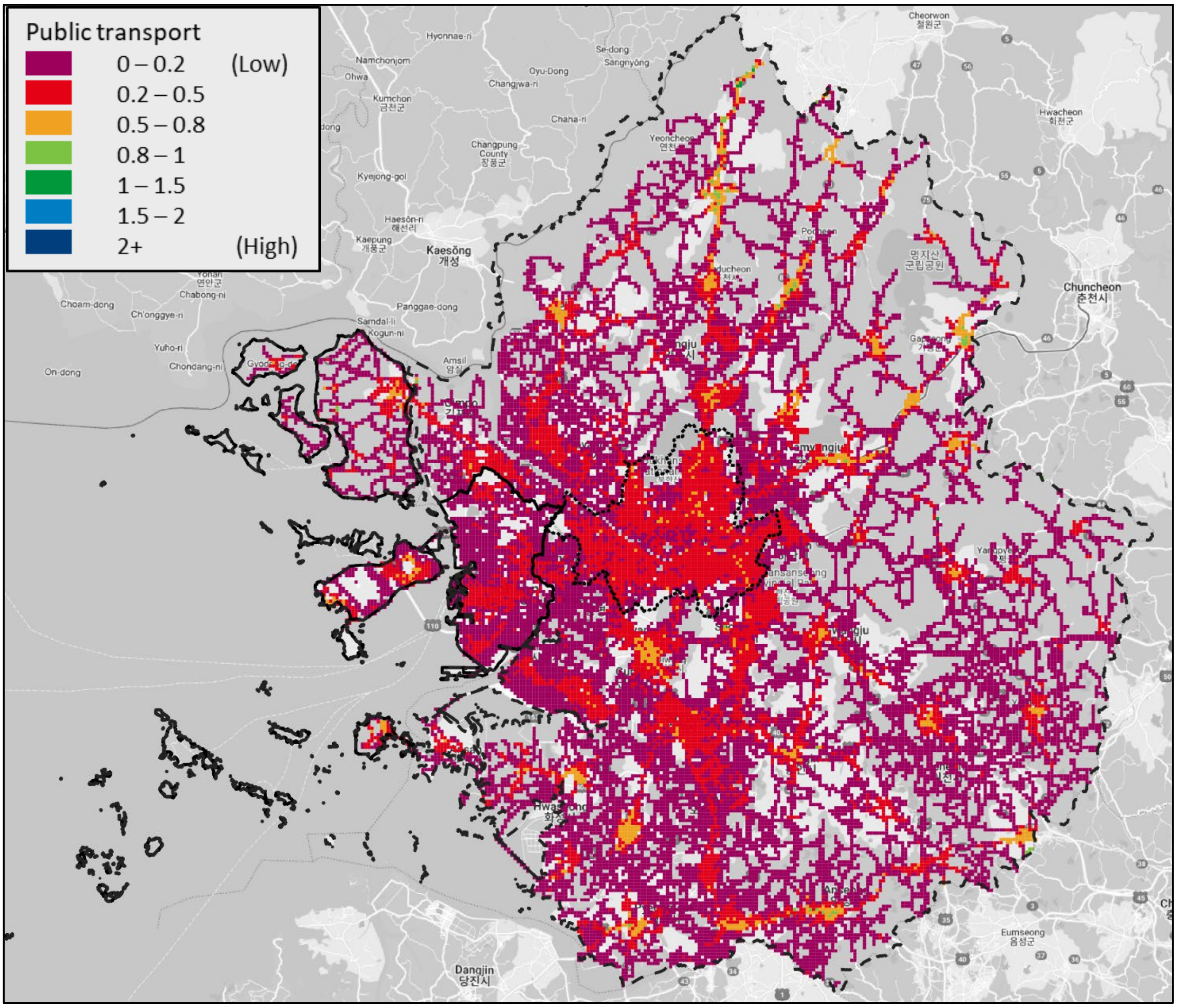
Public transport performance also takes into consideration access, egress, wait, and transfer times. As a result, although the mode may have better performance along some corridors, by nature of its more limited coverage throughout the region, and the access and egress times, it has lower average performance.

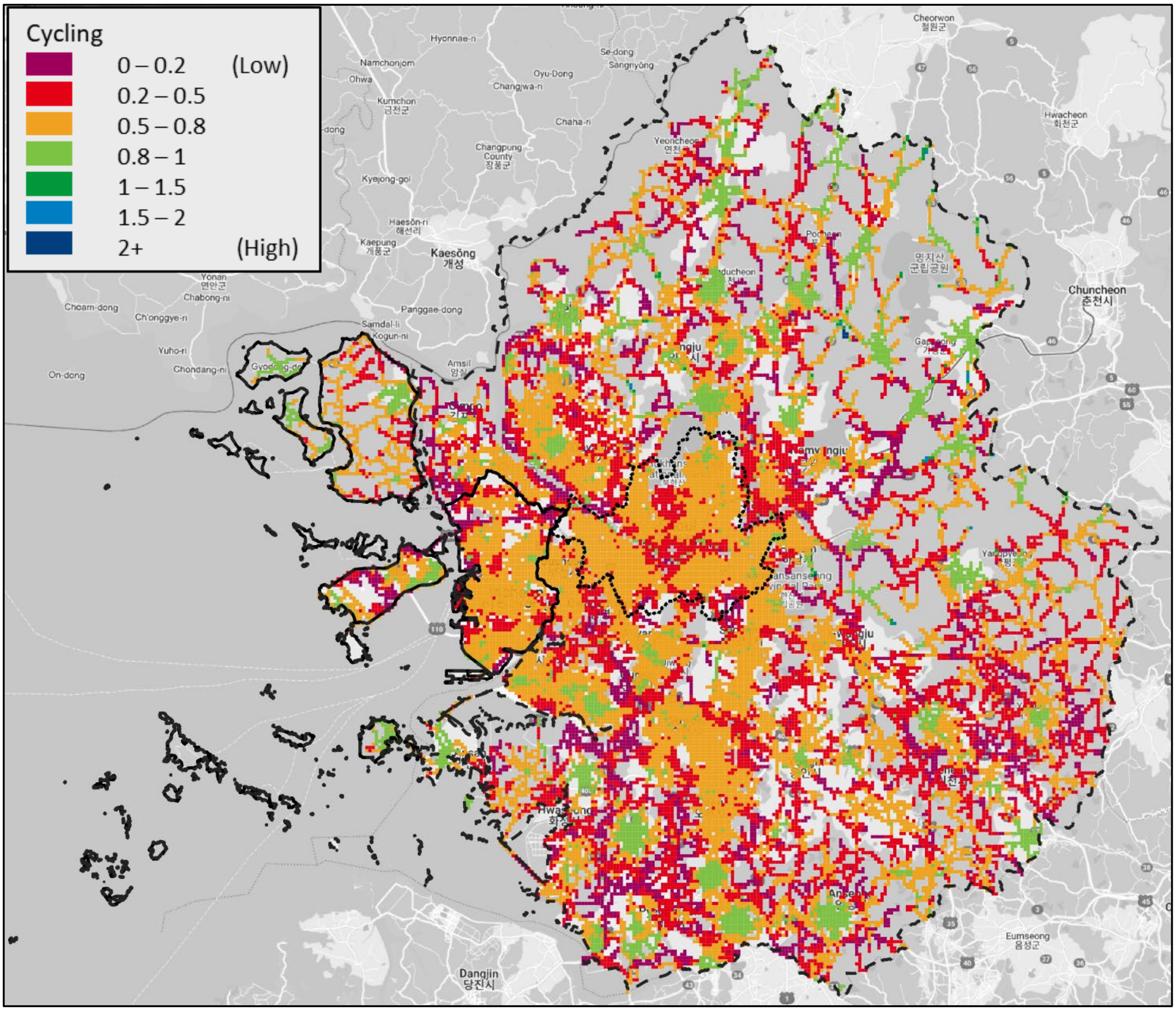
The performance of active modes is better than public transport throughout the study area. These modes experience less variability in travel time compared to buses and cars but are generally slower. Therefore, the quality and availability of infrastructure have a stronger influence on their performance.

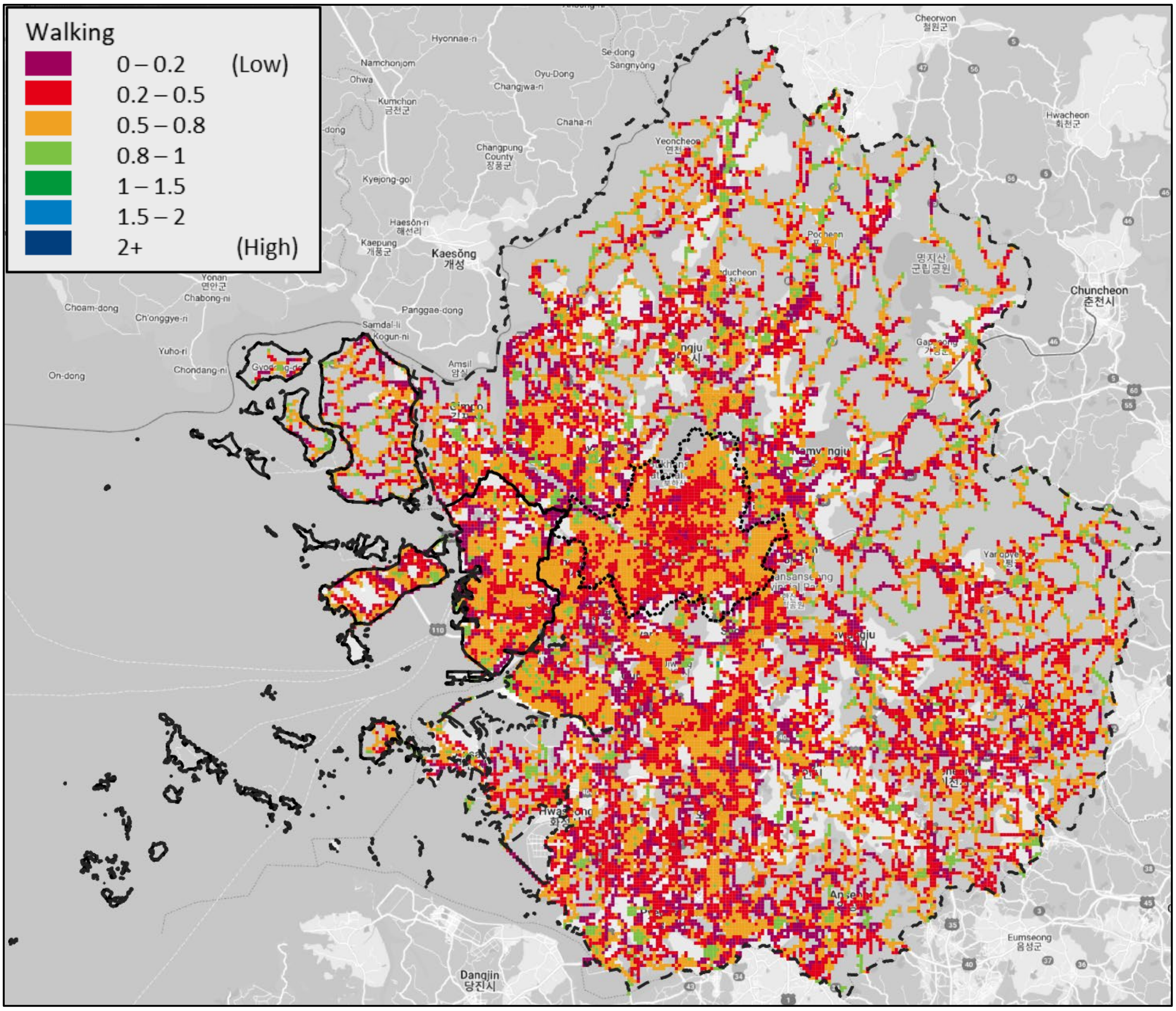
For this analysis, the speed used for the active modes was a uniform average speed, accounting for acceleration, deceleration, and stops at intersections for bikes. The only variation from the average speed was due to elevation, with lower speed for areas with higher grades.

Figure 5. Transport performance by mode within the Seoul Metropolitan Area (30-minute travel time) (scores greater than one illustrate above-average mode performance across the study area)




Public transport
0 – 0.2 (Low)
0.2 – 0.5
0.5 – 0.8
0.8 – 1
1 – 1.5
1.5 – 2
2+ (High)
Kaesŏng
Chuncheon
Dangjin


Cycling
0 – 0.2 (Low)
0.2 – 0.5
0.5 – 0.8
0.8 – 1
1 – 1.5
1.5 – 2
2+ (High)
Chuncheon
Kaesŏng
Dangjin



All roads and modes lead to Seoul

In most areas of the SMA, it takes less time to reach more opportunities by car compared to other modes, partly due to the extensive road network (Annex A). Outside of Seoul, the mode performs consistently, meaning car users' access does not vary significantly based on their geographic location. Public transport, cycling and walking are only comparable to car use where destinations are more concentrated (the urban centre and some sub-centres).

Where land use and transport network design combine to promote car use, opportunities are limited for those who do not have access to a car. Without land-use and transport policy interventions to improve other modes, access by car will continue to dominate, reinforcing inequality of access for users of other modes.

New Towns develop in parallel with road connections, making driving the norm – particularly when local access to opportunities and social infrastructure take longer to establish. However, access by car comes at a high societal cost, and its benefits are limited to car owners. The negative externalities associated with increasing single-occupant vehicle (SOV) use are well documented and include more congestion, pollution and traffic fatalities (Santos et al., 2010).

While higher car ownership rates may mean more and higher quality trips for some, it does not equate to more access for everyone. Additional limitations of car ownership are discussed in Box 4. As individuals and households are priced out of the urban centre, they are forced to become car-dependent or to spend more time, itself a cost, travelling to access opportunities.

For orbital connections outside Seoul, or connections between New Towns and sub-centres, cars have better access as the provision of public transport tends to lag behind demand. The low performance of the public transport network (particularly outside of Seoul and some sub-centres in the SMA) can be partly attributed to its orientation to prioritise commute travel to the City of Seoul (see Annex B). As a result, its coverage is focused along corridors that connect to Seoul. Although the public transport network in the SMA is extensive, the intercity public transport services are radially oriented towards Seoul, while service within Seoul allows for more orbital connections (Annex B).

Frequent and late-night services are also more concentrated in the urban centre, while local routes tend to have more limited service spans. As a result, access, egress, wait and transfer times for public transport increase overall travel time for users of the mode, particularly those looking to make orbital connections and local trips outside the urban centre. The higher travel time associated with public transport is more punitive for persons that are more reliant on public transport, specifically women and older adults (Korea Transport Institute, 2018). The spatial and temporal coverage of the public transport network disproportionately limits access for users that rely on it, despite its lower costs and wider societal benefits (e.g., decarbonisation, less congestion).

Seoul and the sub-centres of the SMA are suitable for active travel due to the density and variety of land uses, as well as the network of low-speed roads with traffic-calming features (e.g., narrow lanes, shared uses). However, geographic constraints such as elevation and other natural barriers can make active travel less accessible, especially for people with limited mobility. In addition, more recently built-up areas have developed to be more car-centric, with a high prevalence of hierarchical grid networks that can limit the connectivity of active modes. This is particularly notable in the Gangnam area, where the multi-lane arterial roads can become obstacles for users of active modes.

The excessive crossing distance on these major arterial roads can be particularly challenging for children and persons over 65, who have the highest walking mode share of all age groups and rely on active modes for the freedom to pursue activities independently (Korea Transport Institute, 2018). In addition to the existing and planned cycling network within Seoul (e.g., along the Han River and major motorways), a network of dedicated infrastructure could improve the perception of safety for active modes and make them more attractive to users.

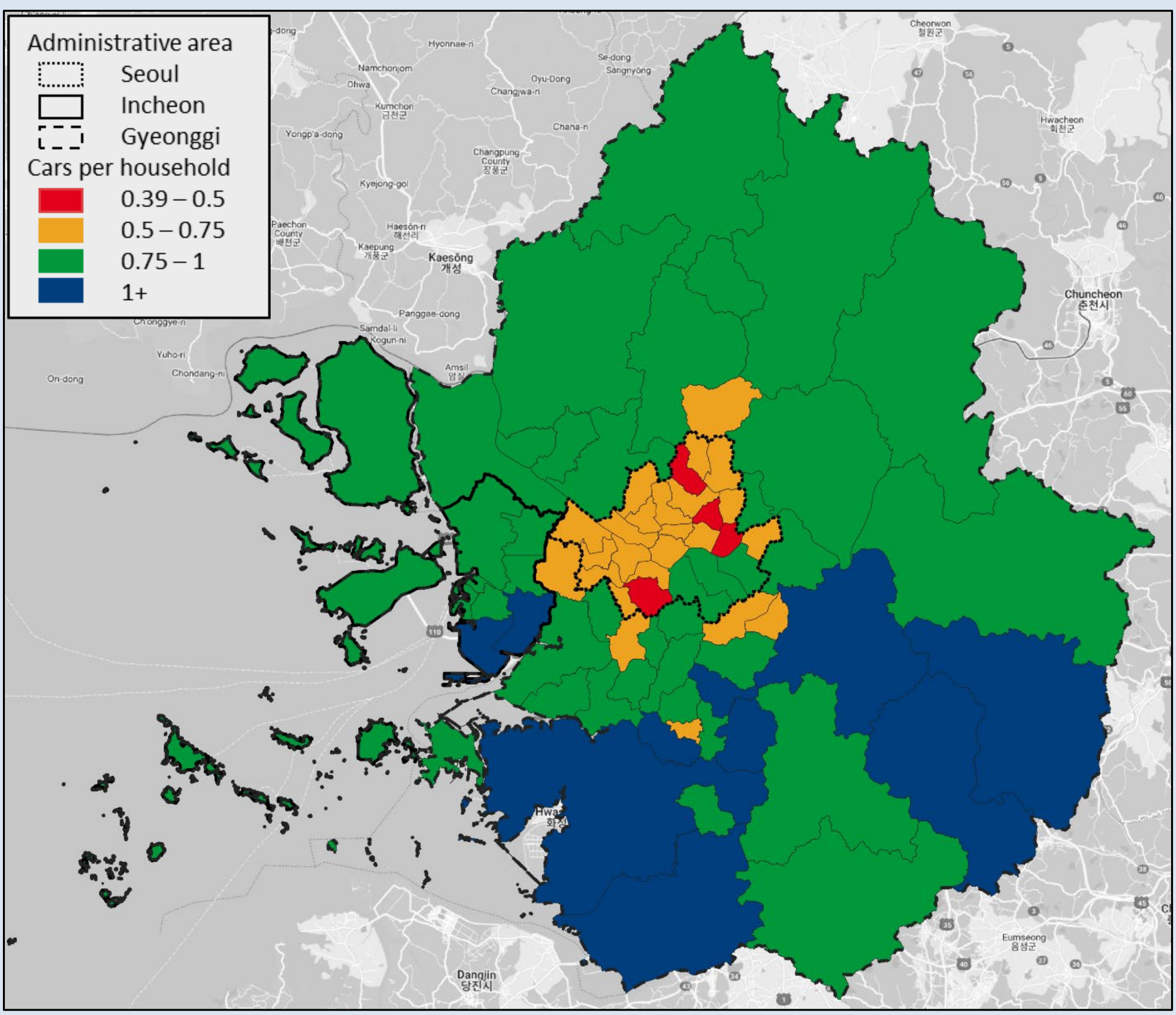
Box 4. Limitations of access by car and its impact on other modes

As the car continues to outperform public transport in terms of access to jobs, car mode share for commutes will continue to increase. This outcome is problematic due to personal and contextual factors that limit car ownership and the negative externalities associated with increased car use. Car ownership is highest in areas with low public transport performance, meaning that residents of these areas are increasingly dependent on cars for access.

However, an increase in car ownership, especially in households with more than one person, does not necessarily improve accessibility for all members of the household. A car in use for commute trips is unavailable for other uses during the workday, although the increasing acceptability of teleworking may reduce the effects of this limitation. Additionally, there is a gender gap in driving-licence holders in Korea, with 1.3 times more male holders of a driving licence than female (Statista, 2022). Although this gap is decreasing for younger generations, it is still evident in car commute mode shares, which are 1.5 times higher for men than for women (Korea Transport Institute, 2018).

As car use increases, the average commute in the SMA is increased due to congestion. Notably, average commute times for trips starting and ending in Seoul are higher than the regional average (46 minutes versus 42 minutes), despite Seoul having the lowest car ownership rates within the region (Figure 6). Within the SMA, however, car ownership is increasing, and average car occupancy per commute is decreasing (1.09 occupants per trip) (Korea Transport Institute, 2018). The increasing single-occupant vehicles for commutes results in decreasing overall access for cars and buses due to increasing congestion.

Figure 6. Car ownership rates in the Seoul Metropolitan Area



Equity considerations enhance access analyses

Land use and transport performance are not the only determinants of access. Personal and contextual factors that influence transport choices also affect the level of access. Analysing them adds an equity lens to accessibility. Equity refers to the fairness and appropriateness of the allocation of resources, along with their benefits and impacts. In transport, equity can be classified into horizontal and vertical equity.

Horizontal equity refers to the distribution of costs and benefits between equal units (individuals and groups). Absolute accessibility illustrates horizontal equity by demonstrating the spatial distribution of opportunities. It does not differentiate between individuals' needs and preferences, instead it only takes into consideration their trip origins, destinations and the transport mode used.

In the Seoul Metropolitan Area (SMA), residents of Seoul and some sub-centres have better access than residents of peri-urban areas, particularly those in Gyeonggi. Additionally, car users have better access than users of other modes. The availability and quality of modes, particularly public transport, varies within the region. Consequently, horizontal equity in the region is influenced by residential location and transport mode.

Vertical equity refers to the distribution of costs and benefits between unequal units based on one or several attributes, such as income, ability or demographic characteristics. It takes into consideration the differences between individuals, even with the same trip origin, destination and mode of transport used.

Since personal and contextual factors influence residential location and mode choice, horizontal and vertical equity are linked. The unequal spatial distribution of access is a challenge that is compounded for some specific groups. Incorporating these considerations into accessibility analysis (or adding an equity lens) can provide a better contextual understanding to develop more equitable policy measures.

Access to jobs is more dependent on cars outside Seoul

The SMA has evolved with Seoul at its core, and as a result, the city has a significant share of large firms, primarily in the tertiary sector, in the historic Central Business District, the Gangnam Business District, and the Yeouido Business District. Major manufacturing and industrial activities are concentrated in Incheon and sub-centres in Gyeonggi, such as Suwon, Siheung and Ansan.

Currently, Seoul and Gyeonggi each account for 45% of commute destinations, and Incheon for the remainder (almost 10%). Nearly half of the SMA population is of working age with commuting to work accounting for over 20% of the region's traffic volume. Given the share of commute trips in the region's travel activity, it is necessary to understand how the transport network serves them to evaluate access in the region.

Due to the region's evolution over time, demand for and costs of housing in Seoul are high. House prices in Seoul, on average, are double those in Gyeonggi and more than double those in Incheon (Jung, 2022). In 2021, over 400 000 people left Seoul: nearly 90% moved to Gyeonggi, and the remainder to Incheon. This trend has caused a spillover effect in housing costs: as more people are unable to afford the Seoul housing market, housing prices increase in the communities they move to, as do rental costs and rent deposit rates (the "jeonse" system) (Kim and Seo, 2021).

As persons with lower incomes, along with renters, are priced out of the urban centre, they are often forced to trade off high housing costs for high transport costs. Jeonse prices have been found to be considerably influenced by the housing market in core areas, even in communities on the outskirts (Kim and Seo, 2021). This results in high jeonse rental costs in some peripheral areas, creating a double burden of housing and transport costs for some renters (Park M., 2019).

Connections between New Towns and employment areas tend to be direct by car, compared to public transport, which often requires transfers and longer trips. Given the limited transport options, residents that live outside of core areas must travel by car to access work opportunities. Additionally, as new employment sub-centres develop, they attract workers from different areas in the region, which do not always have public transport connections.

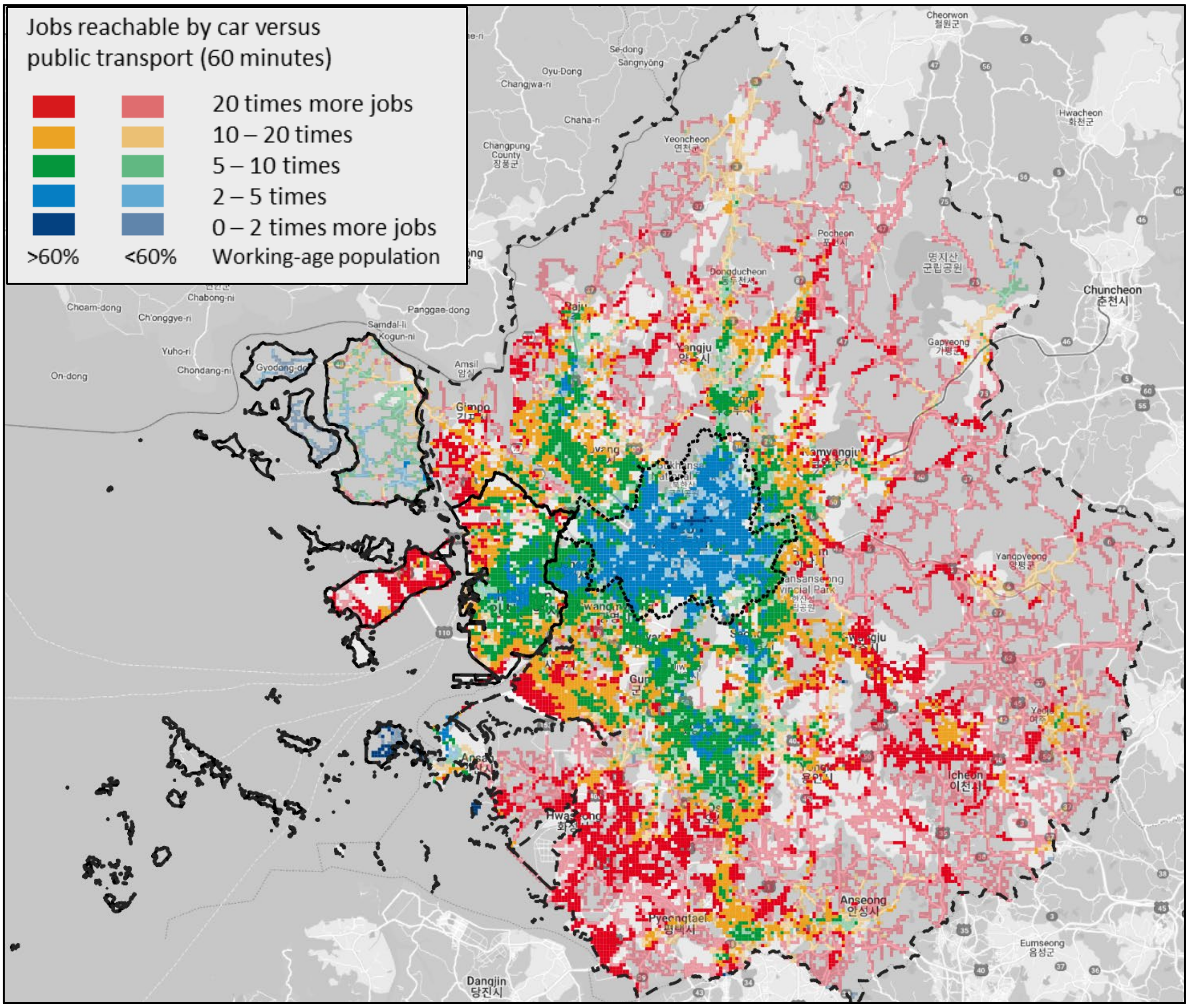
Without local access to work opportunities, commute distances increase, making active modes less viable. This is the case in the SMA, where the average commute distance is shortest in Seoul (8 km), followed by Gyeonggi (23 km) and Incheon (31 km). It is also reflected in the regional commute mode shares: in Seoul, cars account for just over 20% of commute trips, whereas in Gyeonggi and Incheon, they account for 61% and 54% of trips, respectively.

As the SMA continues to sprawl, the travel patterns become more complex and more difficult to serve, given the orientation of the public transport network. This further entrenches car dependence outside the core areas of the SMA, particularly Seoul, as is evidenced by the car mode share for commutes between Incheon and Gyeonggi (63%). To reduce car dependence for these trips, land-use measures supporting a better job-worker balance in sub-centres, as well as better regional public transport connections between New Towns and emerging employment sub-centres, will be needed.

These land-use and transport factors influence access to work in the SMA, where absolute accessibility by car significantly outperforms all other modes. For example, during the morning peak (8 AM), the average driver in the SMA can reach at least twice as many jobs using a car as can the average user of public transport (Figure 7).

In areas of the region where there is more of a balance between workers and jobs, public transport has better access but still lags behind car use. The difference in access to jobs between modes is most significant outside of Seoul, where car users can reach between ten and twenty times more jobs than public transport users. It is also noticeable that the areas outside Seoul that have better public transport access are typically around railway stations.

Figure 7. Difference in access to jobs by car versus public transport (morning peak)



Note: Cells with a share of the working-age population (25-64) lower than 60% of the total cell population are shown in lighter shading

Although the overall difference in access is significant in Gyeonggi, a larger share of the population in the areas with low access by car are not of working age. For policy makers, areas with a high share of working-age residents, low access to jobs using public transport, and high population may warrant further investigation.

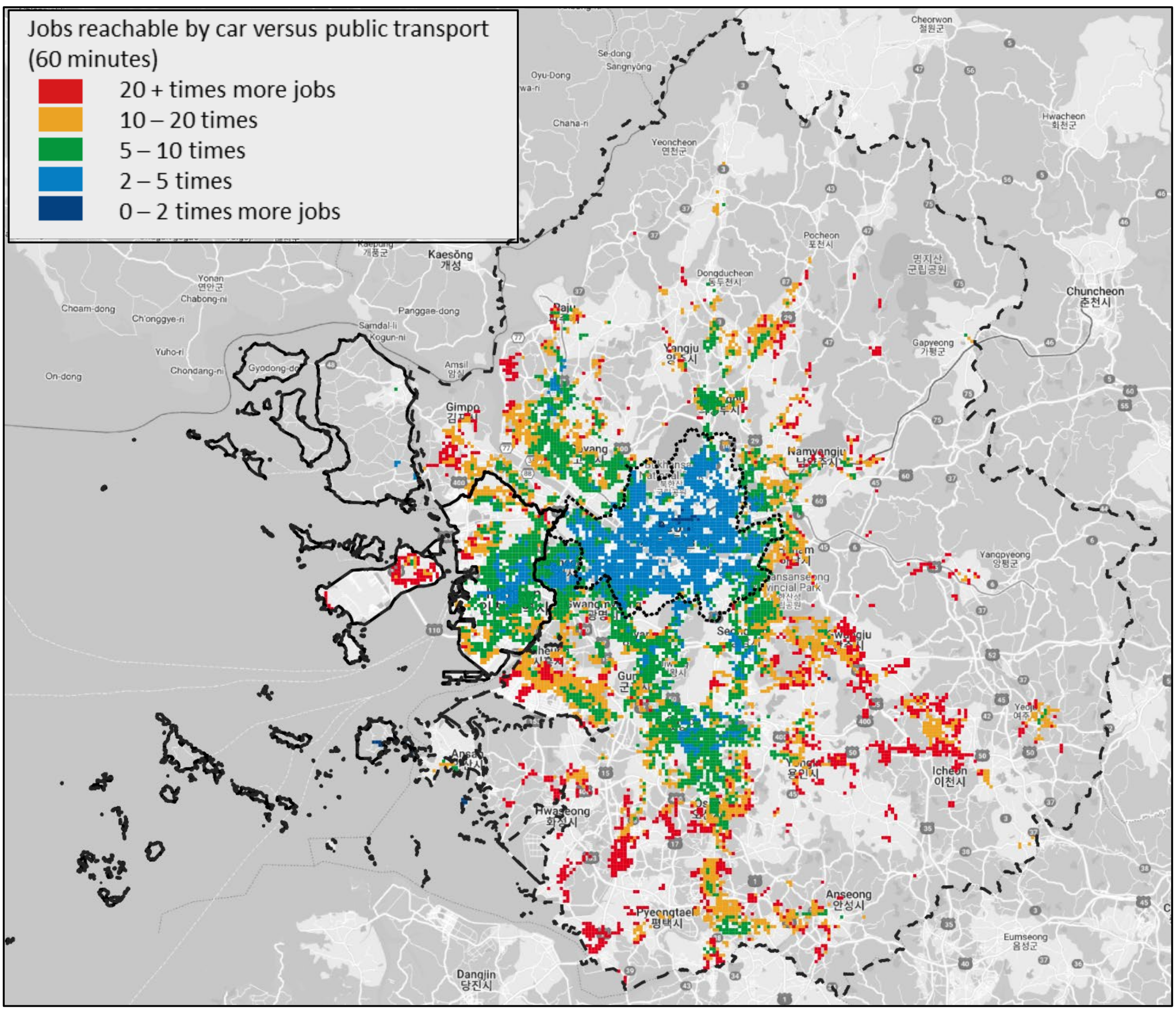
Figure 8 highlights these areas, showing only cells where the working age population is greater than 60% of the total population, and there is a minimum of 30 people of working age. Some areas south of Seoul (in the cities of Hwaseong, Yongin and Gwangju) stand out as having high working-age populations and significantly better access to jobs by car than by public transport.

Hwaseong, for example, is of interest given the city's size and commute patterns: 45% of its commutes are internal and 42% are destined for other areas in Gyeonggi. For all trips within the city, 44% are by car, and nearly 37% are on foot, while public transport only makes up about 13%. The share of internal commute trips indicates some balance between jobs and workers within the city, but the low public transport mode share is worth exploring.

The commute trips to Gyeonggi also stand out because trips to other parts of the province from Hwaseong have a 70% car mode share. The mode shares may be influenced by the large geographic size of the city, which can make the provision of direct and high-frequency public transport service costly.

Figure 8. Difference in access to jobs by car versus public transport,(morning peak)

filtered for target population



Note: Map displays only cells with a share of the working-age population (25-64) greater than 60% of the total cell population and a minimum of 30 working-age persons

Land-use policies that allow for mixed land uses can be explored to improve access to jobs within the city. Such policies would allow for shorter commuting distances and can make investment in public transport more cost-effective.

Policy makers can use accessibility analyses to identify priority areas for public transport improvement that can have the most impact, on both reducing car dependence and improving access to work for people without cars.

A notable additional consideration for policy makers is a more detailed matching of the different kinds of jobs available with the workers they may attract. This analysis groups all jobs together and only shows a snapshot of access during the morning peak. However, shift workers and part-time workers have different start and end times and can have significantly different levels of access as a result.

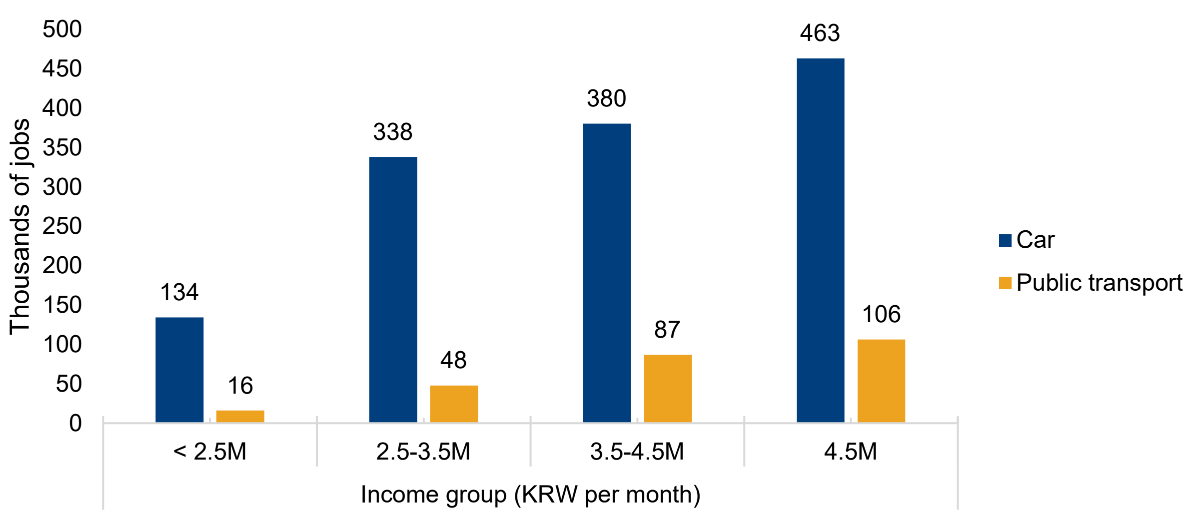
An assessment of the access for different times of day, focusing on job locations that are more likely to have shift workers (e.g., healthcare workers, manufacturing workers), may yield different insights for policy makers in the SMA. Job attractiveness can also vary based on workers' education, which is not accounted for in this study. Including this additional attribute, which is also correlated with income, can yield insight into who benefits from policies to improve public transport, and whether the distribution of benefits and costs is equitable.

Higher income, higher access

Many areas where public transport performance is more comparable to that of cars have several factors in common: numerous large employers, availability of higher-order public transport services (e.g., rail, subway, BRT) and higher median incomes at the "gu" level. The dominance of the urban centre in terms of opportunities in the SMA results in higher congestion and, as a result, investment in public transport priority measures.

Despite high congestion and public transport priority measures, on average, car users can reach six times more jobs than public transport users (Figure 9). This difference is more significant for lower-income earners, who can reach over eight times more jobs if they drive, than for higher-income earners (four times more jobs).

Figure 9. Average number of jobs accessible to working population within 60 minutes



Infrastructure that prioritises public transport, which then increases the travel speed, can help reduce this gap. This is particularly beneficial for bus routes, which are less costly to expand than subways and can have higher coverage. Seoul has a network of bus priority lanes intended to improve the operation of buses in highly congested areas, but their initial orientation focused primarily on connections to the Central Business District (Lee, 2017). As the network is expanded to better connect other major destinations within the city, public transport access can improve within Seoul.

However, given the high housing costs in the urban centre of the SMA, the improvements to public transport in this area further reinforce inequality of access by mode and income level. In fact, the highest-income earners can reach over six times more jobs using public transport than the lowest-income earners.

This is even higher than the number of jobs highest-income earners can reach by car compared to the lowest-income earners (over three times more).

This difference is due, in part, to the concentration of jobs in the urban centre where persons with a higher income are more likely to live. Higher-income earners in the SMA have more choices in terms of residential location and can typically afford a car. However, development patterns and transport policies in the region have also resulted in better public transport access for higher-income earners.

This places lower-income earners at a disadvantage as they are faced with higher transport costs and increased car dependency. This is exacerbated for workers of small and medium enterprises that may not be located in the core areas but rather dispersed throughout the region. It is also challenging for non-regular workers, who may commute during off-peak hours or late at night when public transport services are limited.

To address these gaps more equitably, improvements for public transport cannot focus only on areas of high congestion. Rather, improvements should take an integrated approach to address deficiencies outside of core areas that may disproportionately affect lower-income groups. These may include priority measures and higher frequencies for feeder routes, which can decrease access time for the mode and improve transfers to higher-order services.

Mixed land-use policies can improve access to care activities

As noted, residential location choice in the SMA is influenced by the cost of housing. However, other factors, such as commute time and household characteristics, also play a role. Household characteristics include the age of the head of household, and number and age of children. While accessibility is also a factor in residential location choice, caregiving duties create complex travel patterns and additional accessibility challenges, especially for residents with cost constraints. These combined factors can limit accessibility by necessitating longer trips or creating complex travel patterns, in particular for non-work trips.

Home-based non-work trips account for over a quarter of travel within the SMA (Korea Transport Institute, 2018). Non-work trips typically involve care activities, such as shopping for household necessities and accompanying family members to schools, healthcare facilities and social services. In most countries, women disproportionately carry out care activities, and Korea is not an exception. A higher burden of care work influences gender gaps in labour participation, increasing the likelihood of being engaged in part-time or insecure employment, and thereby affecting income. In Korea, women make up a higher and rising share of temporary workers, which is associated with lower employment security and wages (Jones and Beom, 2022).

It is worth noting that the imbalances resulting from a gendered division of care activities do not have the same effects on all women and are, in fact, applicable to everyone undertaking caregiving duties. Expectations to carry out care activities also vary by age, with the sandwich generation (those simultaneously caring for their children and their ageing parents) typically tasked with more caregiving duties. People with caregiving duties tend to be women, and in Korea women spend four times as much time on care activities as men (OECD, 2009).

Ultimately, the gendered division of caregiving duties reflects a wider societal inequality that cannot be addressed solely through transport interventions. Nonetheless, catering to the travel needs of people with caregiving duties is relevant to transport authorities who are interested in equitable outcomes.

Travel related to care work is typically more complex, often requiring trip-chaining and involving several modes (see Box 5). The combined factors of a higher burden of care work and more complex travel patterns can result in time-poverty (less available time for discretionary activities) for people with caregiving duties. Women in Korea report a higher share of non-work trips than men, the highest share being shopping trips (Korea Transport Institute, 2018). Women also have a higher public transport mode share than men, which is potentially linked to access to cars in single-vehicle households (Korea Transport Institute, 2018).

Box 5. Trip-based versus activity-based accessibility measures

The ITF model does not currently account for trip chains, which is a limitation for measuring accessibility related to care activities. It uses trip-based measures, which are limited to a single trip (or origin, or destination), typically for a single purpose. Activity-based accessibility measures can be used to measure trip chains because they examine all trips and activities, and take into consideration constraints related to the scheduling of activities (such as dropping off children at school before going to work). One challenge with applying activity-based accessibility measures is that comparison across individuals is more complex, due to the various factors that can influence scheduling of activities, including available modes, income, and other individual constraints.

However, given their possibility to better capture individual needs and preferences, activity-based measures may be beneficial for policy makers. For example, a better understanding trip-chain behaviour can help decision makers evaluate how equitable concession fare policies are for public transport. Smart-card data, which provides information on origins, destinations, and travel duration can be particularly useful in this regard.

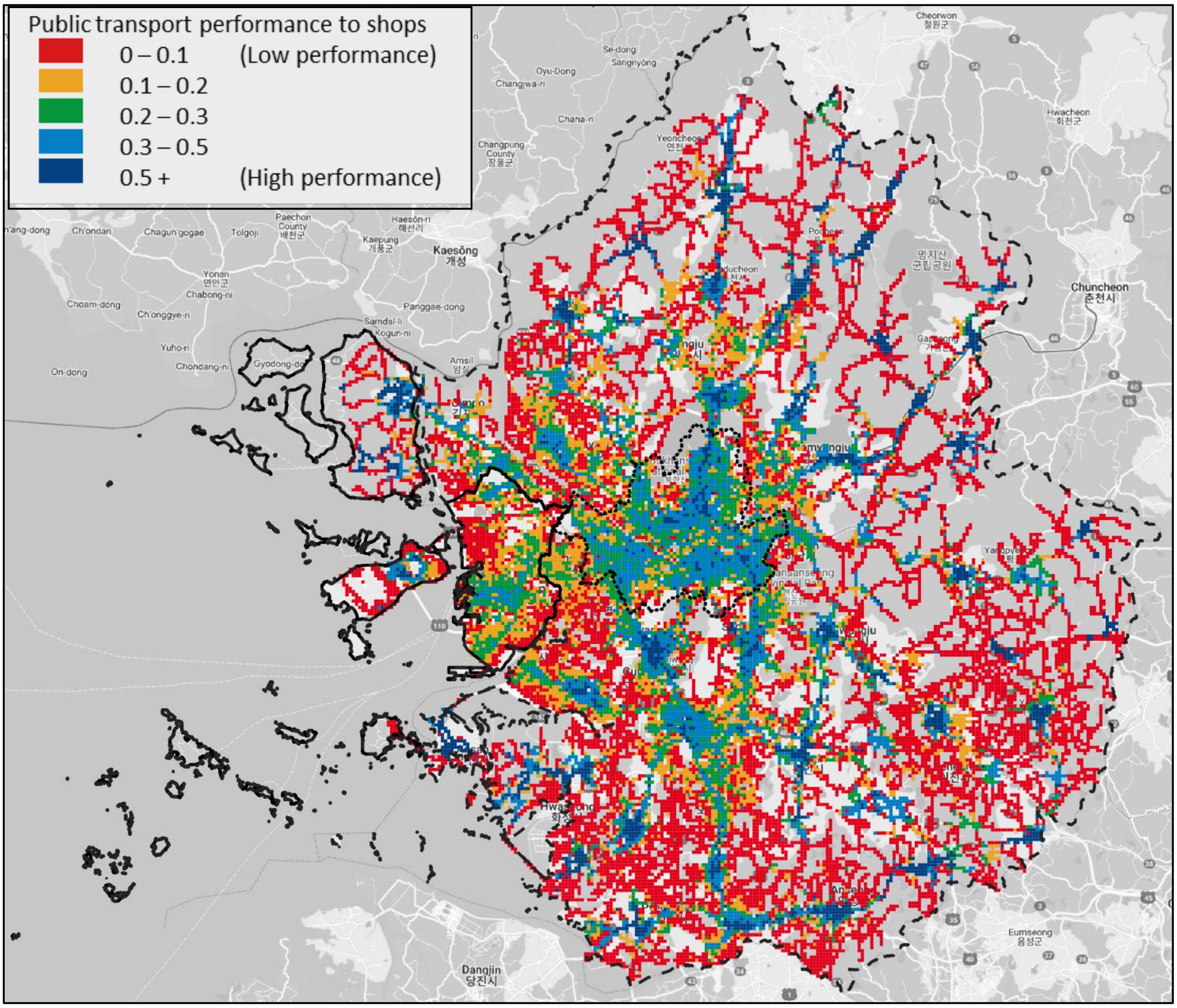
Source: Dong et al. (Moving from trip-based to activity-based measures of accessibility, 2006), "Moving from trip-based to activity-based measures of accessibility", https://doi.org/10.1016/j.tra.2005.05.002.

The public transport performance for trips to shops can provide a starting point for understanding access related to care activities. In comparing peak versus off-peak access to shops using public transport, there is no significant difference between the two time periods, especially in Seoul. This is partly due to the headway-based scheduling of services used in the SMA, which maintains frequency in off-peak hours and extensive bus priority infrastructure, ensuring service reliability during the more congested periods. However, some peripheral areas experience lower service levels in off-peak times due to the design of the public transport network to prioritise commute travel to Seoul.

Assessing public transport has two dimensions: access to the network and access using the network. Door-to-door travel time for the mode includes access, egress, wait, transfer (i.e., out-of-vehicle travel time), as well as in-vehicle travel time. When compared to private cars and bikes, the out-of-vehicle travel time for public transport tends to take up a higher share of overall travel time.

On average, public transport performs better within Seoul and in specific nodes with rail or intercity bus connections (Figure 10). This outcome is influenced by the concentration of shops in the urban centre and sub-centres, and around major station areas. More recent New Town developments have included a specific focus on self-sufficiency to reduce dependency on Seoul, which has resulted in transit-oriented development (TOD) and land-use mixes that are supportive of increasing public transport mode shares (da Silvieira-Arruda et al., 2017).

Figure 10. Public transport performance to shops, off-peak, 30-minute travel time



Note: Scores greater than one illustrate above average mode performance across the study area.

Given the short time spent travelling for shopping in the region (on average 24 minutes per trip), the out-of-vehicle component of travel using public transport can significantly affect the mode's transport performance. Increasing service coverage can reduce access and egress time but can also increase in-vehicle travel time as it necessitates more indirect routing.

However, in areas that are designed to prioritise public transport, access and egress time to public transport is usually decreased through neighbourhood design, land-use mix and density. This reduces the need for costly higher coverage services. The results of the public transport performance to shops illustrate how effective such TOD approaches can be (Figure 10).

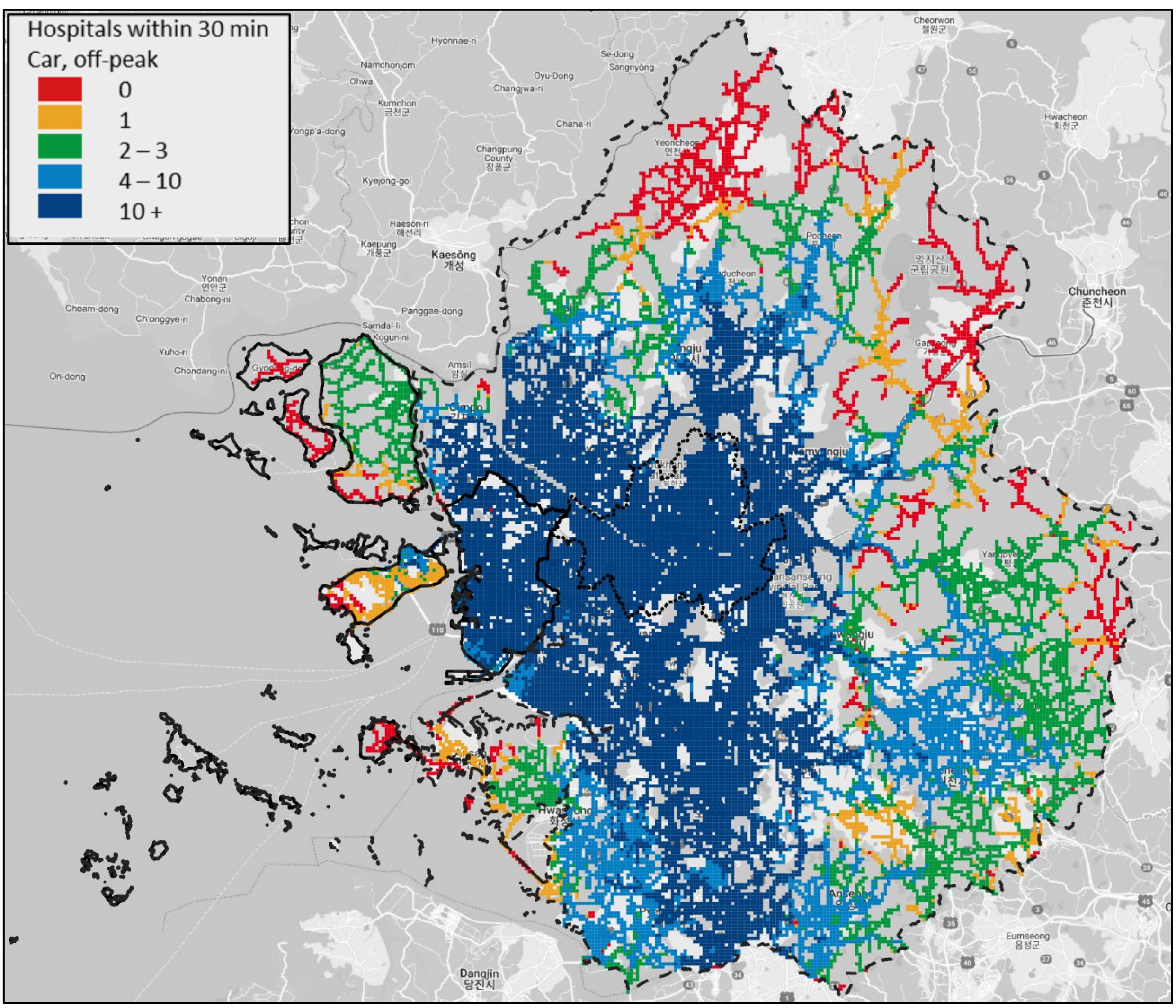
Encouraging land-use diversity within station areas reduces overall trip lengths and supports trip-chaining, which can reduce time poverty for caregivers. Additionally, shorter trips have more options in terms of modes, including active modes, which also improves access.

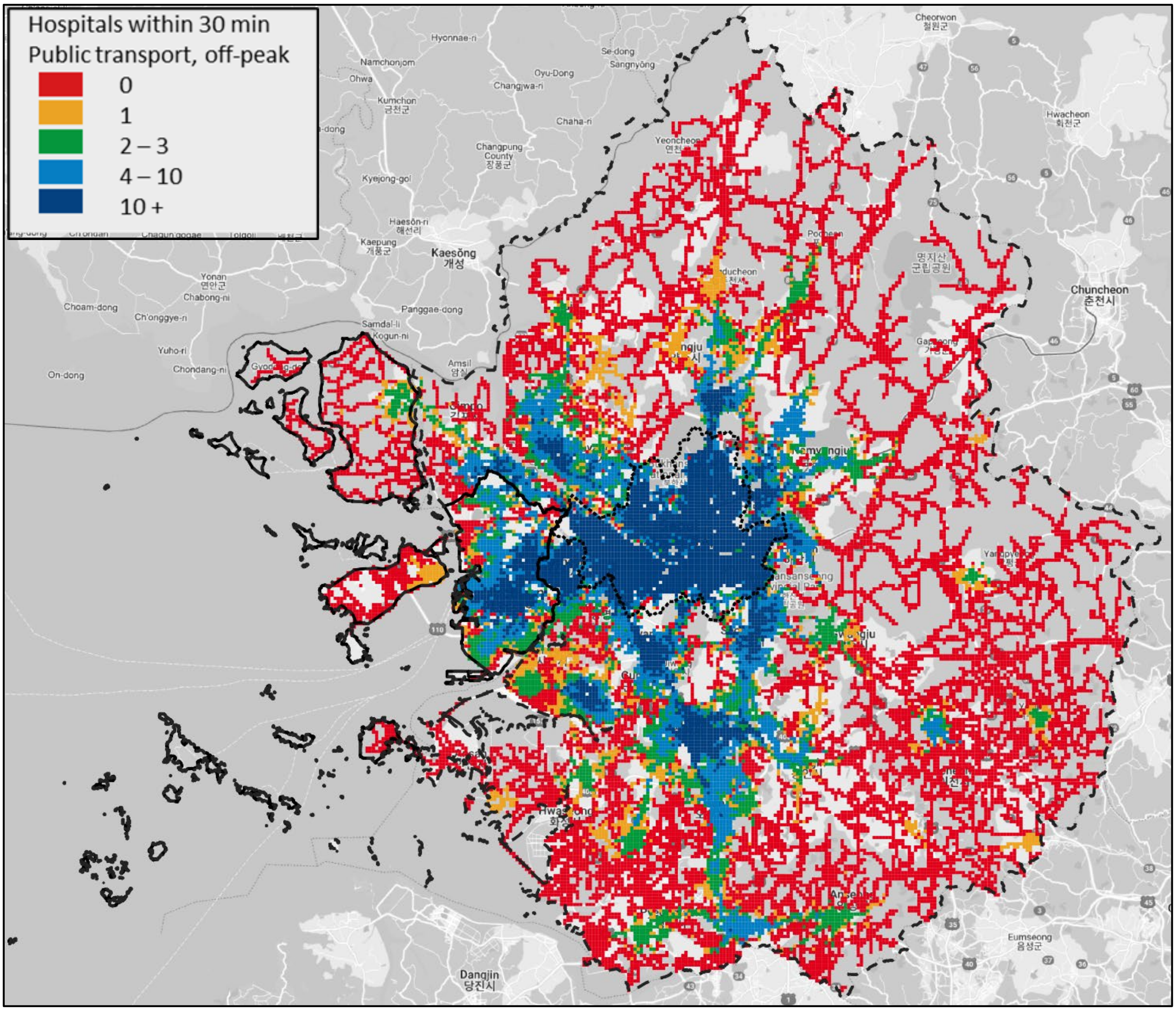
Shorter distances encourage sustainable modes

Trips related to care activity tend to be shorter and closer to home and are often included within trip chains. Accompanying children to school, for example, is typically part of a trip to work for parents. Walking is commonly used for short accompanying trips. However, in various contexts, more complex trip chains are likely to be made by car where one is available in the household (Islam and Nurul Habib, 2012). This is in part due to the spatial and temporal flexibility of the car, which can facilitate trip chains that are more complex within short travel times. Care trips are also often encumbered, which can constrain mode choice.

Where land-use policies do not facilitate access to various activities within close proximity of one another, cars become more attractive, particularly for caregivers experiencing time poverty. Examining access to healthcare facilities – another typical accompanying trip – illustrates how attractive car ownership can be in the SMA context (Figure 11).

Figure 11. Access to general hospitals by car and public transport





Except for a few peripheral areas on the northeast and eastern edges of Gyeonggi, most residents can reach at least one hospital within half an hour by car. By comparison, residents using public transport are much more limited, particularly in the southeastern areas of the SMA. This analysis only includes general hospitals, which are accessible by any patient, and tend to be larger facilities. The region also has numerous clinics and public health centres that can provide primary care functions and outpatient visits. Even areas with low access to general hospitals within the region can be within a reasonable distance to hospitals in communities outside the SMA administrative boundaries that are not captured in this model.

Access is even better in areas closer to the region's urban centre for both modes, with most residents within 30 minutes of more than ten general hospitals. This is due to a combination of the performance of the car within the region, but it also reflects the land-use planning policies supporting density in the region.

Various studies have examined access to healthcare facilities in Korea, and the indicator is included in the nationwide accessibility indicators published by the Korea Transport Institute (KOTI). These studies also find that access to healthcare facilities is worse for public transport users compared to drivers (Lee S., 2022). Access by car is further limited by the rates of car ownership in the region, and the demographic differences in driving licence holders (e.g. older women are less likely to hold a driving licence).

Additionally, research has shown that household resources for mobility are more often geared toward men's mobility, which further impacts women's accessibility, since they are more likely to spend time on caregiving duties. Although narrowing the gender gap in driving licence holders could reduce this limitation for households with cars, policy makers should focus on decreasing car use generally, given the negative externalities associated with the mode. Since care activities tend to be closer to home, they are an opportunity to encourage the use of sustainable modes through land-use policy and neighbourhood design.

Better neighbourhood design can support ageing in place

The share of residents over the age of 65 in the SMA is expected to grow from its current level of 16% to 37% by 2050. This demographic change will have an impact on caregivers as well as on infrastructure needs and costs. As noted, various studies have explored access to healthcare in the Korean context, finding that persons over 65 face barriers in access to various healthcare facilities (Lee S., 2022) and that the effect is worse for low-income persons over 65 living outside of the core areas of the region (Yoon and Park, 2022).

If the transport system is not accessible for older adults to meet their basic needs or allow their independence, the lack of access also affects their caregivers. Where low-income older adults lack access to formal long-term care options, gaps in care fall to family members – typically women. In this regard, inequalities compound over time for low-income individuals and are exacerbated by gaps in access. Mobility needs and travel patterns in the SMA will change as the region ages, and the current orientation of the transportation network may not adequately serve the travel patterns of older adults.

For example, the study on access to primary care in Seoul for persons over 65 noted that local circulation routes (called "village" buses) are more critical than the high-frequency trunk routes and subways in providing access to primary care for this demographic (Yoon and Park, 2022). However, as previously noted, the public transport network performs well where frequent and higher-order services operate, meaning that its current design does not address inequalities in access to healthcare for persons over 65, given its focus on commute trips.

In Korea, the share of persons over 65 has been growing faster in rural areas compared to urban areas (OECD, 2017). Given the role of housing costs in residential location choice, it is unsurprising that a high share of older adults live in the peripheral areas of the SMA. In the region, it has also been found that the likelihood of relocating residences decreases with the age of the head-of-household (Park and Kim, 2016). These factors, when combined, suggest that residents of the region are likely to age in place. Ageing in place has many benefits, including the ability to maintain community connections, thus reducing the risk of social isolation and its associated negative health outcomes.

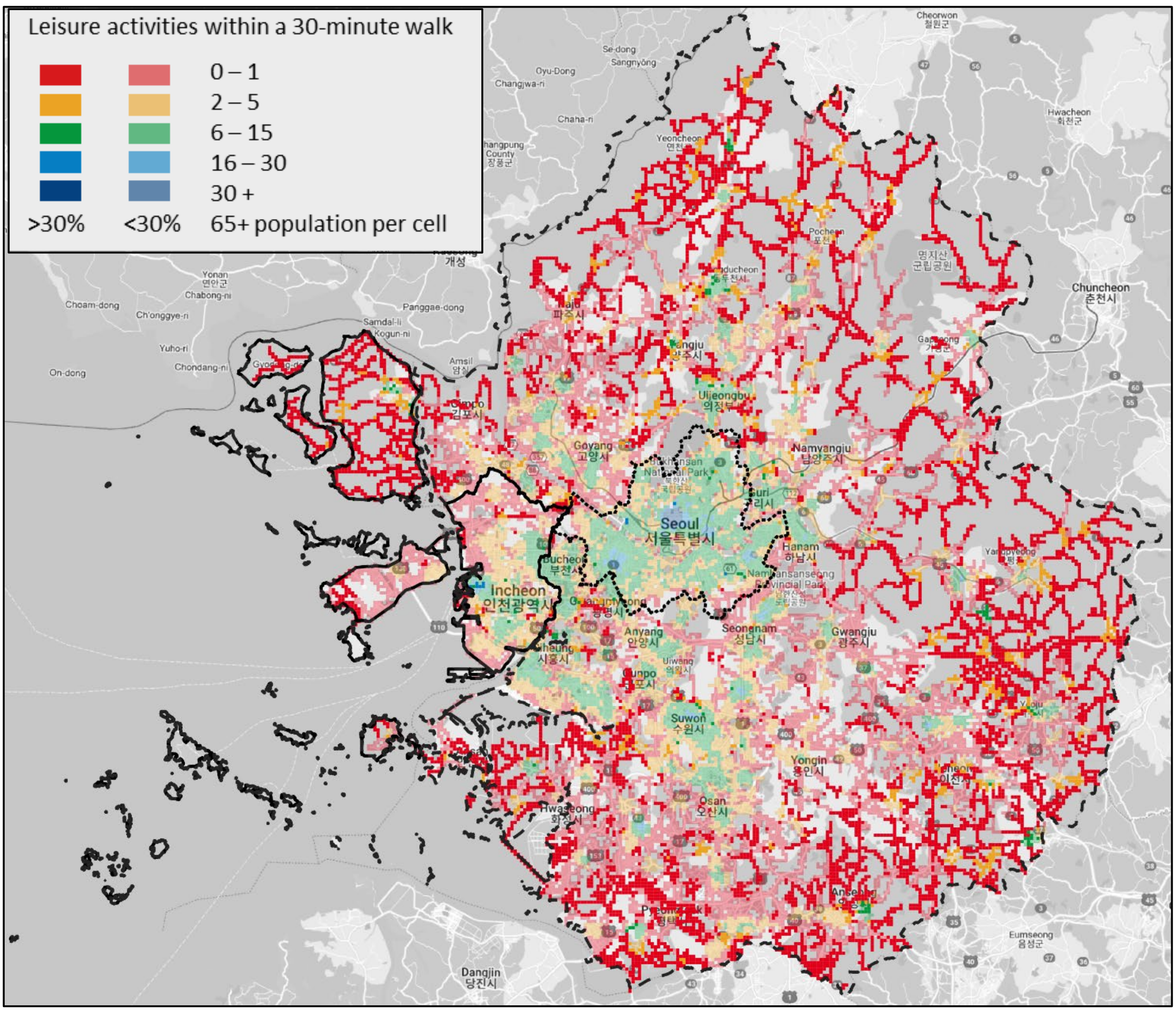
One way that older adults maintain community connections is through access to leisure activities. In fact, in the SMA, the main trip purpose for persons over 65 is leisure, and their main mode of travel is walking (Korea Transport Institute, 2018). An added benefit of their high walking mode share is that active travel is good for health. However, as mobility needs change with age, what was once an accessible form of preventative healthcare may be limited based on the suitability of the pedestrian network, and in some cases, the availability of dedicated pedestrian infrastructure. Therefore, neighbourhood design plays an important role in maintaining accessibility, especially as the population ages (Cao, Mokhtarian and Handy, 2010).

Exploring the absolute access to leisure by walking illustrates the significant gaps in access for older adults outside Seoul and some sub-centres (Figure 12). Even with a 30-minute threshold, access is limited outside

Seoul. The walking speed is affected by the road's grade, as the SMA is a hilly region. For persons over 65, the access speed would be further reduced as the average pace used in the model is higher (4 km/h) than the walking speed in Korea for older adults (approx. 2.4 km/h) (Yoon and Park, 2022).

This is particularly challenging because the share of the population over the age of 65 is higher in the peripheral areas of Gyeonggi, which have the lowest levels of access. By 2050, when the share of people over the age of 65 in the region increases, similar challenges may be found in other areas.

Figure 12. Access to leisure activities on foot for persons over 65



Note: Cells with a share of the population over the age of 65 lower than 30% of the total cell population are shown in lighter shading.

Neighbourhoods that can provide a range of affordable housing options and are close to essential services and amenities can support different generations and allow people to age in place comfortably. Policy makers will need to implement land-use planning policies that encourage leisure opportunities within communities, and they will need to ensure the suitability of the pedestrian network in maintaining access for a growing older adult population.

Suitable land-use policies adapted to an ageing population could be achieved through a participatory process that involves residents in defining what kind of amenities and facilities would allow them to age in place. For example, although the peripheral areas of the SMA have fewer leisure amenities, they are surrounded by green spaces. These natural amenities may be attractive, but if infrastructure and other amenities in those areas are limited, then people may opt to move to areas with better access (Park and Kim, 2016). However, land-use policies typically require longer timescales to implement, which highlights the importance of coherence between land-use and transport policies.

Driving cessation requires alternative options

A key consideration influencing the transport choices of older adults is safety and the perception of safety. In Korea, nearly half of the traffic fatalities are pedestrians, and pedestrians over the age of 65 are at a higher risk. Additionally, increasing car ownership and use have been associated with increasing pedestrian injuries (Adler and Ahrend, 2017).

The safety of the older adult drivers is a significant concern for policy makers. Some proposed measures in Korea to address this challenge include conditional licences, and shortened licence renewal periods. There is also the option for voluntary surrender of licences for drivers over the age of 65. In the SMA, as an incentive to encourage persons over 65 to surrender their licences, some programmes provide a monthly transport allowance for those who give up their licences (Kim D., 2022). However, programmes to encourage driving cessation can significantly reduce mobility for the high (and growing) concentration of older adults living in the car-dependent peripheral areas of the SMA.

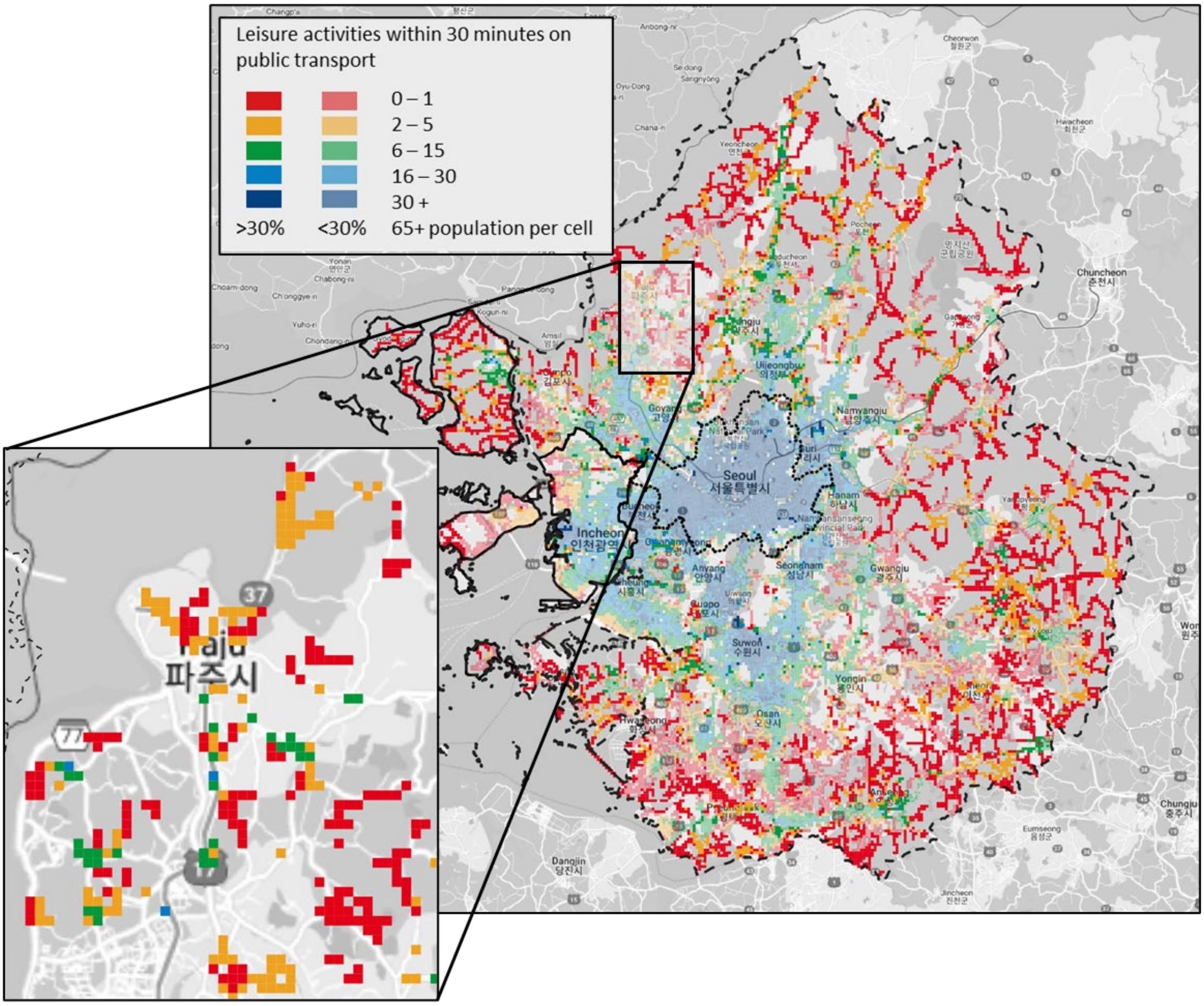
Various factors affect the likelihood of older adult drivers giving up their licences, including income, gender, and cognitive ability. However, the available alternatives to driving that would allow older adults to maintain their mobility and independence also play a significant role in their decision making (Moon and Park, 2020). Concession fares and better local bus services or demand-responsive public transport (DRT) can decrease car dependence for persons over 65, while allowing them to maintain their independence and social inclusion. Targeting public transport improvements to better serve the mobility patterns of older adults can be effective in this regard.

Currently, access to leisure using public transport follows similar patterns as have been previously discussed for other destinations: access in the urban centre and sub-centres, which have a higher concentration of destinations is higher (Figure 13). However, it is notable that a higher share of persons over 65 live in the peripheral areas with limited access due to fewer leisure amenities.

Many of these areas are also more sparsely populated, which can make the provision of public transport options more costly. Where leisure amenities are limited, providing higher coverage public transport options or demand-responsive services can help maintain basic mobility for older adults, as well as independence.

For policy makers, areas with a high share of residents over 65, low access by public transport and sparsely distributed populations can be an opportunity for exploring alternative service delivery methods. The inset map in Figure 13 shows an area highlighting only cells that contain a greater than 30% share of people over the age of 65, and a minimum of five persons that are older than 65.

Figure 13. Access to leisure activities by public transport for persons over 65, off peak



Note: Cells with a share of the population over the age of 65 lower than 30% of the total cell population are shown in lighter shading.
Inset map displays only cells with a share of population over the age of 65 greater than 30% of the total cell population, and a minimum of five persons over 65.

In contexts such as these, semi-flexible (stop-to-stop) and fully flexible (virtual stops) DRT services have been successful in improving access at lower costs and mileage than fixed route services and are an attractive option for persons over 65. The introduction of public transport services that provide basic mobility can have an impact on economic and social activities of older adults, particularly in areas where the provision of fixed-route services can be cost-prohibitive.

A survey by the Ministry of Land, Infrastructure and Transport (MOLIT) of eight DRT pilot projects in rural areas found that outings increased from 7.4 times per month to 8.5 times in the areas where the projects were implemented (Kim, Lim and Hong, 2022). Similar services have improved basic mobility for older adults in Portugal. In Medio Tejo which has DRT services using taxis integrated with the fixed-route services, 91% of the users of the service are older than 51, with half of the trips destined for healthcare facilities. The Coimbra region’s DRT, which was launched during the Covid-19 pandemic, has an average users’ age of 69.6, and a majority of trips for healthcare purposes (EIT Urban Mobility, 2022).

School districts have potential latent demand for active modes

Korea's extraordinarily low fertility rates have long been a concern for policy makers. In most countries, a negative relationship exists between women's participation in the labour force, earnings and fertility choice. Among OECD countries, Korea stands out as having the highest gender employment gap due to childbirth, which impacts fertility rates (Pareliussen, 2022). The high social status associated with educational attainment, and in turn, the high direct costs of education also contribute to the low fertility rates (Kim, Tertilt and Yum, 2023).

Consequently, economic security is a determinant of parenthood, and parents are typically more likely to have fewer children and more intense parenting cultures due to the stakes associated with social status (Pareliussen, 2022; Kim, Tertilt and Yum, 2023). These combined factors suggest that households with children in Korea are more likely to have higher incomes, especially in the costly urban areas.

A study of residential location choice in Suwon (the largest city in Gyeonggi) found that for parents of children under the age of 20, the quality of school districts plays a role in their residential location choice (Jin and Lee, 2018). In addition to the quality of the schools, parents also seem to prefer areas with higher shares of residential land use as opposed to areas with mixed land uses. The preference to live in predominantly residential areas contributes to car dependence and can increase trip lengths.

Higher-income households are also generally more likely to drive. In fact, in Seoul, residents of predominantly residential neighbourhoods (even with high densities) have been found to be more likely to drive than walk (Seong, Lee and Choi, 2021). This is despite the likelihood they can opt to live within their preferred school districts.

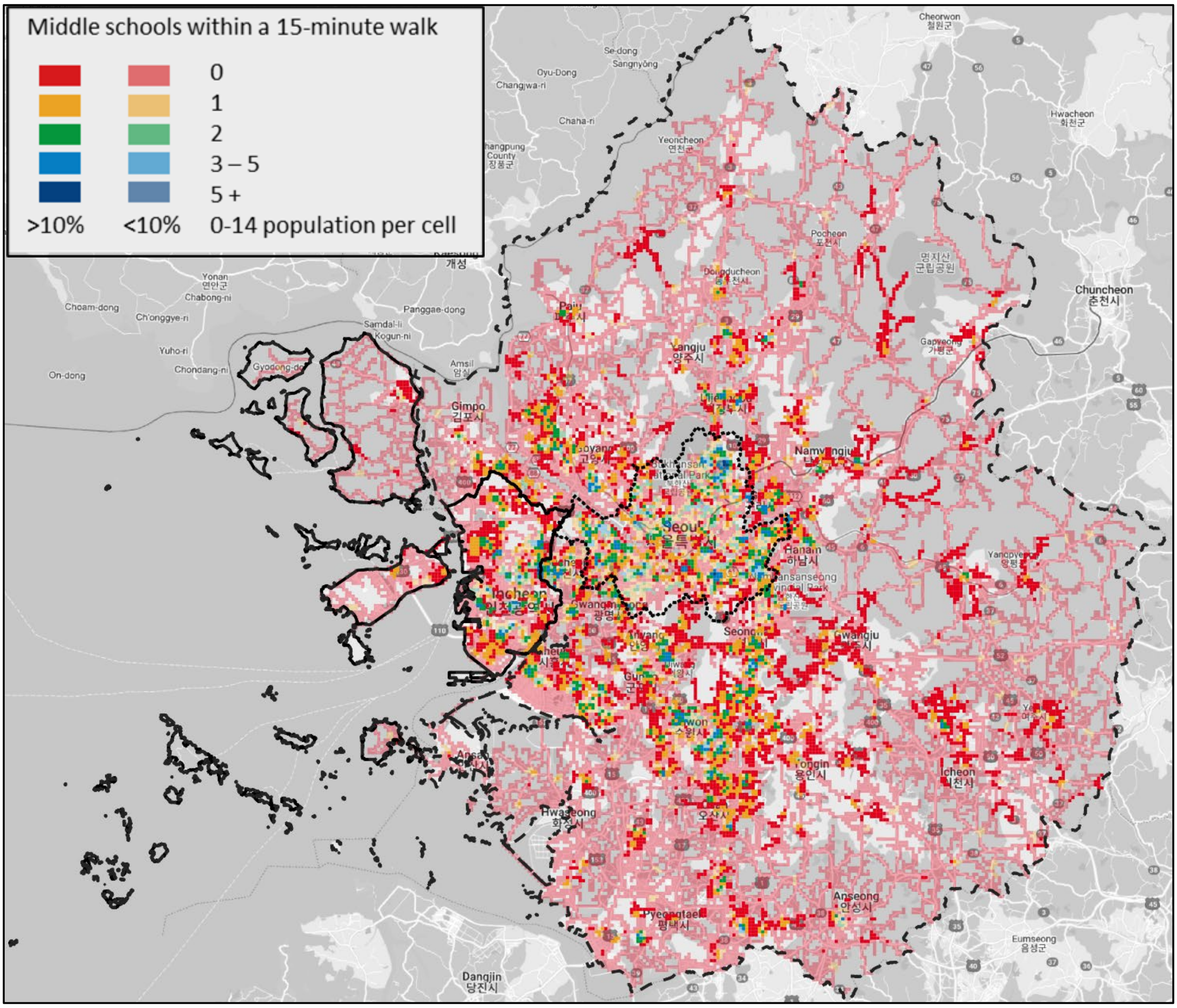
Due to the large number of kindergarten and elementary schools, most young children are within walking distance of their schools. However, there are almost half as many middle schools as elementary schools, meaning each middle school has a larger catchment area. Given the costs of housing and demand within popular school districts, it is unlikely that walking access to schools can be maintained as children grow older. An analysis of walking access to middle schools illustrates that few children currently under the age of 14 will be within a 15-minute walk of middle schools when they're older (Figure 14). This increases the likelihood of children not using active modes to get to school, which will limit their independence and impact their caregivers.

The gap in access is particularly noticeable in some areas in southeast Gyeonggi (e.g., Gwangju, Icheon), which have a higher share of children under 14, and notably also have lower public transport performance (Figure 10). However, these cities are smaller and more sparsely populated than other parts of the region, resulting in lower overall travel activity. In Gwangju, for example, all school trips (including post-secondary school trips) only account for almost 6% of travel, and walking makes up 20% of the city's overall mode share. Similarly, in Icheon, school trips account for just over 6% of trips, and walking accounts for approximately a quarter of the city's overall mode share.

Given that parents tend to select residential locations to access better education options for their children, encouraging mixed land uses in these areas can help reduce trip lengths for other purposes and achieve the additional benefits of reducing the environmental, access and health impacts of car dependence.

Transport interventions will also be necessary, although making a case for investing in active transport infrastructure might be challenging in the context of declining populations. Nonetheless, these areas represent latent demand for better access using active modes, which can allow children to pursue activities independently.

Figure 14. Walking access to middle schools



Note: Cells with a share of the children population (0-14) lower than 10% of the total cell population are shown in lighter shading

With such a low share of travel activity, interventions to increase active travel will need to be targeted to areas where they can be most effective. Policy makers can use accessibility analyses to identify areas that can be prioritised to improve pedestrian connections. These will also help identify which interventions would be suitable based on the travel needs of residents in those areas and on the opportunity to achieve multiple policy objectives at once. School street closure schemes in the United Kingdom have been successful in promoting independent mobility for children, as well as in reducing congestion as a result of drop-offs (Living Streets, 2018).

Policy makers can also focus on low-cost interventions, which have been successfully demonstrated following the Covid-19 pandemic. Cities such as Montreal, New York and Paris have capitalised on pop-up infrastructure implemented during the peak of the pandemic to reallocate urban space to people. Such interventions increased active mode share and, when made permanent, made roads safer and cities more liveable (ITF, 2023).

Safer streets improve access and independence

As noted, a high concentration of children in a neighbourhood can represent a latent demand for more walkable communities and better public transport service. As they grow older, walkable communities can facilitate children's independence. However, expecting children to walk to all their activities, particularly in less dense areas, may not be feasible.

Many children in Korea spend time in private academies for supplemental educational activities. The average travel time to academies in the region is 22 minutes. Students attending both school and academies can spend a significant amount of time travelling for school-related activities. In addition to land-use policies to promote mixed land uses, encouraging cycling can be a way to decrease overall travel time for school-related activities.

For example, with the exception of some peripheral areas in Gyeonggi, increasing the walking travel time to middle schools to 30 minutes puts most children within walking access of middle schools (Figure 15). Alternatively, considering access by bike to middle schools for the same cohort, given the existing cycling network (which includes low-speed shared roads) yields nearly identical access results, but within 15 minutes.

However, cycling is uncommon in the SMA, accounting for only 1.6% of trips. In countries with a limited share of utilitarian cycling, fatalities tend to occur outside of urban areas and typically involve recreational cyclists. The bike mode share is very low even in urban areas where the density and land-use mix are conducive to cycling.

The low share of cycling as a mode is partly related to perceptions of safety, despite a steady decrease in pedestrian and cyclist fatalities in the country due to efforts by policy makers to reduce traffic fatalities. Between 2010 and 2019, pedestrian and cyclist fatalities decreased by nearly 40% and 30%, respectively (ITF, 2022a).

Going forward, the National Transport Safety Plan (2022-2026) has explicit targets to reduce fatalities among vulnerable groups by nearly 40% in 2026 compared to 2021. The National Transport Safety Plan also includes policy guidance for increasing dedicated space for cycling and walking, and municipalities are eligible for funding to implement such facilities. (MOLIT, 2022c)

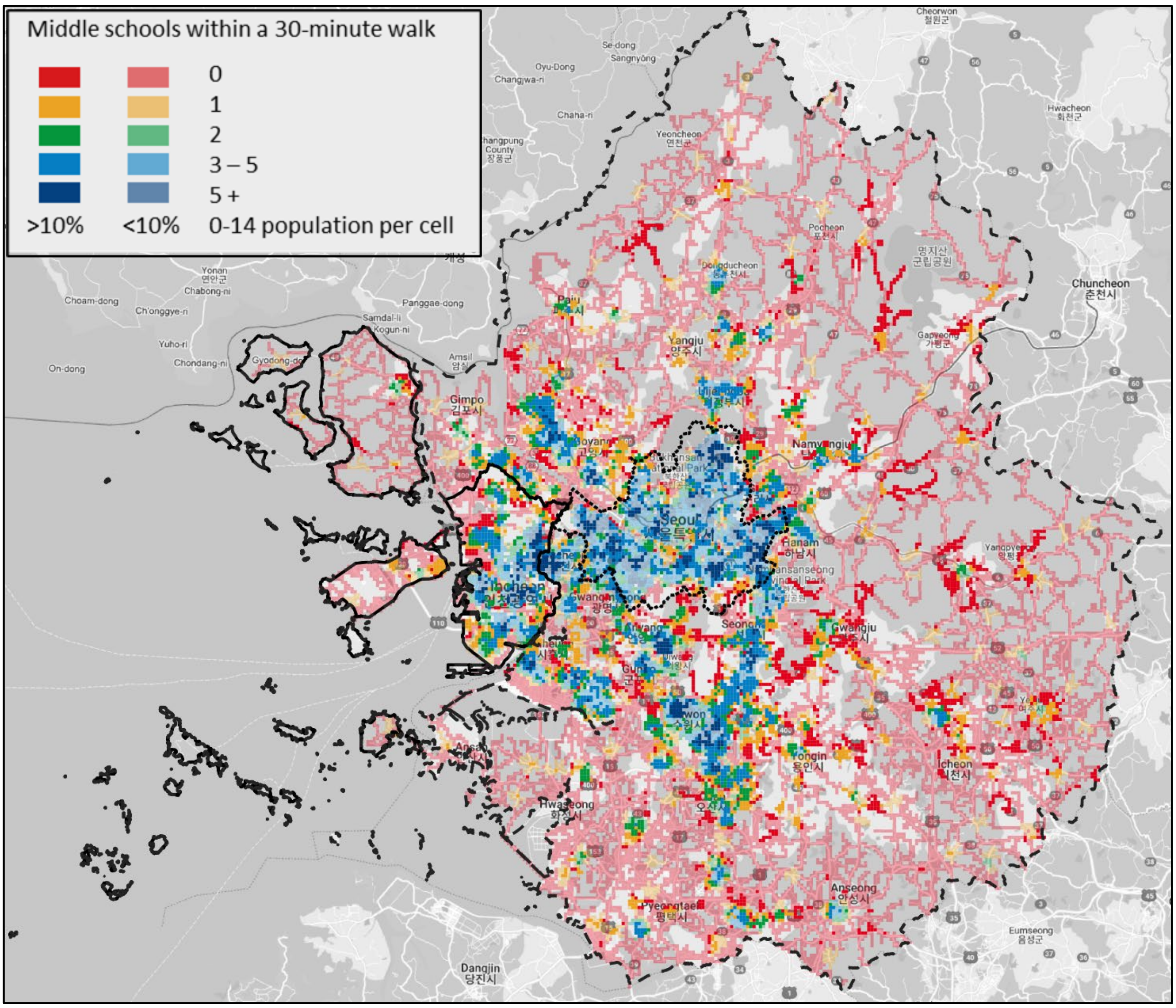
Improving the public's perception of the safety of cycling can help increase the use of the mode, which also achieves environmental and health co-benefits. This will require dedicated infrastructure, context-specific strategies, and a systemic approach to safety (see Box 6).

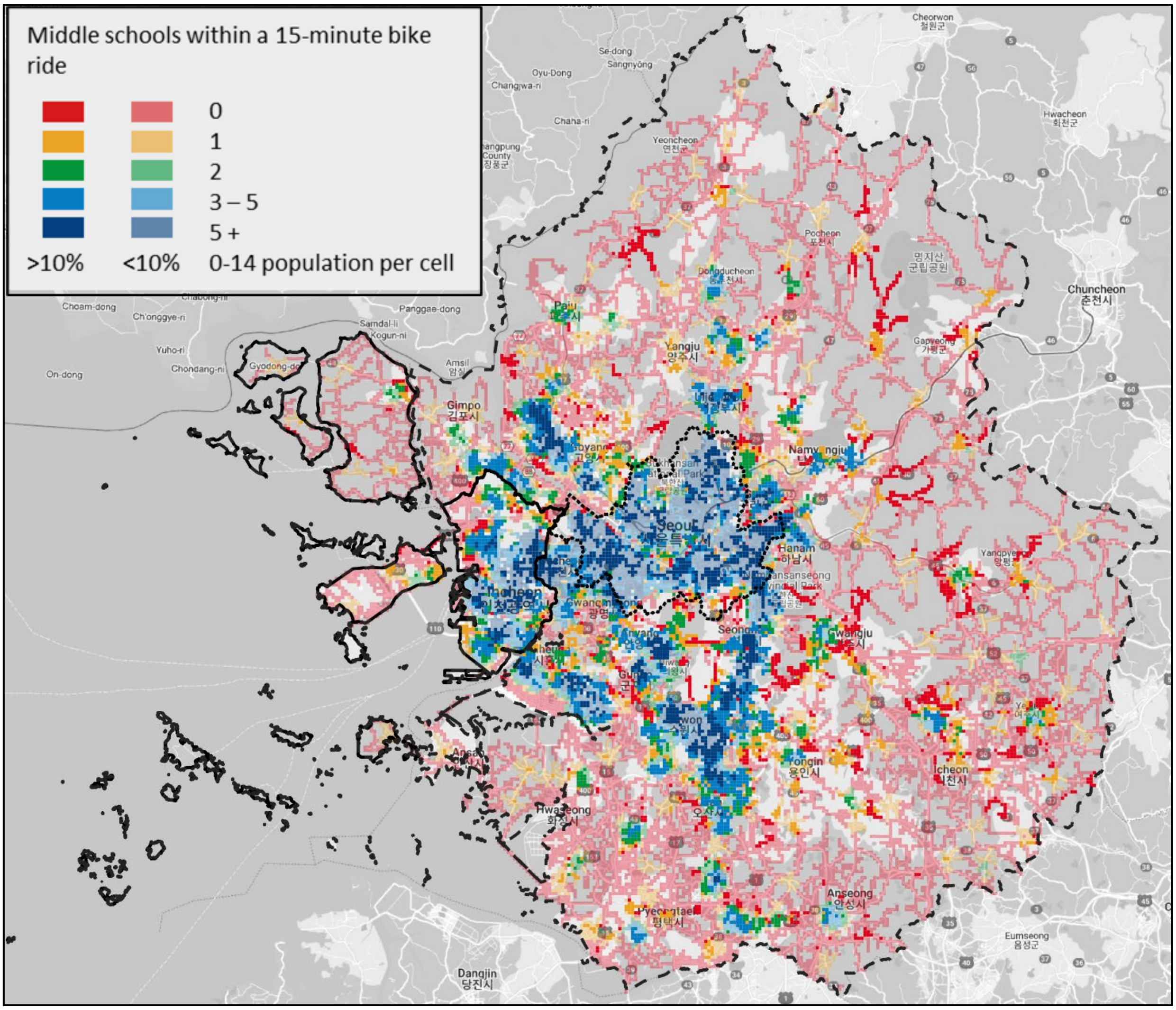
A stated preference analysis on bike users' perception of cycling safety in Korea revealed that speed reductions and dedicated cycling infrastructure could be effective in improving the perception of safety, but that narrow shared streets are perceived as less safe due to various obstacles (ITF, 2013). This perception is unique, given the association between vehicle speed and the design features of roadways: wider travel lanes and fewer access points, as found on major arterial roads, are correlated with higher travel speeds and thus greater risk of crashes (Fitzpatrick et al., 2001).

Within Seoul, various measures to make school zones safer have been implemented, including speed reductions and increasing the visibility of crosswalks (Seoul Metropolitan Government, 2017). Lower speed limits have been found to reduce traffic fatalities, and when combined with additional traffic calming measures that can reduce the design speed of roads, they can be even more effective (World Bank, 2021). These measures can also make cycling safer.

Additionally, narrow, shared streets with low speed limits provide natural traffic calming features that can provide de facto active transport connections. Given the prevalence of such streets, especially in Seoul, there is an opportunity for policy actions, such as better enforcement of parking violations on narrow streets, which can improve sightlines and make existing shared streets safer for pedestrians and cyclists.

Figure 15. Walking access to middle schools (30 minutes) compared to bike access to middle schools (15 minutes)





Note: Cells with a share of the children population (0-14) lower than 10% of the total cell population are shown in lighter shading

In addition to improving cycling safety to increase use, transport policy makers can work with public health officials to promote cycling for its health and environmental benefits. Integrating active mobility into health policies has become more commonplace since the Covid-19 pandemic.

Various cities accelerated policies to reallocate city space from cars to people, and the result has been momentum towards higher walking and cycling mode shares in many cities, including Paris, Jakarta, and Mexico City (ITF, 2023).Policies such as purchase incentives for electric bikes as offered in France (combining regional and national incentives) and the expansion of shared micromobility have increased the popularity of cycling and made the mode more accessible to more people.

Box 6. The Safe System approach

The Safe System approach to road safety, pioneered by Sweden and the Netherlands in the 1990s, takes the ethical position that no level of road deaths and serious injuries is acceptable. Road users respecting the rules of the road have the right to expect that they will be safe. It is a “forgiving” strategy for road-injury prevention that acknowledges the inevitability of human error on the road but not of death or serious injury resulting from a crash (ITF, 2016).

The Swedish Parliament adopted a Vision Zero (*Nollvision)* strategy in 1997, stating that “the transport system’s design, function and use should be aligned so that no one is killed or seriously injured” (Swedish Government, 1997). It also recognised the reciprocal rights and responsibilities of road users and managers. A similar policy, known today as Sustainable Safety, was developed in the 1990s by the Dutch Institute for Road Safety Research to promote “an inherently safe road traffic system” (SWOV, 2018).

The Safe System approach opposes the claim that driver error is the cause of 90% of road fatalities. Many crashes that involve driver error also involve other critical factors, such as design-induced weaknesses in vehicles and infrastructure, making driver error the final failure of a chain of events leading to a crash. Overstating the role of road-user error may result in a reduced focus on effective countermeasures that address systemic failures in this causal chain (ITF, 2022b).

Four guiding principles are central to a Safe System (ITF, 2016):

1. People make mistakes that can lead to crashes. The transport system needs to accommodate human error and unpredictability.
2. The human body has a known, limited physical ability to tolerate crash forces before harm occurs. The impact forces resulting from a collision must therefore be limited to prevent fatal or serious injury.
3. Individuals have a responsibility to act with care and within traffic laws. A shared responsibility exists with those who design, build, manage and use roads and vehicles to prevent crashes resulting in serious injury or death and to provide effective post-crash care.
4. All parts of the system must be strengthened in combination to multiply their effects and to ensure that road users are still protected if one part of the system fails. This includes the emergency and post-crash care services that are critical to mitigating the consequences of crashes.

The Safe System approach is based on the understanding that effective road-injury prevention is achieved through the interdependence and multiplier effects of various policy measures and a well-balanced set of effective interventions. The focus on these four principles encourages a broad range of interventions to improve road safety that emphasises the shared responsibility between road authorities and users, and applies to all parts of the road system.

Policy making informed by desired outcomes

The focus of the transport field on improving mobility and connectivity can improve accessibility. However, the traditional forecast-led approach for determining investment priorities presents practical risks due to uncertainties about future travel patterns and can replicate inequitable outcomes from past practices (ITF, 2021). It is evident that in the context of increasing uncertainty following the Covid-19 pandemic, this approach requires rethinking to better account for the distributional effects of transport policies and interventions.

Determining policy priorities based on desired outcomes (a "decide and provide" approach) would be more in line with improving social welfare and can yield more equitable outcomes. Policy priorities can be based on the common understanding that the core function of the transport system is ensuring accessibility. At a minimum, transport policies should enable a basic level of accessibility for all people in a majority of contexts (Martens, 2017). Alignment and coherence between land use and transport policy objectives at all levels of government will also play an important role in this approach.

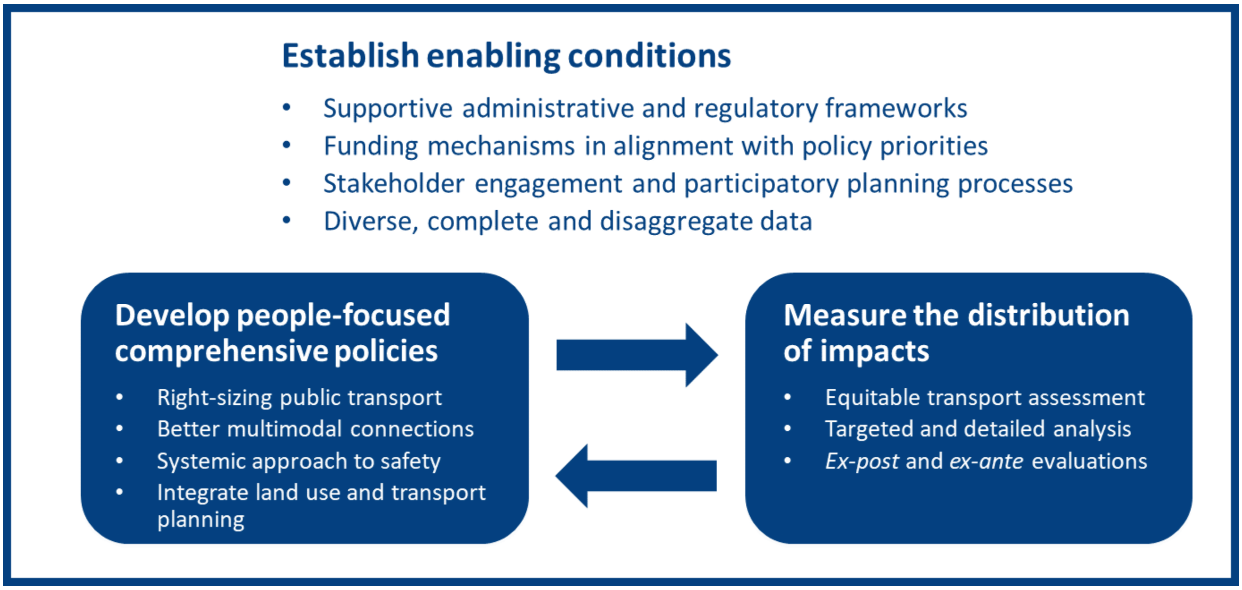
There is an extensive national legislative framework that guides the development of policies related to land use and transport in Korea. Several plans that include objectives to improve overall accessibility and equity in the Seoul Metropolitan Area (SMA) stem from this framework, including the Metropolitan Area Transport Master Plan (2021-2040) (MOLIT, 2022a); the National Master Plan for Public Transportation (2022-2026) (MOLIT, 2022b); and the National Transport Safety Plan (2022-2026) (MOLIT, 2022c).

Specific objectives in these plans, such as guaranteeing people's mobility and reducing traffic-related fatalities among vulnerable groups, are of particular relevance to improving accessibility and equity in the SMA. Nationwide accessibility indicators are already published annually in Korea by KOTI, measuring access to hospitals, schools, stores and interregional transport services by private car and by public transport. At the regional and local levels, more in-depth analyses of accessibility conducted through an equity lens can be a valuable addition to the evaluation frameworks for specific land-use and transport policy objectives. For example, access to interregional transport can be of particular significance to policy makers in the SMA as the region becomes more polycentric and new patterns of travel demand emerge between regional sub-centres.

This approach (illustrated in Figure 16) can add social and economic value to communities and improve the quality of life for residents of the SMA. Local authorities are well positioned to conduct accessibility analyses through an equity lens to support their decision making, given their understanding of the contextual factors influencing travel behaviour. Including accessibility and equity in transport decision making entails three key elements:

- people-focused comprehensive policies that address multiple and interdependent challenges together;
- measuring the distribution of benefits and impacts to encourage the shift towards a "decide and provide" approach for transport decision making; and
- establishing enabling conditions to improve access for all people and lower associated costs.

Figure 16. Proposed framework for including equitable accessibility analyses in decision making



Develop people-focused comprehensive policies

In the SMA, various complex and interconnected challenges influence access, and the opportunities available to address these challenges may vary by demographics and contexts. Within the context of an ageing and shrinking population, and given the concentration of opportunities within the core areas of the region, challenges in access can be compounded for specific people or groups living in certain contexts. A people-focused comprehensive mix of complementary policies should be considered to address both the multiple and interdependent challenges together.

Rather than focusing on improving the performance of individual modes, decision makers could instead focus on meeting the travel needs of people to achieve vertical equity. Such an approach can enhance integration between modes and provide people with more options for travel, which will improve access. Some examples of comprehensive people-focused policies are included in the following sections.

A systemic approach to safety

The increased focus on prioritising pedestrian safety in the National Transport Safety Plan will play a role in improving access to public transport and safety for active modes. A safe system approach, or one that emphasises the interdependence of a combination of policy interventions in minimising the risk of human error in the design of transport infrastructure, can make active travel more attractive for all road users.

Outside urban centres and even on major arterial roads within Seoul, the road network prioritises the through movement of vehicles. As a result, the connectivity of the pedestrian network is limited. Excessive crossing distances, infrequent pedestrian crossings, and the use of overpasses and underpasses reduce the quality of the pedestrian environment and, consequently, access to public transport.

Long blocks with infrequent crossing opportunities increase distance for pedestrians and can encourage mid-block crossings, which can be unsafe. Additionally, excessive crossing distances and overpasses and underpasses can make the pedestrian realm hostile, reducing access for people with limited mobility, as well as persons over 65 and children.

These features of the road network improve travel time for drivers at a tangible cost to pedestrians and cyclists. When longer pedestrian signals were implemented in Gyeonggi in an effort to reduce pedestrian fatalities at crosswalks, the result was a 14% decrease in pedestrian fatalities (Lee M. H., 2020).

Improvements to crossing infrastructure on major arterial roads can increase the connectivity of the active transport network and enhance access to public transport in the SMA. In Korea, intersections and junctions account for a disproportionate share of fatal cycling crashes (ITF, 2013). Various guidelines recommended in the National Transport Safety Plan address the design of roads and crossings to improve safety, for example, the implementation of leading pedestrian intervals (which allow pedestrians to enter the intersection before corresponding car traffic receives the green light), design elements to improve visibility at intersections, and various traffic calming features.

Improving the connectivity of the pedestrian network (shorter blocks and more crossing opportunities) in the development of New Towns, along with walking access to public transport, are key factors for improving safety and can improve the quality of travel for the complex trip chains associated with caregiving responsibilities.

Peri-urban areas with rural roads that typically have less dedicated infrastructure for active travel will require different approaches to improve safety for pedestrians and cyclists. Dedicated infrastructure in these areas may be more costly to implement and will likely be less used. However, rural roads tend to have higher speeds than urban roads, which poses additional risks for users of active modes in those areas.

In addition to exploring funding opportunities from higher levels of government to improve pedestrian facilities in these areas, policy makers can use accessibility analyses to prioritise where interventions can have the most impact. Policy interventions to address safety for pedestrians and cyclists in these areas will also need to address driver behaviour through education and enforcement measures.

Better multi-modal connections

A people or traveller-focused approach to improving public transport would consider not only the user's experience of the mode but also how they access the mode. All public transport trips (and, to a lesser degree, all car trips) are multimodal, because they all begin or end with walking or cycling. The quality of travel is then affected by the quality of the access and egress modes, for example, barrier-free stations and pedestrian infrastructure (Sung and Oh, 2011).

The Seoul Metropolitan Government is increasing the number of barrier-free bus stops to go with the expansion of low-floor buses for fixed routes (Seoul Metropolitan Government, 2017). These measures will improve access for people who rely on mobility devices, as well as for parents with strollers. Low-floor buses can also reduce the time buses spend at bus stops for boarding and alighting activity (dwell times), especially at stops that allow for level-boarding from the platform to facilitate easier boarding and alighting.

Since public transport users also depend on pedestrian connections, measuring accessibility through an equity lens may result in a shift in perspective on how improvements to the pedestrian network are prioritised. This approach would also improve the overall performance of the public transport network.

Within Seoul, the metropolitan government has taken various measures to improve the pedestrian experience, including creating dedicated pedestrian-priority streets. In the core of Seoul, over three-quarters of the roads are shared streets, allowing for better pedestrian access (Koh, 2017).

Improving connections between public transport modes can also allow for better coverage of the public transport network. Integrated fares, which are available in the SMA, are particularly useful for improving connections for public transport users. The distance-based fares allow for up to five transfers, which is especially beneficial for trip chains. The high uptake of smart cards also results in decreased dwell times for buses, as they make boarding and alighting quicker. Dwell times can be further improved with all-door boarding at major stops, which the SMA fare payment systems can accommodate.

As shared new mobility services (e.g., bikeshare, e-scooters) become more common, integrated fares across modes can also improve access in the region. Currently, smart cards can be used for taxis in the SMA. Integrating payments for shared services with public transport fares can leverage the flexibility of those modes in improving first and last-mile access to public transport. Policy makers play an integral role in shaping the regulation to allow for the operation of emerging modes and in making sure that their deployment improves overall access for residents.

The potential for policies to improve multi-modal connections can be measured with accessibility analyses. For example, e-bikes and e-scooters can decrease access and egress times to public transport, increasing the mode's absolute accessibility. Adding an equity lens to this analysis can help prioritise areas to deploy shared services and make sure that the benefits are distributed to the people and groups that most need them.

Right-sizing public transport services

Seoul continues to play a central role in regional travel, and thus regional transport networks must maintain and expand connections to the capital. However, as the region becomes more polycentric and the population ages, a singular focus on Seoul will result in imbalanced access for some residents. Public transport will have to keep pace with shifts in trip-making patterns within the SMA. For non-work trips especially, public transport use is influenced by trip travel times (Frank et al., 2008).

Minimising overall public transport travel time will help maintain its mode share. Better coverage of the public transport network can reduce out-of-vehicle travel time and consequently improve access for the mode. This will be particularly important, as the implementation of land-use measures that can decrease trip distances in new development areas (e.g., mixed uses, infill development) typically require a longer timescale.

The established hierarchy of public transport services in the SMA is effective in providing a range of location-adapted services with higher-order services and dense coverage concentrated in core areas. However, for developing New Towns, providing public transport services will require a balance between coverage and frequency to attract users and provide basic mobility.

In 2015, demand-responsive transport (DRT) was legislated in the Korean Passenger Transport Service Act as an alternative to public transport in rural areas. It has since expanded in scope and is included as an alternative service delivery method for public transport in urban areas identified as blind spots for public transport. DRT can allow for the reallocation of assets and services to support productive routes in major corridors, supplemented by first and last-mile shuttles. Before travel patterns in New Towns are established and demand grows, it can be an interim measure for providing basic mobility.

Finally, DRT can provide spatial and temporal coverage in sparsely populated areas or during low-demand time periods. Implementing effective DRT services requires routing decisions to minimise travel time and operating costs, as well as selecting service areas and identifying target users that can most benefit from such a service. Including equity considerations, such as minimising travel time for caregivers or reducing access distance for older adults, in the evaluation of the DRT pilot programme will increase benefits. Authorities can also use accessibility analyses to prioritise service areas for the implementation of future services.

Integrating land use and transport planning

Long-term plans for land use inform investment in transport infrastructure, affect proximity and travel behaviour, and as a result, accessibility. However, land-use policies can take a long time to elaborate, and policy instruments outside the domain of urban planners can influence how effective land-use policies can be. Integrating land-use and transport planning processes can help co-ordinate policy objectives to improve accessibility.

For example, increasing density in already built-up areas (infill development) with existing public transport services and other transport alternatives can reduce sprawl and car dependence. However, infill development policies should also include consideration for access to green space and amenities as well as affordability and heritage preservation to maintain the quality of life of existing residents.

Land-use policies can also encourage neighbourhood design that can improve transport performance. Focusing on transit-oriented development (TOD) and mixed uses, for example, can allow for shorter trip distances and improve the viability of public transport and active modes for complex trip chains. More recent New Town development in the SMA has included TOD-supportive policies, which has been beneficial for the performance of public transport in major station areas.

Access and design guidelines in land-use plans can influence the permeability of the road network. They guide intersection density as well as site planning and the arrangement of buildings on sites, which can influence the pedestrian and cycling experience. Local authorities can use accessibility analyses to link land use and transport planning, as described in the next section.

Measure the distribution of impacts

Evaluating the policies necessary to address interdependent challenges can be complex and requires leveraging diverse and disaggregated data. The data can come from a wide range of public bodies, such as statistical agencies, transport and land-use authorities, health and welfare authorities, and employment and labour authorities. Increasingly, data related to mobility patterns and beneficial for transport decision making is also found in the private sector.

This framework is suitable for facilitating collaboration between different authorities and various private actors because it provides insights that cut across various functions of government and can be relevant to various sectors. The focus on the core purpose of the transport system (to connect people to destinations) allows policy makers to explore a range of potential solutions that are not limited to their own expertise.

The assessment of transport costs and benefits typically takes a utilitarian approach, focusing on maximising benefits for the largest number of people. As a result, benefits tend to be minimised and communicated as targets that can be easily measured. This can result in unintended consequences such as increased car use and emissions as a result of optimising the road network to reduce traffic congestion; and commuter-oriented public transport networks that underserve non-work trips and increase car dependence outside core areas. Although collective solutions that benefit the majority are essential to address some challenges, policy makers also need to balance those with minimising the unequal distribution of impacts and negative externalities.

Using accessibility analyses with an equity lens allows policy makers to assess the distributional effects and unintended consequences of their policy interventions. Exploring the different factors influencing access (time, users, destinations, etc.) allows for a shift from a general perspective toward a more targeted, people-centric understanding of effects.

For example, travel time savings are a key metric used to measure the benefits of transport improvements. Travel time savings can be achieved through transport performance interventions or through land-use policies. Setting the target of “travel time savings” from a transport perspective can naturally lead to increasing speeds for public transport. Repositioning bus stops can increase travel speeds and improve bus reliability when combined with public transport priority measures. However, changes in the distance between bus stops (stop spacing) may result in longer access and egress distances for some users.

On the other hand, land-use policies encouraging infill development, density and mixed uses can reduce trip distances and save travel time. In addition, higher proximity to destinations lowers the costs of providing public transport services and maintaining transport infrastructure. However, land-use policies can also have an impact on local property markets, reducing affordability. Additionally, without accompanying consideration for access to green space, amenities, and transport alternatives, they can affect liveability and congestion.

This approach can help authorities identify which indicators are appropriate to assess the benefits and impacts of future policies and projects. It can also help shift from siloed solutions to address complex challenges, towards more integrated decision-making processes.

For example, accessibility analyses can link land use and transport planning, as demonstrated in the Greater London Area with their Public Transport Accessibility Level (PTAL) indicators. PTAL not only informs transport decision makers about gaps in service or opportunity areas, it is also used in the land-use planning processes to provide guidance on appropriate levels of density in developments (ITF, 2018).

Such tools clearly communicate the interaction between land use and transport, and allow for the engagement of diverse stakeholders across different functions, to enable policy coherence and co-ordination in decision-making processes.

Although nationwide accessibility indicators are available for private car and public transport in Korea, there are no indicators for active modes. At the local level, there is additional value in developing walking and cycling accessibility indicators since these modes can improve access and independence for children and persons over 65.

Accessibility analyses can be used to test different policy interventions to improve the pedestrian network and identify priority areas for interventions, or for pilot projects for alternative public transport service delivery. This will require more disaggregate data and local expertise and capacity.

This analysis of the SMA context took a high-level approach intended to illustrate potential use cases for such analysis. However, for local authorities who implement policies, deliver services and regularly interface with individuals, these examples are only a starting point. For example, considering access to different types of jobs based on education attainment (and thus the attractiveness of the jobs) can guide investment in public transport services.

However, it can also reveal areas where transport interventions may not be relevant due to factors outside the transport sector, such as changes in the economy or education policy. For decision makers, this people-focused assessment is one way to determine what kind of policies can distribute impacts equitably, and where a collaborative approach across sectors can be most effective.

Establish enabling conditions

To normalise a people-focused approach in transport and land-use decision making, enabling conditions will need to be in place. These include supportive administrative and regulatory frameworks, funding mechanisms in alignment with policy priorities and meaningful engagement with stakeholders.

Ensuring the appropriate authorities can undertake this type of analysis and are empowered to implement it within their processes and procedures can be an important first step. National governments can systematically involve local authorities in establishing policy priorities to ensure coherence between the levels of government. This approach will also encourage dialogue and collaboration across functions.

National governments can provide guidelines for including accessibility and equity considerations in the assessment and approval processes of new policies and projects. This can go hand in hand with aligning funding mechanisms to meet policy objectives. Funding can become a bottleneck given the ageing population in Korea. The increasing age dependency ratio (there will be a ratio of nearly 80 people over the age of 65 for 100 people of working age by 2050) will have long-term economic implications and affect scarce public resources (OECD, 2023).

Policy makers will be faced with important trade-offs as a result. Decisions regarding the funding of transport infrastructure and services will need to make effective use of resources while ensuring vertically equitable outcomes. Transport improvements that need funding from the national government may be required to incorporate accessibility analyses as part of their evaluation, with a focus on equitably distributing benefits and impacts. This can ensure that scarce resources are targeted where they can be the most beneficial.

Similarly, local authorities can also require accessibility and equity considerations in their approval processes for procurement. This can ensure alignment with policy objectives for projects that are contracted out to third parties.

To encourage innovation with a focus on integrated policy making, supportive regulatory frameworks that take the broader urban policy environment under consideration will also be necessary. For example, Korea's Promotion of Smart City Development and Industry Act (Ministry of Land, Infrastructure and Transport, 2018) included a regulatory exception that allows pilot programmes that use new technologies to provide smart city services.

This regulatory exception has allowed local governments to partner with private companies to explore DRT as a solution for public transport in 37 New Towns, with support from the Metropolitan Transport Committee of the Ministry of Land, Infrastructure and Transport (MOLIT). The pilot programme is ongoing with one of the service areas located in the SMA (in the city of Paju, with a service provided by Hyundai Motor Company). Early usage statistics indicate its popularity among different age groups and users.

Such supportive regulatory frameworks can give local authorities more autonomy in exploring context-relevant solutions beyond what is currently defined in existing regulations. They can allow collaboration between the public and private sectors to explore innovative solutions in an environment where policy makers can address potential risks early on. For example, policy makers can identify potential conflicts with existing services and operations during the pilot phases. This approach facilitates innovation within existing regulatory frameworks and establishes the evidence-base needed to bring innovative solutions to scale.

In the SMA, data on car ownership and income is available at the “gu” (district) level, but from a local decision makers’ perspective, more disaggregated data, perhaps stratified by income level, occupation, gender or household composition, can yield further insights. On the other hand, the extent and availability of empirical road network data in the SMA improved the quality of accessibility analysis for this study. However, data related to active modes was more limited.

Data needed for accessibility analyses require more granularity but can still be collected and reported at an appropriate level of disaggregation that preserves individual privacy, as guided by national data-governance frameworks. Increasingly, data related to mobility and beneficial for the improvement of transport systems come from various sources, including the private sector.

Public authorities who can benefit from these data need to establish appropriate data-governance frameworks that can reduce data sharing and data reporting risks, as well as establish data collecting and handling protocols that protect personal and commercially sensitive data (ITF, 2022c).

Authorities should also evaluate whether these data continue to be relevant in meeting the stated purposes of their collection to avoid observational biases – just because data can be easily collected does not mean it provides an accurate and useful assessment of the “ground truth” (ITF, 2022c).

Local governments will play an integral role in this, given their expertise in the local context. The nationwide statistics and travel survey data are a valuable resource but require local knowledge and expertise to analyse and interpret them. For example, the national accessibility indicators are a useful starting point, but still have some gaps that can be more appropriately addressed by local practitioners. Local authorities will need the resources and capacity to undertake such analysis. National agencies, such as KOTI, can play a role in local capacity building, particularly in small municipalities that may not have the resources.

Finally, local governments can enhance their public and stakeholder engagement processes with accessibility analysis tools. Meaningful engagement through participatory planning processes requires transparency and accountability from policy makers, which can be facilitated by regularly reporting such analyses. Simple accessibility tools and dashboards can be made available through government open data portals to allow both authorities and residents to understand how well accessibility needs and goals are being met.

Such tools can also allow for the inclusion of individual lived experiences in transport decision making, which helps to address the limitations of quantitative methods. This is particularly important as most sources for such information, including household travel surveys, are limited in their ability to provide the context for travel choices and individuals’ capacity to pursue activities that are essential for survival and development, all of which play a role in equitable accessibility.

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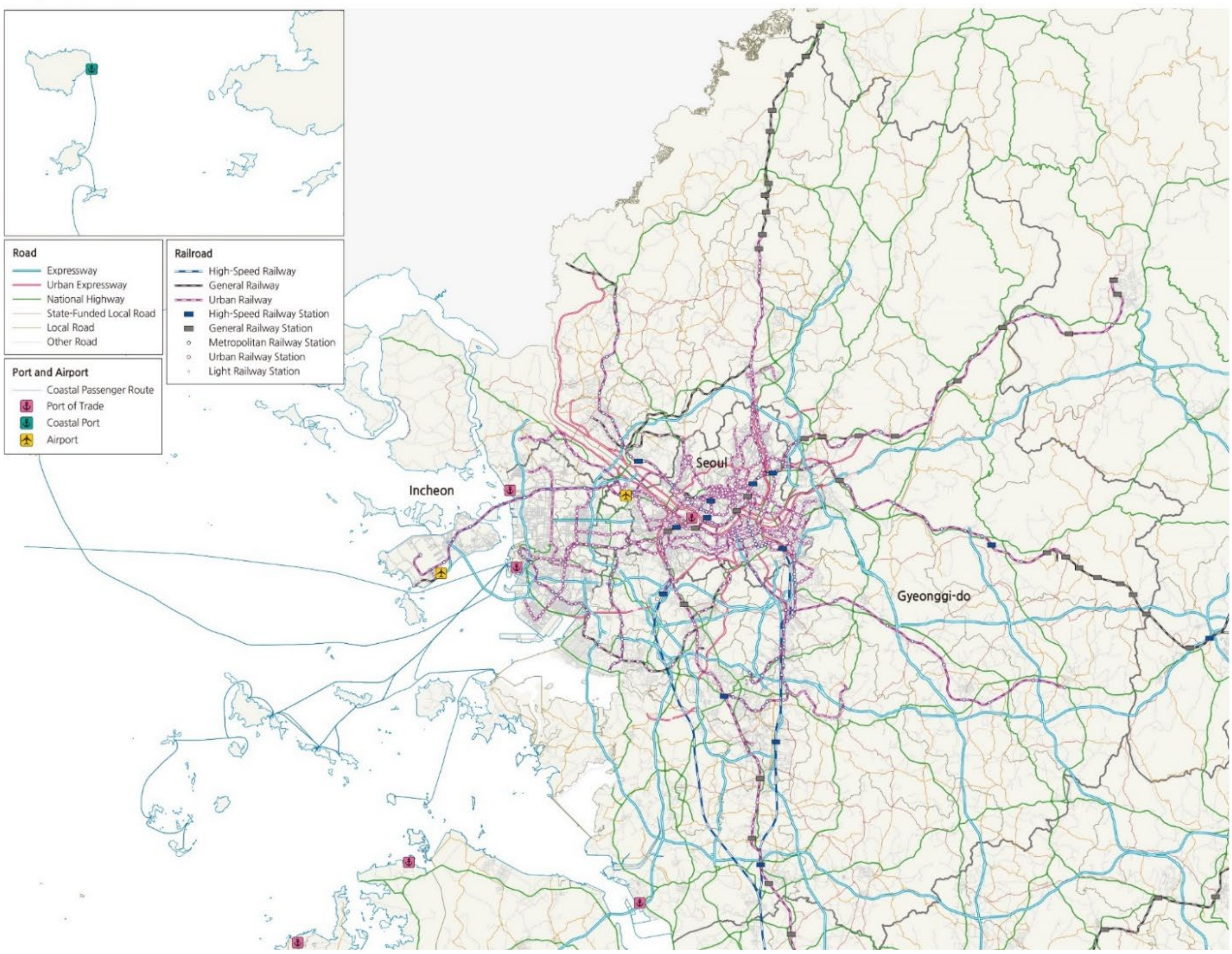
Annex A. Seoul Metropolitan Area Transport Structure

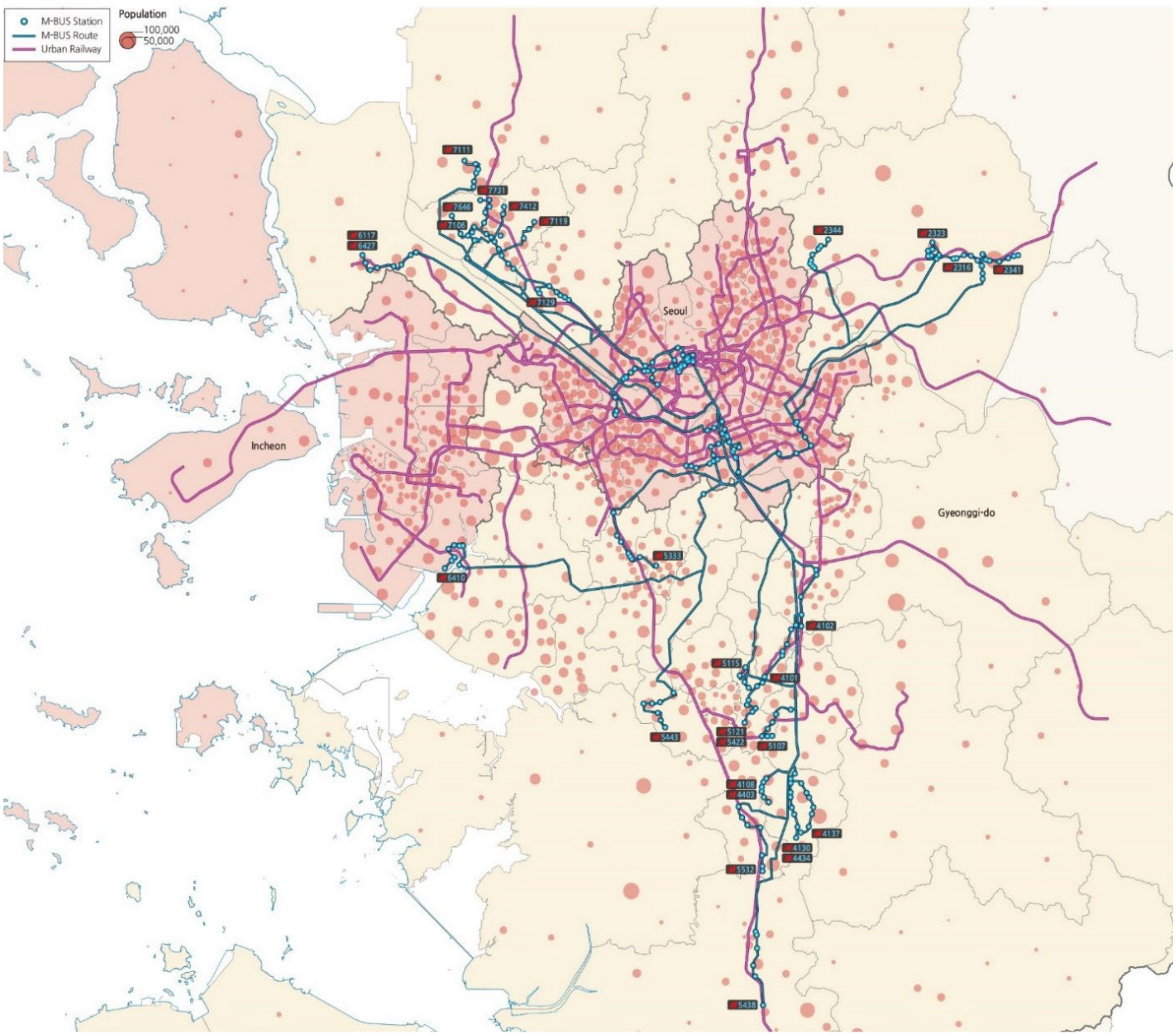
Transportation Structure



Source: (National Geographic Information Institute, 2021), *Seoul Metropolitan Area, http://nationalatlas.ngii.go.kr/pages/page_2649.php*

Annex B. Seoul Metropolitan Area Public Transport Network

Development of Public Transport Network



Source: (National Geographic Information Institute, 2021), *Seoul Metropolitan Area, http://nationalatlas.ngii.go.kr/pages/page_2649.php*

International Transport Forum

Accessibility in the Seoul Metropolitan Area

Does Transport Serve All Equally?

Over half of Korea's population lives in the Seoul Metropolitan Area. This report looks at how the region's transport system and land uses serve different socio-economic groups and offers insights for reducing inequalities in access. Are services and opportunities equally accessible to all residents of the Seoul Metropolitan Area? Which factors influence accessibility gaps? How can transport planning and decision making take into account accessibility and equity considerations?

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