4 Geographical accessibility and public transport

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Both academics and practitioners have long grappled with how geographical accessibility (hereafter referred to as 'accessibility') should be defined and measured. Currently, there is no consensus regarding which definition(s) or measure(s) of accessibility should be applied in what context [1] [2] [3]. The most common definitions include 'the ability to physically reach activities' and/or 'the ease with which activities are reached' [4] [5]. Recently, based on insights from research, it has been suggested that accessibility should be defined as '*the possibility to be able to participate in society by overcoming barriers (such as a distance)*' [6].

The term 'accessibility' is considered to relate to the transport and land use system, how people and their different characteristics interact with the system, and the time it takes to move to and from starting points and destinations within the system [7]. The different components of accessibility interact with and influence one another in many different ways. It can thus be argued that the concept of accessibility encompasses more or less 'everything', if it takes into account people, their combinations of different characteristics, the transport and land use system and everything that influences the respective components. Therefore, it could actually be difficult to come up with anything that does *not* affect accessibility in one way or another, even if it is to a very small extent.

This chapter focuses on research on accessibility at the meso or macro level [8] [9].[1]This means that the content of the chapter is delimited to research regarding accessibility that concerns travel between city districts or from one municipality to another, focusing in particular on journeys that are or could be made by public transport. Accessibility at what is known as the 'micro level' (such as between starting points and destinations within districts) is thus beyond the scope of this

1 This can be compared to accessibility at municipal and regional level for simplicity.

chapter. As accessibility can be regarded as encompassing or being influenced by ‘everything’ (or almost ‘everything’), it can be argued that virtually all of K2’s research relates to accessibility in one way or another. However, this chapter includes projects, reports and articles that explicitly address accessibility.

Why has there been more focus on accessibility?

In recent years, greater attention has been paid to the concept of accessibility, both within Sweden and elsewhere. This development appears to have come about partly in response to the sustainable mobility transition required in the context of the climate crisis [9], and partly in tandem with a greater emphasis on transport justice in transport and urban planning contexts [10]. Transport justice (and distributive justice in particular) has become more prominent in research and policy agendas over the last decade. In the context of this shift, there has perhaps been slightly less focus on the optimisation of the transport system itself [11] [12], and more on the role of the transport system in facilitating participation in society.

The concept of accessibility characterises both Sweden’s national transport policy goal [13] and objectives found in policy documents at regional and municipal levels, although the approaches, definitions and measures applied in different contexts differ [6].

Accessibility is approached and measured in different ways

The prevailing approach to transport planning assumes that accessibility is an objectively understood concept that can be measured and quantified [14]. A great deal of emphasis has been placed on the design and development of standardised accessibility measures that describe accessibility within a given geographical area, or between geographical areas.

Accessibility is usually measured by applying one of the following four methods [1]:

1. distance (or journey time by a specific means of transport) to the closest type of destination;

2. cumulative measures (the sum of a certain type of destination, e.g. the number of jobs to be found within a certain radius, based on a certain distance or journey time);
3. gravity models (which weight destinations where values decrease with increasing distance or journey time); and
4. measures based on marginal utility (such as the log-sum, that takes average preferences into account).

Results, conclusions and choices may differ depending on the definition, method and measure applied. That is why it is important to be able to identify *what kinds* of differences can arise and *why* when applying different definitions, methods and measures.

Many measures of accessibility overlook variation

In some cases, employing simpler measures can be justified. Simpler measures can mean that the application and results can be communicated and explained with greater ease. They can also allow for changes to be measured and monitored in a standardised manner over time [9] [15] [16]. However, these simpler measures do not capture all aspects related to accessibility, and they tend to overlook certain types of people, usually people who are further away from the characteristics associated with 'the average individual' [16] [14] [5].

A study based on data from Canada [5] has indicated that what are known as **normative accessibility measures** are specified in terms of how far it is considered reasonable for people to travel, while what are known as **positive accessibility measures** are specified in terms of how far people actually travel (based on data from travel behaviour surveys, for example). There are several problems associated with both types of measures. Both can influence people's actual travel behaviour, regardless of whether the approach defines new frameworks for travel behaviour going forward or reinforces the frameworks associated with existing travel behaviour.

Some of K2's research has aimed to highlight aspects that are sometimes overlooked when defining and measuring accessibility, both methodologically and theoretically [16] [17] [18] [19] [20].

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What do we know about accessibility?

K2's research into accessibility is characterised by elements and perspectives from various disciplines. Some studies include the estimation and analysis of (potential) effects **from a socio-economic perspective,** with emphasis on residential location and commuting patterns [21] [22] [23], while others are characterised by **transport justice perspectives** [24] [25] [16] [26] with less emphasis on commuting and where specific groups [27] [18][2], specific geographical areas [20] and other activities [28] [29][3] are considered. Ongoing K2 projects are characterised by more focus on **environmental aspects**[4] and **links between other means of transport and public transport** [30].

These themes and multidisciplinary cross-fertilisation of approaches and methods also characterise the composition of accessibility research in general [9].

Effects of public transport initiatives to increase accessibility

Several aspects related to accessibility such as regional development, proximity, agglomeration and location effects linked to public transport investments have been studied in detail in a K2 project [31] . This project studied aspects such as the scale and character of public transport investments in the region of Scania and along the West Coast Line (Västkustbanan) within the project. Comparisons between rail and bus investments and their respective estimated impacts were also conducted. The project concluded that, in line with other research findings in the field, the effects of investments in increased accessibility appear to be highly dependent on context. Thus, there are no set rules that can be applied across the board (in all contexts) to determine or predict the outcome of investments.

Property prices served as an indicator of willingness to pay in one of the studies included in the larger project [23]. The study found that property prices around stations with high labour market accessibility (either in terms of shorter journey times or actual physical proximity) appeared to be more affected by price

2 There is also an ongoing project that is focusing on accessibility for children. Read more here: https://www.k2centrum.se/barns-tillganglighet-och-mobilitet-i-ett-digitaliserat-transportsystem-hur-arbetar-nationella-och

3 A recently completed research project focused on accessibility to, from and outdoor recreational areas. For more information on the project, see: https://www.k2centrum.se/aurora-pre-study-accessibility-and-areas-national-interest-outdoor-recreation

4 A project is ongoing that is focusing on accessibility and planning across planetary and social boundaries. See: https://www.k2centrum.se/kollektivtrafikens-roll-och-egenskaper-mellan-planetara-och-sociala-granser-troskelvarden-scenarier

increases. The effects for stations with lower accessibility to labour market centres were not as clear-cut.

The study also found that railway stations characterised by accessibility to major labour markets in large parts of the region appear to be regarded by households as more attractive [23]. The study concluded that cities that are located close to other cities can be strengthened by means of their public transport connections, which in turn contributes to agglomeration benefits.

The overall results of the project indicate and emphasise that the effects of public transport investments do not happen by themselves but need to be complemented by other measures in order to promote regional development and increased accessibility. The authors emphasise the fact that there are distributional aspects that may be important to take into account and include in the planning of both infrastructure investments and service provision [31].

Investments and cuts in public transport

The effects of changes in public transport provision for some areas were analysed as part of another K2 study. Here, some areas saw increased access to public transport with the introduction of the 'Pågatåg Nordost' service, while other towns or parts of towns experienced reduced access, when regional bus services were partially or entirely withdrawn [20]. The location of railway stations on the outskirts of towns was associated with reduced access to public transport for some people, with a number of respondents feeling that public transport was further away than it used to be (compared to when bus routes formed the core of public transport provision). This change appears to have had the effect of reducing (perceived) access to – and accessibility of – public transport for some residents.

Variation in pre-conditions for public transport accessibility among different groups

Mobility strategies with a particular focus on how public transport is perceived, used and can meet the mobility needs of people who live, work or pursue other activities in selected disadvantaged areas in Swedish cities were examined as part of a K2 study focusing on accessibility [24]. This study focused on how public transport could contribute to accessibility and social equity in the transport system.

The study concluded that an efficient public transport system is important for aspects such as participation and integration in society, especially where, for various reasons, there are limited opportunities to obtain a driving licence, acquire a car, relocate or change jobs. Accessibility by public transport was perceived to

be particularly limited by people who work evenings, nights and weekends, as opening hours/timetables did not correspond to their working hours.

The K2 *Access* project studied how conceptualisations of 'collective mobility' can be adapted to groups with low levels of car possession and access [18]. The study culminated in a number of recommendations for how the mobility needs of different groups (such as people living in sparsely populated areas and young people) could be met by the introduction of new mobility concepts, functioning as a complement and/or alternative to public transport. The project has culminated in several recommendations, including the fact that just one ticket should be valid for several modes of transport, that the vehicle pool could include a range of different vehicles, that stakeholders should communicate and provide information in different languages, and that a specific stakeholder should be designated as being responsible for providing information about transport options.

Methodological development focusing on the dimension of time

A number of K2 studies have had a particular focus on methodological development, targeted at refining and adjusting accessibility analyses. Methods and perspectives have been both developed and broadened [16] [25] [28] [26]. The advent and standardisation of GTFS data [5] has facilitated the development of public transport-based accessibility analyses during the last decade. Developments have also allowed delays to be taken into account in accessibility analyses by applying positioning and real-time data [26]. K2 research has used GTFS data in various forms in accessibility analyses. Tools such as Network Analyst [19], OpenTripPlanner [16] and, more recently, r5r through R5 have been used [32] [25] [28] [26].[6] The K2 project *Equitable accessibility by public transport: Moving from static analyses to incorporating time-space dynamics* is one example of a project where there has been an emphasis on methodological development related to the time dimension of accessibility, and where the tools and methods referred to above have been applied and adjusted. This project studied the concept of accessibility in different ways with case studies in the regions of Stockholm, Västra Götaland and Scania. The project aimed to develop the understanding of the concept of public transport-based accessibility, taking into account the times of

5 For more information on GTFS, see: https://gtfs.org/.

6 For more information on Network Analyst, see: https://pro.arcgis.com/en/pro-app/latest/help/analysis/networks/what-is-network-analyst-.htm. For more information on OpenTripPlanner, see: https://docs.opentripplanner.org/en/dev–2.x/Product-Overview/. For information on R5 and r5r, see: https://ipeagit.github.io/r5r/.

day that different individuals travel and how the opportunities for and accessibility of different (potential) passengers are influenced by public transport provision.

The project analysed travel survey data from the region of Stockholm in combination with estimated journey times by public transport [25]. It compared accessibility by public transport to workplaces for different groups of people during different timeframes. Factors that may influence the timeframe within which commuters (choose to) travel and the transport modes they select were studied. The results showed that accessibility by public transport in the region of Stockholm varies when accessibility during peak hours is compared with accessibility within timeframes before and after peak hours. This means that some groups are more likely to benefit from 'better' accessibility (shorter travel times to work) than others. The results suggest that commuters who have the opportunity to be flexible choose to travel during peak hours, which can be partly explained by the fact that public transport-based accessibility is better during those timeframes. Commuters who do not have the same flexibility are more likely to use other transport modes to get to work.

The distribution of accessibility losses arising as a result of public transport delays in Scania was studied in order to highlight the potential effects of such delays [26]. The analysis shows that recurring public transport delays lead to a reduction in accessibility to work in the order of 4–9 per cent in the region of Scania. The study also shows a correlation between recurring delays and a lower propensity to travel by public transport compared to other motorised modes of transport.

Spatial inequalities in accessibility were analysed as part of another K2 project. This was done by investigating how the public transport provision can influence the time available to public transport passengers living in two selected districts located on the outskirts of the city of Malmö [19]. The study applied a GIS-based analysis to explore whether and how the public transport provision (a) enables study participants to take part in activities; (b) is spatially and temporally consistent with their activities; and (c) supports or hinders study participants' ability to manage their time. The results of the study suggest that public transport provision results in inequalities of opportunity in terms of faster connections for some and slower ones for others, which may mean an increased risk of time-related transport problems among some passengers. Additionally, there is evidence that the service provision does not always meet participants' accessibility needs, especially during off-peak hours.

Differences in estimated and perceived accessibility

In line with the broader research trend of a sharpened focus on differences between how accessibility is ('objectively') measured and how it is ('subjectively') perceived [14] [33] [34] [35], K2 research has explored what we (analysts or researchers) miss when measuring accessibility [16]. A K2 study compared estimated and perceived accessibility among different groups of older people by means of an accessibility analysis and a survey. The accessibility analysis was adapted by adjusting the values of estimated (often referred to as 'objective') accessibility for respondents who felt that they did/did not have access to the mode of transport to which the accessibility analysis related. Furthermore, cases in which there was a 'mismatch' between the estimated accessibility and the self-reported accessibility on account of the perceived inability to use certain transport modes were analysed. The study found that respondents with greater 'mobility resources' (such as access to more transport modes) were less likely to have a mismatch between the self-reported and estimated accessibility indicators. Thus, the transport modes available to people seem to play a role in how different people perceive their accessibility. This aspect is not usually captured by standard accessibility measures and analyses.

In the K2 project *Capturing the impacts of changes in public transport accessibility*, emphasis was placed on applying and developing the use of what are known as participatory-GIS methods. The objective was to capture perceptions of changes in the accessibility of and access to public transport. The project was based on two case studies: one in an urban context in Malmö, and the other in a regional context in the region of Västra Götaland. A survey was conducted within the framework of the project with a view to capturing changing travel patterns among residents of the city of Malmö at the start of the pandemic [36]. The results showed that (not least perceived) accessibility by public transport was severely limited at the start of the pandemic.

A survey was conducted among residents in sparsely populated areas in the Västra Götaland region within the framework of the K2 *BAS* project. This survey was conducted among two samples, one consisting of residents aged 15–18 and the other consisting of residents aged 19 and over. The survey aimed to answer questions about the accessibility needs of different groups and whether such needs are or are not met by the public transport provision, and to what extent. The results suggest that young people are more affected by relatively low accessibility, with some respondents stating that they limit their activities and adjust their

expectations of participation in society according to the low levels of accessibility in which they live.

The concept of accessibility in policy documents

How the concept of accessibility is considered when drafting policy documents and in policy development in general has been addressed in a number of different K2 studies [17] [37] [38] [39]. Given the fact that accessibility is defined and measured in so many different ways, it comes as no surprise that the concept is treated differently when drafting policy documents.

How a basic, equitable and sufficient level of public transport-based accessibility could be defined and implemented was explored in a study that focused on policy development in Sweden's metropolitan regions [17]. Officials in Sweden's metropolitan regions were interviewed so that they could provide their perspectives on their experiences working with the concept. Additional interviews were conducted with officials and experts in Belgium and the UK, and approximately 40 policy documents were analysed as part of this study. The study resulted in recommendations for how an equitable and basic level of accessibility could be defined as a policy concept, and how the concept could be implemented in connection with the drafting of various policy documents such as public transport service provision programmes. The recommendation comprises four different steps: (1) how accessibility is defined and measured is agreed upon and established, (2) a standard and an assessment framework is put in place by means of a process involving a series of different stakeholders, (3) the scope of the standard is delimited and defined, (4) where the responsibility (or responsibilities) for the coordination, implementation and monitoring of the standard among stakeholders and public authorities is established and formalised.

Another K2 study focusing on policy development in relation to accessibility examined the case of the region of Uppsala [37]. Uppsala was selected as a case because the region's general objective is to ensure that its transport system provides accessibility for all. The study found that people with disabilities are the group whose accessibility receives the most attention in the material studied. The study found that officials appear to have more vague perceptions of what accessibility means and how providing accessibility should be achieved for groups other than people with disabilities. Interviewees were aware of other groups and any public transport-related accessibility problems they may encounter, but the work focusing on accessibility appeared to be focused on people with disabilities as a group.

Accessibility influenced by interactions between policy areas

A number of K2 projects have studied how the interaction between different policy areas may potentially affect the accessibility of or to different places, One study analysed how accessibility to schools by sustainable transport modes could be affected by (1) the introduction of municipal school choice policies and (2) the public transport infrastructure investment in the form of the Malmö Ring railway line [28]. The accessibility of lower secondary schools (grades 7-9) in Malmö was studied by estimating hypothetical school catchment areas. Furthermore, the study examined how the potential redistribution of accessibility could affect the composition of the schools affected. The results indicate that potential impacts are not distributed evenly throughout the city. However, the possibility of reaching schools further away may be greater among economically stronger groups/districts, among whom/which there is also a greater possibility for flexible work arrangements (among parents/guardians). Furthermore, it was argued that travel needs (travel demand) may increase as a consequence of the introduction of policies such as municipal school choice. This, in turn, may impose a temporal and economic burden on certain groups in society. The results of the study highlight the importance of taking a holistic approach to policy choices related to transport and urban planning (in combination with the planning of e.g. education and healthcare). Moreover, another K2 study has found that the Malmö Ring railway line does not seem to contribute much to the perception of accessibility by public transport in the affected areas. This is considered to be due to the fact that the areas affected most by the investment are served by high-quality bus services with higher service frequency and shorter journey times (to Malmö Central station, for example) than the train connection and service [40].

Whether accessibility can explain food prices in Swedish supermarkets, and to what extent, was examined in another K2 study [29]. This was done by analysing links between accessibility and food prices. The study found that there is a quadratic relationship between accessibility and food prices, with prices in the least and most accessible parts of Sweden being 2–3 per cent higher than in the cheapest parts.

What will be interesting to study going forward?

Although K2's research has contributed a great deal of knowledge regarding accessibility and public transport, there is still much to explore. There are a number of particularly interesting questions to study going forward.

Interventions that focus on increasing accessibility in areas that have previously been characterised by low accessibility may have unforeseen consequences. Property prices may increase, causing groups that would benefit from increased accessibility to instead relocate to areas with lower property prices. These areas are also likely to be characterised by lower accessibility. ‘Can transport interventions truly compensate in the long run for uneven distributions of accessibility in a more or less free housing market?’ is a particularly interesting question.

Giving greater consideration to perceived accessibility in transport and urban planning is gaining more attention. There is scope to develop and adapt transport models in order to take these aspects into account in a more nuanced way [6]. Studying ways of doing this is becoming increasingly important as more and more research shows that common accessibility measures fail to capture the perceptions of different people.

In the context of an increased focus on ‘collective’ or public mobility, and links between public transport and various forms of micromobility, accessibility becomes more dynamic and hence even more difficult to capture and measure. As new micromobility solutions – often viewed as complementing public transport – have become more prominent, it is important to investigate whether these solutions do actually complement – or whether they merely compete with – public transport and walking [41], whether they can help reduce – or whether they potentially increase – inequalities [42], and whether they can reduce emissions from the transport system, or whether they simply contribute to more emissions per passenger kilometre from a life cycle perspective [43].

It is imperative to ensure that the accessibility planned for by society paves the way for lower emissions and a fair existence within the boundaries of our planet [44]. This is also rather urgent.