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Community Accessibility or Personal Mobility: A Planning Choice

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Abstract

While the concepts of accessibility and mobility are central to urban and transport planning issues, the philosophies underlying their application are not clearly understood, and they remain difficult to define in a way which enables them to be easily quantified. For example, mobility, especially when excessive, can have a negative connotation, whereas accessibility is always seen as making a positive contribution to a community. In investigating the relationship between mobility and accessibility it emerges that planning policies which favour the one, act against the other, and the two can be seen as opposites. A quantitative indicator of community accessibility is derived which is intuitive and simple to use, yet robust and effective.

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Introduction

The private motor vehicle has provided users with high levels of mobility, flexibility and comfort, but its excessive use has had a major impact on social, environmental and economic aspects of cities. Natural bushlands, urban wetlands, coastal zones and air quality have all suffered as the private motor vehicle has enabled urban areas to extend their boundaries, seemingly endlessly. Also, rising transport costs, longer journeys, the negative effect on health of noise and air pollution, deterioration of the public realm, inequitable transport systems, unviable public transport networks, and dangerous road environments, are some of the social and economic consequences of this development.

In response, researchers are querying whether we should in fact be planning for accessibility rather than mobility (Cervero, 1997a), recognising that these concepts are central to urban and transport planning, and that a practical and robust definition would be useful in the realm of policy and professional practice. However, while the concepts have long been in common use, they nevertheless remain difficult to define in a way which makes them easily and objectively measurable (Engwicht, 1993).

This paper begins by defining personal mobility and community accessibility. A short discussion on indicators is followed by a study of various methods of quantifying accessibility, including a look at zonal and corridor approaches. An indicator of community accessibility is selected which is simple to use, does not require the collection of large quantities of data, and which enables accessibility to be compared between cities, between regions, and which can show changes over time. The community accessibility indicator is applied to data collected by researchers at the ISTP in 46 cities, and the relationship between accessibility and mobility within cities is investigated.

Personal mobility

The concept of mobility is often linked to discussions about individual rights and freedoms and, like many transport-related issues, it continues to be surrounded by controversy (Janssen, 1993). Mobility is often seen as a basis for prosperity, or as an expression of freedom and choice, but it is also recognised that by itself, motorised mobility contributes nothing to wealth, can be wasteful of resources, damages communities, and contributes to air, water and noise pollution (Kreibich, 1992).

Americans, unlike many Europeans, are credited with the ability and willingness of being able to move from city to city and state to state as they improve their education and job prospects. In doing so, Americans become national citizens but lose their allegiances to a community, while the British and other Europeans identify strongly with the region of their birth. Such 'mobility and footlooseness' (Foley, 1966, p13) negates the need to discuss aspects of community such as its meaning, size or structure, and indicates how the urban region can be reduced to merely providing a level of resources. It seems that the relationship between mobility and community is one of mutual exclusion.

Clearly, personal mobility is most efficiently provided by the private motor vehicle, and it can be measured by vehicle kilometres travelled, vehicle occupancy, passenger kilometres, traffic speed or vehicle ownership. While trip rates, trip lengths and/or the proportion of the population who are travelling on a given day may be used to measure mobility, all of these values can be interpreted ambiguously, and it is difficult to say whether more or less travel is preferable, and whether more or fewer trips are better (Jones, 1987). Two examples illustrate this point: firstly, parents often drive children to school out of fear of road accidents or physical harm, resulting in a trip which can hardly be seen as positively contributing to lifestyle; and secondly, the growth of suburban centres, focusing on shopping, entertainment, education and medical services, perpetuating the segregation of land-uses, and often poorly served by public transport, can result in longer individual journeys than if these concentrated complexes were dispersed throughout the suburbs. These forms of 'forced mobility' equate to a loss of freedom for both adults and children (Engwicht, 1993).

As car ownership becomes more affordable, the number of motorised trips, trip length and overall distance travelled continues to grow (Felz, 1988). In modern suburban environments, shopping, recreation and other activities can often no longer be carried out in the local neighbourhood but require longer, motorised journeys. Under these circumstances, it appears that mobility is rising to maintain accessibility (Würdemann, 1993), suggesting that accessibility and mobility are opposites (Beckmann, 1993).

Community accessibility

The Germans, from whom many of our notions of 'community' derive, have two words for community: *Gemeinde*, which defines a locality, could be translated as neighbourhood; and *Gemeinschaft*, with a wider meaning, includes the quality of the relationship of a particular group of people, and could be distinguished as 'moral community'. As an example, phrases such as community school, community care and community centre, all of which may serve the needs of the local neighbourhood, also have an additional sense of implied value. The community school is not the same as the local primary: perhaps the parents take on a special role, are more involved in their children's education; maybe the curriculum is less academically inclined and more socially oriented; or the teachers may be more caring and less likely to mete out punishments. Community in this latter sense is a participative concept which incorporates 'we' rather than 'I' and 'they' (Batten, 1967; Daly and Cobb, 1994; Plant, 1974). So, while mobility is more akin to individualism and freedom, community encompasses ideas of membership and participation.

Accessibility, unlike mobility, is always seen as a positive, but it is nevertheless more difficult to define and measure than mobility (Gould, 1969). A standard definition may include terms of time, money, distance travelled, level of comfort, availability, reliability of service, or any combination of these (Department of the Environment, 1996; Schoon et al., 1999). It is generally accepted that accessibility can be achieved through mobility or proximity but also through the modern telecommunication networks. In urban geography, the term is used to explain the growth of towns, where facilities are located, and the relationships between different land uses (Ingram, 1971). It is often a stated aim of new developments. For Black (1992, p5), accessibility is:

> a description of how conveniently land uses are located in relation to each other [...] and how easy or difficult it is to reach these land-use activities via the transport network of both public and private transport modes.

Community accessibility then, can be seen as a level of accessibility which enables every-day trips such as to work, for shopping, visiting and education to be undertaken in the local community. Such trips, because of their shorter distances, can be undertaken using the community modes: walking, cycling and public transport.

Indicators

The purpose of an indicator is to measure and communicate a trend of events, and to simplify our understanding of these (Eckersley, 1997). Indicators can be used as a tool for policy makers as a means of driving change in a particular direction. For all their disadvantages, common indicators in use include: gross domestic product (GDP) as a measure of the amount of goods and services a country produces; consumer price index (CPI) as a measure of inflation; and the many indices used by stock exchanges to express the business community's expectations of future economic growth. A number of indicators are emerging for use in sustainability planning, and these amalgamate a wide range of separate indicators such as those of climate change, air quality, biodiversity, poverty, population health and economic health to provide general information on the environment (Lang, 1998; Newman and Kenworthy, 1999; Selman, 1996).

While economic indicators, measured in monetary terms, may be relatively simple to use and understand, it is far more difficult to measure environmental and societal values, as there is no easy way of counting factors such as biodiversity, the state of human health, the social effects of unemployment or the effects of climate change. One use of indicators is seen in the testing of water at swimming pools, and beaches near sewage outfalls. Improperly or untreated sewage can carry a range of pathogenic organisms including viral hepatitis, polio, typhoid fever, amoebic dysentery and cholera. But rather than conducting expensive and time-consuming tests for the presence of each of these organisms, health inspectors test for the presence of just one indicator species, the *coliform bacterium*, and so determine whether faecal contamination has occurred at the site (Chiras, 1991).

The ability to objectively quantify differences in accessibility would provide a tool which could supply valuable information to planners: accessibility could become a basic element in defining urban form; it could highlight areas of unequal access opportunities to facilities so that these inequities may be addressed; and level-of-service changes could be monitored for their affect on accessibility (Schoon et al., 1999; Wachs and Kumagai, 1973).

Accessibility indicators

While mobility can be an aid to accessibility, it is clear that costs rise as distance travelled, or mobility, increases. Planners recognise that the outward growth of cities encourages car usage and mobility, reduces the effectiveness of public transport and reduces the accessibility of residents in these areas (Department of Planning and Urban Development, 1992) As a general truth, it is postulated that an accessibility indicator should not increase in an environment where distance travelled is increasing, suggesting an element of reciprocity in accessibility and mobility (Weibull, 1976).

While an indicator of accessibility may combine measures of the transport system with those of land use, its aim is to provide a means of quantifying 'ease of travel' (Morris et al., 1979), and therefore, it is possible to measure a proxy if this can be shown to accurately represent accessibility. The resulting indicator should inform planners as to how an area of low accessibility can be improved, how new developments can consider accessibility at the planning stage, and how accessibility in a city is changing over time.

In determining accessibility, planners may attempt to measure the value of time, perceived and real costs, public transport frequency, land use, transfers, travel distance, parking cost, network connectivity etc. But some of these components, such as perceived costs, are subjective, others, such as public transport frequency and travel time, change during the day. While an indicator incorporating such data could provide valuable information, its formulation is extremely complicated, requiring a level of data collection which enormously reduces its functionality. An indicator of this type will be out-of-date as soon as bus timetables change, inflation pushes costs up, network connectivity changes, or fuel prices change. A further disadvantage is the integrity of the data, especially when its collection occurs in different cities on different continents: the chances that all the data are available and have been collected in a consistent manner can be disputed, thus limiting its use as a comparative indicator.

A zonal approach to accessibility indicators

Researchers often take a zonal approach to accessibility, but several problems arise with indicators based on zones: they often presuppose segregated land uses, but this is not a planning approach which generates short trips or promotes community accessibility; and a zonal approach using the gravity models cannot account for intra-zonal trips, the very trips which really give a true idea of accessibility.

The credibility of the zonal approach may also be questioned for several reasons: firstly, the number of activities which can be carried out in a given area is often theoretical in non-homogeneous cities; secondly, a zonal approach cannot take into consideration the appropriateness of the activities in one zone to the population of the other zones; and finally, as has been previously mentioned, a major drawback with a zonal approach is that it cannot account for intra-zonal trips, the most important trips with regard to community accessibility.

A corridor approach to accessibility indicators

Accessibility along transport corridors such as a heavily-used commuter route can also be investigated. In a UK study, journey to work time and cost by motor vehicle, bicycle and bus were compared in a corridor by formulating two indices: one involved the out of pocket travel costs of each mode, the other was based on travel time (Schoon et al., 1999). In both cases, the bus was found to be slower and more expensive than either the motor vehicle or the bicycle. Once established, a means of addressing such inequities can be sought, and in this case, may include the installation of bus priority lanes, traffic light priority for bicycles and buses, or increased parking charges for motorists.

Hansen's accessibility indicator

A long-standing, often cited and well recognised method of measuring accessibility is given by Hansen (1959), who relates accessibility of, for example, jobs in one zone directly to job density in that zone and indirectly to the distance between that zone and another, possibly residential zone, with total accessibility to jobs being the sum of the accessibility from each of the residential zones. According to Hansen's formula, accessibility increases as job density increases, and as travel distance falls.

This section has illustrated some of the work which has been carried out on accessibility indicators, and provided an indication of the difficulties associated with its measurement. It also becomes apparent from the above discussion, that rather than promoting accessibility, any increase in distance travelled is indicative of a reduction in accessibility. In the following section, an indicator of community accessibility is derived and applied to 46 world cities.

Choosing an indicator to describe community accessibility

After taking into account the research work carried out in the field of accessibility as described in the previous section, and from the literature (for example Black and Conroy, 1977; Brockelt, 1995; Cervero, 1997a; Cervero, 1997b; Damen and Davidson, 1998; Forster, 1978; Ingram, 1971; Morris et al., 1979; Ryan and McNally, 1995; Schoon et al., 1999; Wachs and Kumagai, 1973; Weibull, 1976), the search for an accessibility indicator in this paper was guided by several principles: it should be simple to use and understand; and, to be accepted by interested users, it must be based on credible data with a convincing and rational method of calculation. An acronym often used in the computing world is *KISS*, keep it simple and safe. In the same vein, the principle known as Occam's Razor states that where there is a choice of explanations of a phenomenon, the simplest explanation, with the fewest number of assumptions, will be the most preferable. It has already been demonstrated how easy it is to be led into including many variables when developing an accessibility indicator. The dangers associated with this approach include the difficulty in collecting data of consistent quality, and the lack of credible and meaningful results.

The relationship between community accessibility and mobility

This paper has noted that accessibility and mobility are indirectly related, and indicated how mobility must often rise to maintain accessibility. However, the shape of the graph linking these two variables has not been discussed. In searching for a suitable formula, it was originally thought that a simple reciprocal relationship (Figure 1) could adequately describe this relationship, and in some ways, it does. By combining Newton's second law of motion ($F = ma$), where F is the force producing an acceleration a on a body of mass m, and his law of gravitation ($F = GM_1M_2/d^2$), a formula for gravity can be derived ($g = GM/d^2$), where g, the force of earth's gravity, is determined by dividing the product of the gravitational constant G, and the mass of the earth M, by d, the distance of the body from the centre of the earth (Isaacs A. (Ed), 1990). Accessibility models often use this form of equation by likening gravity, the force of attraction between two masses, with accessibility, the level of attraction of activities between two locations. Hansen's formula is based on the gravity model and determines the level of attraction between two zones for a specified purpose such as that of residents in one zone for employment in another.

The negative exponential function (Figure 2) of the form $a = e^{-d}$, where accessibility a is related to e raised to the negative power of the distance factor d, is sometimes used as an alternative to the reciprocal function. By not declining as rapidly as the reciprocal function, the positive attribute and strength of accessibility over shorter distances can be better appreciated. The exponential function is also favoured since, by remaining valid where distance equals zero, it has some chance of handling intra-zonal trips successfully.

Finally, the Gaussian, or normal, curve as described by Ingram (1971) is reasonably flat-topped at the origin after which it begins to dip and descend smoothly before again flattening out and reaching zero at infinity. This paper is claiming that accessibility can in fact be quantified by a formula based on mobility, defined as per capita vehicle kilometres travelled, which expresses the reciprocal nature of their relationship. While Ingram related distance, either straight line, rectangular or curvilinear, to accessibility, this paper relates mobility, defined as per capita vehicle kilometres travelled, to accessibility:

$$A = 100.e^{(-M^2/k^2)}$$

Formula 1: A formula for a community accessibility indicator, based on Ingram (1971)

where: A is accessibility, M is mobility measured as vehicle kilometres travelled per capita, and k is a constant for a given sample. By giving k the median value of the per capita distance travelled of the sample being investigated, a dispersed spread of points is achieved on the graph.

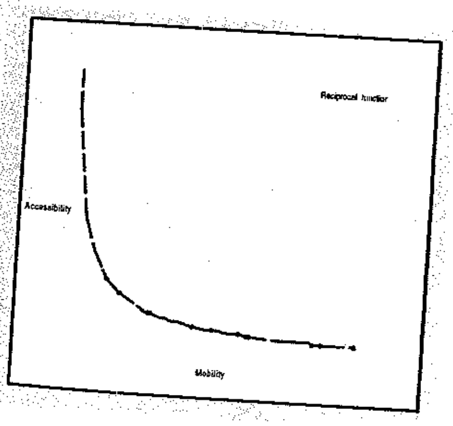

Figure 1: Reciprocal function for relative accessibility

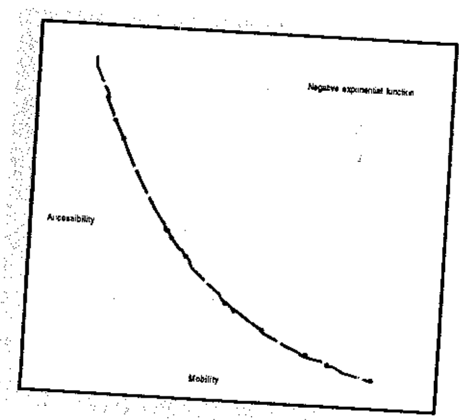

Figure 2: Negative exponential function for relative accessibility

While Formula 1 was first presented in this form by Ingram, there are significant differences in the way he used it and the way it is used in this paper:

- firstly, Ingram defines accessibility as:

  the inherent characteristic (or advantage) of a place with respect to overcoming some form of spatially operating source of friction (for example, time and/or distance) (p101).

While not disputing this definition, it is quite a different concept to that of community accessibility as presented here;

- secondly, Ingram does not use the formula in the same way as it is used in this paper. While he uses distance to distinguish a) relative accessibility between two points, and b) integral accessibility at one point, this paper uses mobility to determine community accessibility; and
- thirdly, Ingram's methodology only allows accessibility to be measured and compared within one city, while the community accessibility indicator, allows comparisons to be made within one city, between cities, and over time.

This section has looked at the principles and the criteria an indicator should possess in order to accurately portray community accessibility. A summary of these points follows (Table 1).

Table 1: A summary of the attributes of the community accessibility indicator

Criteria		How the criteria is achieved
Simplicity	- data collection	The number of data variables to be collected is limited to just one - vehicle kilometres travelled
	- assumptions	The indicator, in relying on just one data variable, requires a minimum of assumptions
	- methodological approach	Because the community accessibility indicator is based on average vehicle kilometres travelled, it is not reliant on arbitrarily defined zones
Credibility	- data collection	Data on vehicle kilometres travelled is relatively easy to collect, and often readily available
	- units of accessibility	As would be expected, the community accessibility indicator has no units
	- relationship to mobility	Accessibility increases as mobility decreases, and this indicator improves as vehicle kilometres travelled falls. This can occur with by way of a mode change to a community mode, or by changes to urban form
	- community modes	While the only data item used in the formula is vehicle kilometres travelled, the community modes are accounted for indirectly due to the strong negative relationship between their use and private motor vehicle use.

The community accessibility indicator as applied to the 46 cities in the ISTP study

Formula 1 has been used to translate the mobility data into the community accessibility indicator. Both data items are given in Table 2 alongside the 46 cities from the ISTP study. Average accessibility in the Australian and Canadian cities is nearly identical and very close to the mean of 6422 kilometres of all the cities in the study, although the spread of the Canadian cities is greater. The US cities have the lowest accessibility, and the Asian cities the highest. European cities in the study have uniformly high accessibility.

Table 2: The community accessibility indicator applied to 46 world cities

City	M (km/cap)	A	City	M (km/cap)	A
Adelaide	6 690	27.5	Boston	10 280	4.8
Brisbane	6 467	30.0	Chicago	9 525	7.3
Canberra	6 744	27.0	Denver	10 011	5.6
Melbourne	6 436	30.3	Detroit	11 239	2.6
Perth	7 203	22.4	Houston	13 016	0.8
Sydney	5 886	36.8	Los Angeles	11 587	2.1
Australian	6 571	28.8	New York	8 317	13.6
			Phoenix	11 608	2.1
Calgary	7 913	16.4	Portland	10 114	5.2
Edmonton	7 062	23.8	Sacramento	13 178	0.7
Montreal	4 746	52.2	San Diego	13 026	0.8
Ottawa	5 883	36.9	San Francisco	11 933	1.6
Toronto	5 019	48.4	Washington	11 182	2.7
Vancouver	8 361	13.3	USA	11 155	2.8
Winnipeg	6 871	25.6			
Canada	6 551	29.0	Amsterdam	3 977	63.4
			Brussels	4 864	50.6
Hong Kong	493	99.3	Copenhagen	4 558	54.9
Singapore	1 864	90.5	Frankfurt/M	5 893	36.8
Tokyo	2 103	88.0	Hamburg	5 061	47.8
Wealthy Asia	1 487	93.8	London	3 892	64.6
			Munich	4 202	60.1
Bangkok	2 664	81.5	Paris	3 459	70.8
Jakarta	1 112	96.5	Stockholm	4 638	53.8
Kuala Lumpur	4 032	62.6	Vienna	3 964	63.6
Manila	573	99.1	Zurich	5 197	45.9
Seoul	1 483	93.9	Europe	4 519	55.5
Surabaya	1 064	96.8			
Dev Asia	1 821	90.9	Median (*k*)	5 890	36.8

Data source : Kenworthy et al. (1999)

The data is diagrammatically presented in Figure 3, and it becomes clear that the cities in the regions shown have accessibility indicators which are quite closely grouped together. The trend in accessibility, from cities with the highest to cities with the lowest, goes from the wealthy Asian cities, to the developing Asian cities, followed by the European, Canadian, Australian and US cities.

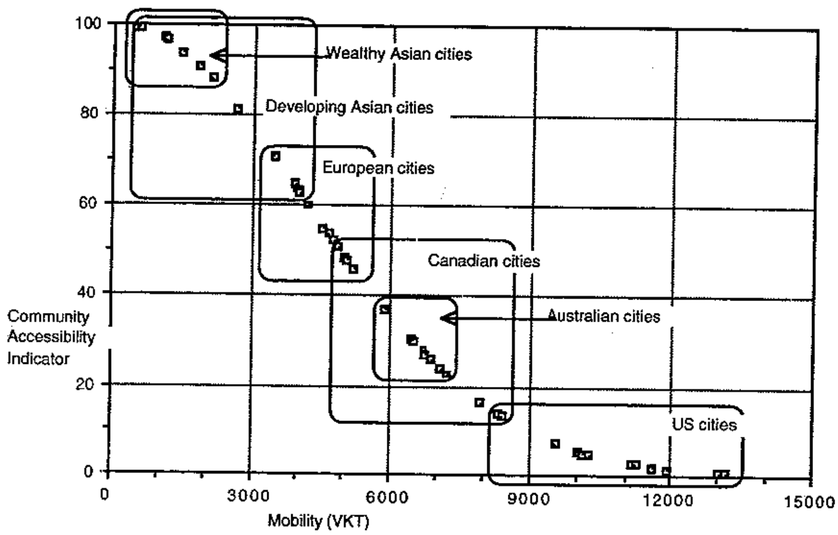

Figure 3: Relationship between the community accessibility indicator and mobility (measured as per capita VKT) graphed using Formula 1, and showing the regional groupings of 46 world cities

The following section adds further weight to the argument that community accessibility is, in fact, the reciprocal of mobility.

Accessibility comparison within a city

A major study of 8,350 households in Sydney and Melbourne looked at housing, transport and urban form characteristics across these cities. The Housing and Location Choice Survey (HALCS) provides information on the accessibility of services for a full range of household types and income levels (Newman et al., 1992). For all household types, households in the core suburbs were found to have above average accessibility, and in the fringe suburbs, below average accessibility. Furthermore, for all income groups, core and inner suburbs were found to be the most access advantaged, while the outer and fringe suburbs were the most access disadvantaged.

Generally, the HALCS study found higher income households experienced fewer access difficulties, but with a significantly worsening trend in the direction core to fringe areas observable at all income levels. However, while income seems to play a role in access to services, it was found that location can negate this advantage: all income groups, including the lowest, in the core area have better access than all income groups, including the highest, at the fringe areas. Locational disadvantage has also been recognised by other researchers:

- in Adelaide, accessibility to work generally declines with distance from the central city (Forster, 1978), cited in Black (1992);
- average fuel consumption of residents of inner Sydney suburbs was found to be 60% that of residents in the outer suburbs, while in Melbourne, inner city residents used just 41% of the fuel used by residents in the outer suburbs (Newman and Zhukov, 1996); and
- Perth census data shows a similar trend. While 8.6% of employed people travelled to work by public transport, the highest percentage of these resided in inner suburbs or in suburbs along the rail lines (ABS, 1997). In contrast, they note that 81.7% of employed people in Perth travelled to work by motor vehicle and that these came mostly from the outer suburbs where public transport was poorly developed, and were least likely to come from the inner suburbs.
- Canadian studies also show that the number of motor vehicles owned per household increases as the distance from the centre increases. Furthermore, while more than half of all households in the inner core of Toronto did not own a motor vehicle in 1996, in the outer suburbs only six percent of households did not own a motor vehicle. It is noted that mobility increases as distance from the centre increases, showing that accessibility is highest in the higher density inner core area where job and shopping opportunities are greatest, public transport more available, and where the use of public transport and cycling modes is higher (Gilbert, 1998).

These examples add further support to the general argument of this paper that accessibility and mobility are linked by a reciprocal relationship. This knowledge, together with the community accessibility indicator as a tool, can now be used by planners interested in improving accessibility in urban areas.

Conclusion

The private motor vehicle can provide a level of mobility, measured as vehicle kilometres travelled, unequalled by other transport modes. However, this paper has shown that community accessibility is lowest where mobility is highest, and that, far from being complimentary, the relationship between accessibility and mobility is one of reciprocity.

A community accessibility indicator was derived and, using data collected by researchers at the ISTP, the accessibility of 46 world cities was determined. The advantages of the community accessibility indicator can be summarised as follows: its determination requires the collection of only one variable, which is often readily available in many cities; the integrity of the data collected depends on fewer assumptions; being dimensionless, it allows easy comparison, especially between cities in different countries; and its very formula makes clear the means by which a city's or region's accessibility may be improved, namely reduce per capita vehicle kilometres travelled. As such, the community accessibility indicator provides an excellent indication of a city's or region's accessibility, and can provide a valuable tool in the area of planning and urban design. Its application to planning of corridors or regions of cities should now be attempted.

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