Structural Accessibility Layer (SAL)

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Background

Urban mobility problems, such as congestion, have been threatening the quality of life, competitiveness and sustainable development of urban areas. The need for an integrate approach to land use and transport in mobility management has been widely recognised. Accessibility measures are believed to provide a useful framework to support this integrated approach. We believe that measures of comparative accessibility by transport mode can operationalise the accessibility concept for this purpose. The comparative accessibility measure proposed here is the Structural Accessibility Layer (SAL). This instrument reveals how the urban structure enables or disables travel choice, i.e. how urban structure constraints mobility into a range of potential mobility choices (more specifically mode choice). Thus, the focus here is to understand what mode choices are made available by the urban structure in contrast to the mainstream research focussed on understanding how urban structure influences travel behaviour. Thus, distinction is made between the potential for travel provided by the urban structure and the effective travel choices made within these conditions (wider influenced by far more than the availability of choice).

SAL was developed as a design support tool for integrated land use and transport planning providing foresight for how specific land use and transport policies constraint travel choices of inhabitants and thus enable or limit particular choices. This foresight is relevant in the planning of specific issues such as new development (zoning), development density, land use mix and location of activities for master plans or other land use plans in connection to transport planning regarding, network design and reach, service level and price.

Conceptual framework and theoretical underpinnings

The Structural Accessibility Layer (SAL) is a geographical representation of comparative accessibility levels by types of transport modes to different types of opportunities generating travel (Silva, 2008). It is based on the concept of Accessibility defined as the extent to which the land use and transport system enable individuals to reach different types of opportunities (adapted from the accessibility concept presented by Geurs and Eck, 2001; 36). More specifically, the SAL proposes the concept of Structural Accessibility assessing how urban structure constraints travel choices (Silva and Pinho, 2010).

The SAL includes two main accessibility-based measures: the *diversity of activity index* and the *accessibility cluster* (the comparative measure). The first measures the accessibility level by each transport mode (non-motorized, public transport and the car), counting the number of the most relevant travel generating activity types that one can reach from a given origin (using contour measure based on the 'dissimilarity index' of Cervero and Kockelman, 1997). The accessibility cluster uses the results of the previous index to develop the comparative analysis of accessibilities by transport modes, identifying the mode choices made available to inhabitants by local land use and transport conditions.

The scheme in Figure 1 summarises the conceptual choices made in the development of the SAL with regard to the balance between soundness and plainness of the accessibility measure, central to the development of the conceptual framework of the SAL. Soundness of the basic contour measure was enhanced by using disaggregated spatial analysis (at the census track level, or grid based of at most 1km²) of accessibility levels by different transport modes to several types of activities. These choices (which to some extent are case-specific) provide the necessary detail for the thorough modulation of small scale variations of local land use and transport conditions for mobility. Aggregation of accessibility measures is used, on the other hand, to recover simplicity and the communicative qualities of the measure.

The high level of disaggregation by scale is complemented by a general indicator of accessibility for the entire study region. The range of disaggregation of activities is made usable and understandable by the measure of diversity of activities. Finally accessibility levels by transport mode are combined through a comparative measure.

Operational aspects

As referred to above the SAL compares the variety of travel generating activity types reachable by different transport modes within a giving travel time and travel price limit. Activity types considered should at least include, employment, schools, leisure, shopping, healthcare and other activities, but ideally with higher levels of disaggregation across these activity types. Accessibility limits are defined by cut-off criteria such as, travel time, travel price and travel cost limits (chosen and calibrated by, for instance, political choice or user survey).

The diversity of activity index provides an average of the number of activity types accessible, weighted by the potential frequency of use [1]. Results of this index range from zero (no accessible activities) to one (all activities are accessible).

The general form of the diversity of activity index is the following:

$$DivAct = \frac{\sum_{y}(Act_y * f_y)}{\sum_{y} f_y} \qquad (1)$$

Where, y is the activity type, Act_y a value representing the existence or not of the activity type y inside accessibility boundaries ($Act_y \in \{0; 1\}$) and f_y the potential frequency of use of the activity type.

The results of the diversity of activity index are then used to develop the comparative analysis of accessibilities by transport modes, identifying the mode choices made available to inhabitants by local land use and transport conditions. The different combinations of accessibility levels by transport modes are grouped into 7 accessibility clusters according to the mode (or modes) choice which is considered to be favoured by land use and transport conditions:

- Cluster I - NM modes;
- Cluster II - NM modes and PT;
- Cluster III - all modes;
- Cluster IV - NM modes and car;
- Cluster V – PT;
- Cluster VI - PT and car;
- Cluster VII – car.

The use of a particular transport mode is considered to be favoured by the urban structure when accessibility levels by that particular transport mode are perceived to be high, i.e. when an acceptable range of activities can be reached making its use competitive in comparison to the other modes. The choice of this threshold (one of the many case-specific choices of the SAL) is based on the potential use frequency of activities considered unnecessary according to the local perception of high accessibility levels (which can be calibrated through, for instance, political decision or surveys).

The data requirements for the implementation of the SAL include:

- Georeferenced data:
  - Population, Employment and presence or absence of each of the activity types considered, by census track;
  - Transport infrastructure layout, service level (capacity, speed, slope, frequency, etc.) and price.
- Other data such as basic data on travel behaviour (travel frequency by trip purpose, travel time by mode, O/D matrix, etc.).

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[1] The access to activity types with higher frequency of use provides higher values of diversity of activities than the access to activity types with lower frequency of use.

This data is generally purchased (or even produced) by local land use and transport authorities and thus available.

Computation of SAL can be processed with any GIS software able to develop network analysis (measuring accessibility areas along transport infrastructure), with several free and licence products available in the market. However, in the absence of specific processing scripts, advanced technical expertise in GIS is required to operationalize SAL concepts into GIS measures. In this condition, calculation times may reach out to weeks (depending on the size of the study area). On the other hand, results of the SAL are easy to understand and are very intuitive, considering both the perceptions used for accessibility and the map representation process.

Relevance for planning practice

The main outcomes of the SAL are the diversity of activity index maps for each transport mode and the cluster map (comparing accessibility levels by all transport modes). These maps identify small-scale variations on accessibility conditions provided across different census tracks of the study area. Diversity of activity maps provide important information on availability and service level and quality of each transport mode across the territory. This information provides information on spatial inequalities with regard to land use and transport opportunities with potential role in the development of public service standards for public transport, in the identification classification of the hierarchy of urban centralities, or in the definition of priorities for mixed development strategies. The cluster map provides the baseline information on potential mode choices, categorizing relative competitiveness of different transport modes and thereby identifying areas where inhabitants clearly have no competitive alternative to the car. For illustrative purposes, see Figure 3 providing the relative competitiveness of the car, public transport and walking for the Greater Oporto.

So far, the SAL has not been used in planning practice, having been applied within research contexts to analyse accessibility conditions of Greater Oporto (Silva, 2008; Silva and Pinho, 2010) and Copenhagen Metropolitan Area (Pinho, 2010). The first application, to Greater Oporto, was designed to test and validate the SAL for planning practice, both for improving the understanding of accessibility conditions and for supporting the development of planning strategies. Research results obtained were validated through expert interviews with very positive results. The second application was within a research on the influence of urban structure on travel behaviour were the role of urban structure as constraint and influence of travel behaviour was analysed comparing monocentric and polycentric urban structures. The diversity of activity indicator was shown to have significant influence on travel behaviour in multivariate regression models considering urban structure and personal characteristics as independent variables of travel distance and mode share. In addition, the results of this research reinforced the concept of structural accessibility put forward with the SAL, revealing the role of urban structure in constraining travel choices, enabling and, in particular, disabling particular travel choices.

Strengths and limitations

The SAL was built with high concerns on usability taking into consideration the 'rigour-relevance dilemma' (see for instance, Hoetjes, 2007; Brömmelstroet, 2007). Figure 3 summarized the main debate around potential and limitations, in theory and practice, of the SAL regarding the main choices made in its development. So, the use of special representation (via GIS) and of a regional scale of analysis are responsible for providing an integrated approach and view on the urban structure at the same time surpassing administrative boundaries and enabling the picturing of small scale variations. However, the regional perspective of the tool disables micro scale analysis in spite of the ability to identify small scale variations. Another important choice within the rigour-relevance dilemma was the use of a simple accessibility measure (contour measure) providing a tool which is easy to communicate and understand but does not consider some of the complexity of accessibility such as distance decay or competition effects. This choice is balanced with the high disaggregation level of analysis (regarding, spatial scale, transport modes and activity types) which enhances the understanding of the urban structure conditions, but, at the same time limits the simplicity of the tool. Again, the complexity introduced by the high disaggregation level is reduced through the introduction of an aggregate measure (the accessibility cluster comparing accessibility across transport modes) which synthetises much of the disperse information and provides a framework for thought facilitating the development of objectives and the testing of different scenarios. Finally, the SAL is highly adaptable to local conditions since it leaves a large number of issues to be defined and fine-tuned locally, when calibrating the case specific SAL, however, this adaptability and the disaggregation level of the tool are highly dependent on the availability of data which may limit its use.

So far, the SAL has not been used in planning practice but its potential has been assessed resorting to semi-structured interviews to experts in related core fields (Silva, 2008). This assessment aimed to discuss the *robustness* as analysis tool, the *usefulness* as design support tool; and, the *applicability* by local planners and politicians; in summary the potential of the SAL for planning practice. The main advantages of the SAL referred to by experts were the ease of use, understanding and communicating of the tool and the coherence of the measures. Some authors recognize the ability to support thought for policy development, especially with regard to integration. The main advantage of the SAL was ascribed to its synthesising capacity as a diagnosis tool and to the ability of testing different policy scenarios. Many of the aspect referred to as advantages are also responsible for some disadvantages. For instance the capacity of synthesising information of the diagnosis tool is responsible for the loss of important detail. The regional scale of analysis limits micro-scale approaches. Finally the SAL is data and time consuming and therefore expensive, being out of reach of average local authorities.

References

Brömmelstroet, M. (2007). *Desired characteristics of expert knowledge to support the integration of land use and transport planning*. In Proceeding of the Bijdrage aan het Colloquium Vervoersplanologisch Speurwerk 2007, Antwerpen; copy available from M Brömmelstroet, Amsterdam Institute for Metropolitan and International Development Studies, Amsterdam

Cervero, R. and Kockelman, K. (1997). *Travel demand and the 3Ds: Density, diversity, and design*. Transportation Research Part D: Transport and Environment, Vol. 2 (3): 199-219

Geurs K. and Eck, J. (2001). *Accessibility measures: review and applications*. Evaluation of accessibility impacts of land-use-transport scenarios, and related social and economic impacts National Institute of Public Health and the Environment.

Hoetjes, P. (2007). *Planning as a Design Science – Design Science as a Methodology*. In Proceeding of the AESOP 2007, Naples; copy available from P Hoetjes, Amsterdam Institute for Metropolitan and International Development Studies, Amsterdam

Pinho, P., Silva, C., Næss, P., Sousa, F., Reis, J., Giulietti, F., Torres, M. (2010). *MOPUS - Mobility Patterns and Urban Structure*. Porto, Faculty of Engineering of the University of Porto

Silva, C. (2008). *Comparative Accessibility for Mobility Management. The Structural Accessibility Layer.* Faculty of Engineering of the University of Porto. Porto, University of Porto. PhD thesis.

Silva, C., and Pinho, P. (2010). The Structural Accessibility Layer (SAL): revealing how urban structure constraints travel choice. Environment and Planning A, 42: 2735-2752.

Figures

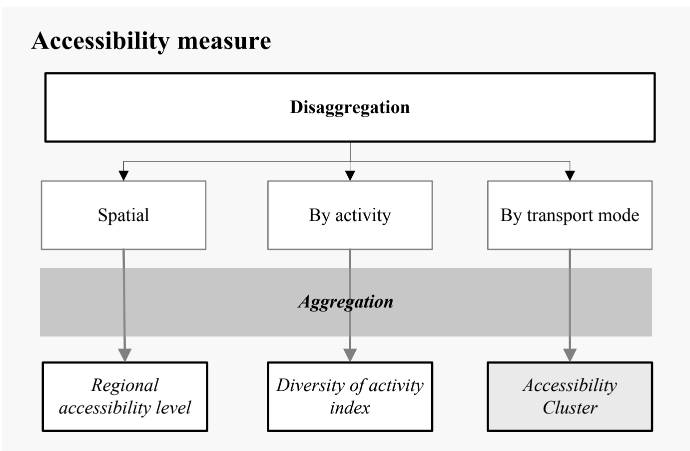

Figure 1 Balance between soundness and plainness of the accessibility measure (Source: Silva, 2008)

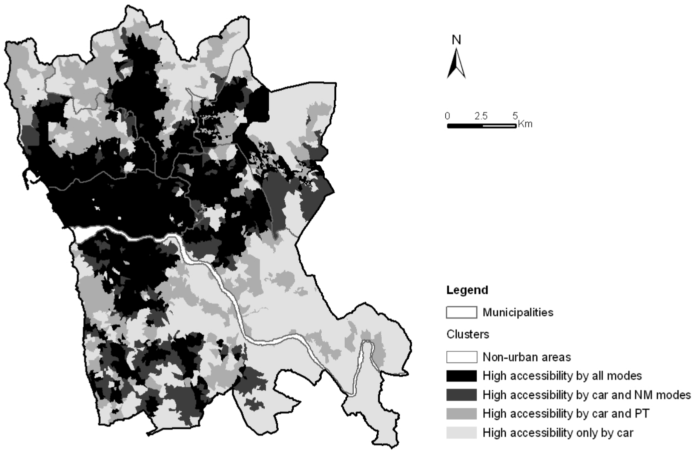

Figure 2 Clusters of accessibility in the Greater Oporto

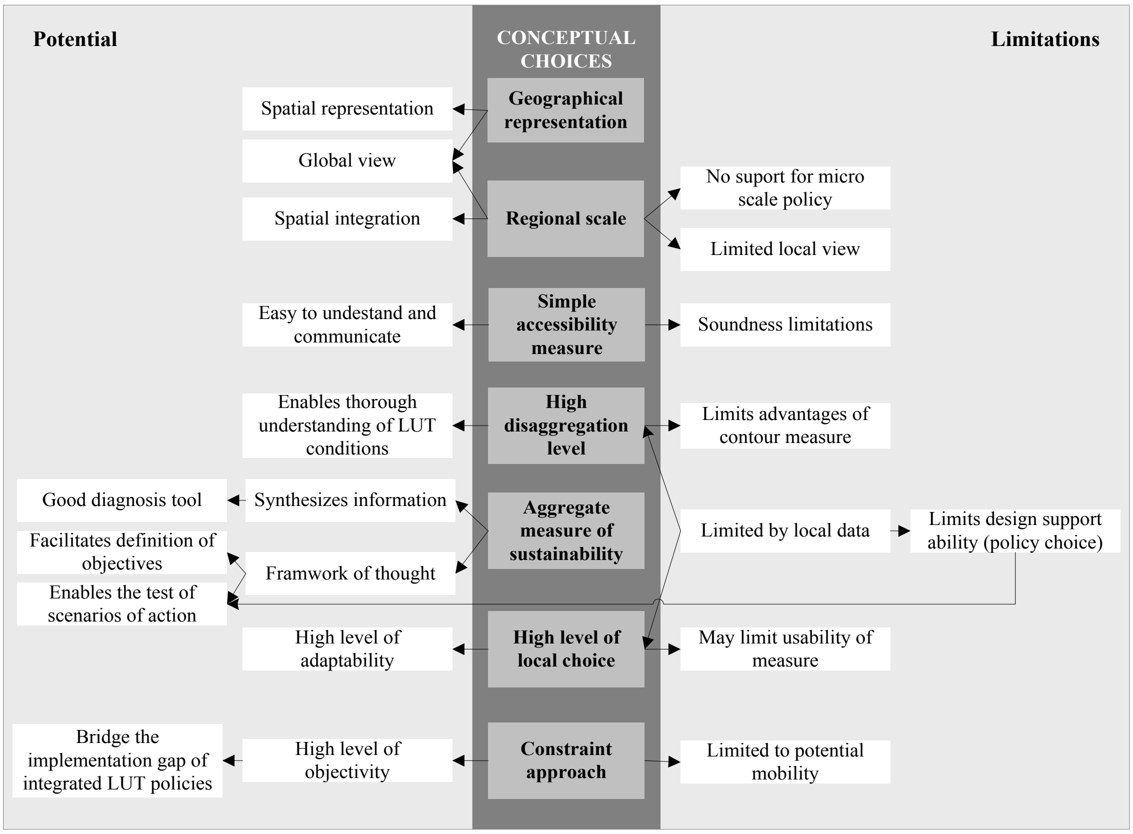

Figure 3 Potentials and limitations of SAL (Source: Silva, 2008)