Accessibility

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UFABC – WORKSHOP 15-MINUTE CITY

17-18 SEPTEMBER 2024

Objectives

- Understand the concept of accessibility
- understand the various ways that accessibility can be measured;
- get familiar with the types of metrics available and their use; and
- understand the most popular accessibility metrics.
- Get insight on how it can be used as a tool for the 15mC

This session:

- The concept of accessibility
- Components of accessibility
- Types of accessibility metrics
- Location/ placed-based accessibility measures

What is accessibility?

How do YOU use the term accessibility?

Can you define it?

"Accessibility [...] is a slippery notion [...] one of those common terms that everyone uses until faced with the problem of defining and measuring it."

Gould (1969, page 64)

Gould, P.R., 1969. Spatial Diffusion, Resource Paper No. 4.

Accessibility

"Accessibility is the geographic definition of opportunity.

The opportunity individuals have to participate in necessary or desired activities, or to explore new ones, is contingent upon their ability to reach the right places at the appropriate times and with reasonable expenditure of resources and effort."

Helen Couclelis (2000, page 1)

Couclelis, H. (2000). From sustainable transportation to sustainable accessibility: Can we avoid a new tragedy of the commons?. In Information, place, and cyberspace (pp. 341-356). Springer, Berlin, Heidelberg.

Accessibility

"accessibility is defined as the potential of opportunities for interaction"
(Hansen, 1959: 73)

Accessibility = ease of access of opportunities

Now we agree on the definition, can we identify the elements that make a good or bad accessibility?

Accessibility

Concept links land use and transportation:

"My stumbling ended with a true "aha" moment when I came across the concept of accessibility: here was a way to think about my two questions, to understand and indeed measure the relationships between transportation investments and land development as they affect daily human life"

Susan Handy (2000, page 1)

Handy, S. (2020). Is accessibility an idea whose time has finally come?. *Transportation Research Part D: Transport and Environment*, *83*, 102319.

Accessibility

"In the geographic literature accessibility has been studied mostly as a ***property of individual locations*** or as a ***locational requirement of individuals or groups***.

A location […] is accessible if it is easily reachable from most other locations.

[…] accessibility is a critical consideration for people who typically require access to jobs, services and other activities and opportunities.

[…] there is a clear spatial (and eventually also temporal) distinction between an origin, where the need for a contact originates, and a destination, where that need is satisfied, the two being separated by a physical (spatial or spatiotemporal) distance.

Accessibility then is a question of ***how easy*** (fast, cheap, comfortable…) it may be for that distance to be overcome, and the answer has traditionally been sought in the availability and quality of transportation."

Couclelis (2000), page 1

Couclelis, H. (2000). From sustainable transportation to sustainable accessibility: Can we avoid a new tragedy of the commons?. In Information, place, and cyberspace (pp. 341-356). Springer, Berlin, Heidelberg.

What is accessibility?

Is this concept related to 'universal accessibility'?

How?

Difference between mobility and accessibility?

Components of accessibility

Now we know what accessibility is, can we identify the elements that are define it?

What makes good or bad accessibility?

[discussion]

Components of accessibility

Handy, S. L., & Niemeier, D. A. (1997). Measuring Accessibility: An Exploration of Issues and Alternatives. Environment and Planning A: Economy and Space, 29(7), 1175–1194. https://doi.org/10.1068/a291175

"Accessibility is determined by the spatial distribution of potential destinations, the ease of reaching each destination, and the magnitude, quality, and character of the activities found there.

Travel cost is central: the less time and money spent in travel, the more places that can be reached within a certain budget and the greater the accessibility.

Destination choice is also crucial: the more destinations, and the greater the variety, the higher the level of accessibility.

Travel choice is equally important: the wider the variety of modes for getting to a particular destination, the greater the choice and the greater the accessibility.

Accessibility is thus determined both by patterns of land use and by the nature of the transportation system, although two people in the same place may evaluate their accessibility differently, as wants and tastes vary."

Handy and Neimeier (1997)

Components of accessibility

Geurs and van Wee (2004) classify the componentes of accessibility in 4 types:

- **Land-use component**
  - Amount, quality and spatial distribution opportunities supplied at each destination (jobs, shops, health, social, recreational)
  - Demand for these opportunity at origin (residential locations of population)
  - Confrontation between supply and demand for opportunities (competition for activities with restricted capacity – for example jobs and places at schools
- **Transportation component**: "expressed as the disutility for an individual to cover the distance between an origin and a destination using a specific transport mode"
  - Time: travel, waiting, parking
  - Costs: fixed, variable
  - Effort: reliability, level of comfort, accident risk
  - Infrastructure: location and characteristics (capacity, timetables, road conditions)

Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, *12*(2), 127-140.

Components of accessibility

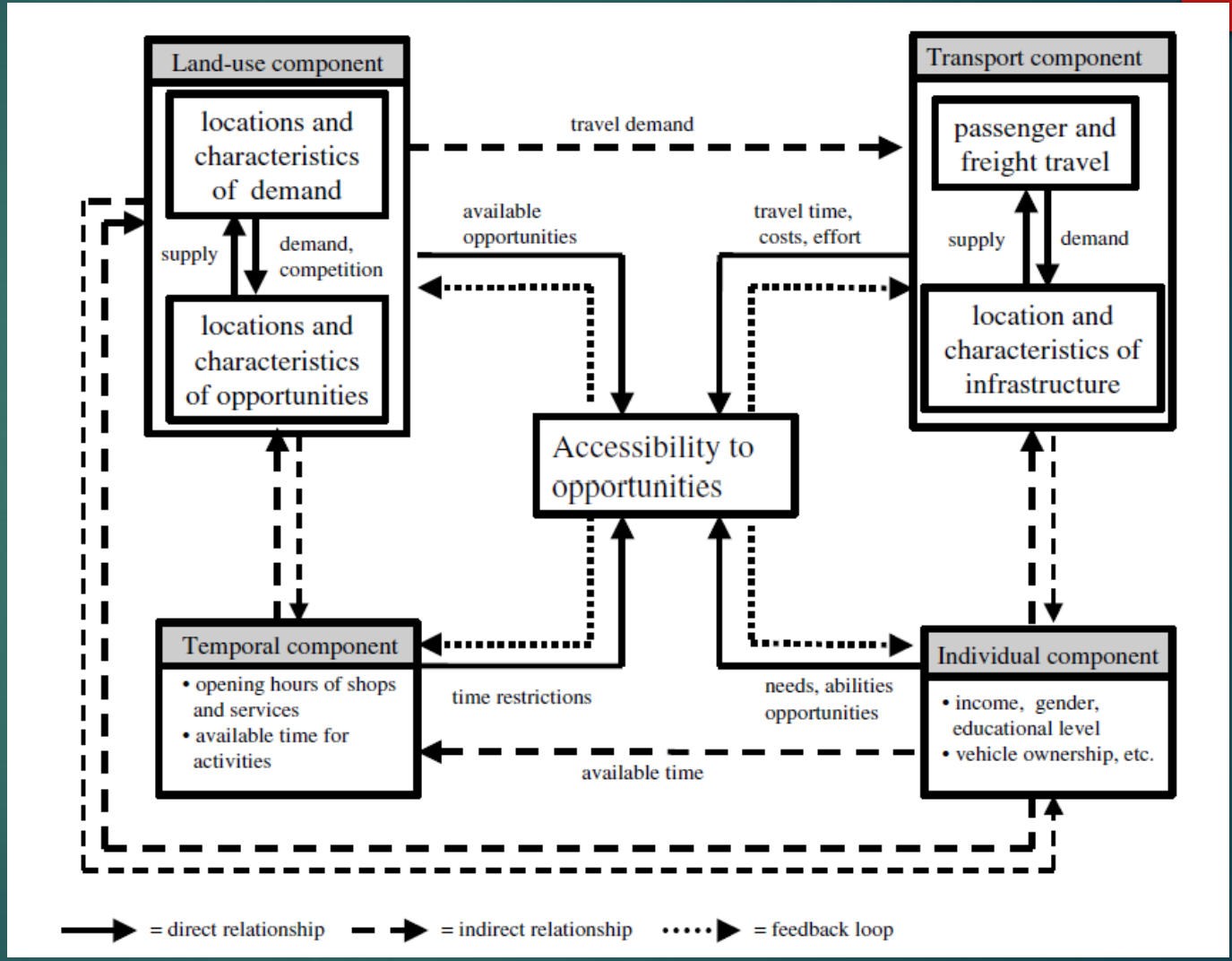
Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, *12*(2), 127-140.

Geurs and van Wee (2004) 4 types of componentes of accessibility (continuation):

- **Temporal component**
  - Time constraints: availability of opportunities at different times of day/week
  - Time available for individuals to participate in certain activities (shopping, entertainment)
- **Individual component**: individual characteristics that influence one's level of access to transport modes and opportunities
  - Needs: depend on age, income, educational level, household situation
  - Abilities: depends on people physical condition, availability of travel modes
  - Opportunities: depend on income, travel budget, educational level,
    - Examples: skills to quality for specific jobs that are spatially accessible

Components of accessibility

Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, *12*(2), 127-140.



Metrics

Now we know what are the components of accessibility, can we think how we can measure it?

And why do we want to measure it?

[discussion]

Accessibility metrics

Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, *12*(2), 127-140.

- Many components to consider!
- Availability of data on some aspects is an issue
- Different metrics and methods that incorporate some but not all these components

Perspectives on accessibility and components

Measure	Component			
	Transport component	Land-use component	Temporal component	Individual component
Infrastructure-based measures	Travelling speed; vehicle-hours lost in congestion		Peak-hour period; 24-h period	Trip-based stratification, e.g. home-to-work, business
Location-based measures	Travel time and or costs between locations of activities	Amount and spatial distribution of the demand for and/or supply of opportunities	Travel time and costs may differ, e.g. between hours of the day, between days of the week, or seasons	Stratification of the population (e.g. by income, educational level)
Person-based measures	Travel time between locations of activities	Amount and spatial distribution of supplied opportunities	Temporal constraints for activities and time available for activities	Accessibility is analysed at individual level
Utility-based measures	Travel costs between locations of activities	Amount and spatial distribution of supplied opportunities	Travel time and costs may differ, e.g. between hours of the day, between days of the week, or seasons	Utility is derived at the individual or homogeneous population group level

Types of accessibility measures

Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, *12*(2), 127-140.

Infrastructure-based measures (transport planning)

Performance or service-level of transport infrastructure. Levels of congestion, average travel speed on road network

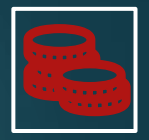
Location-based measures (urban planning and geography)

Portray the level of accessibility of locations

Person-based measures (time-geography)

Portray accessibility at the individual level.

Limitations on individual's freedom in the environment (time and spatial constraints)



Utility-based measures (economics)

Analyses people's economic benefit from access to spatially distributed activities

Types of accessibility measures

- Focus on location / place-based measures

Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, *12*(2), 127-140.

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Location or place-based measures

→ **Measure the accessibility of a place or location**

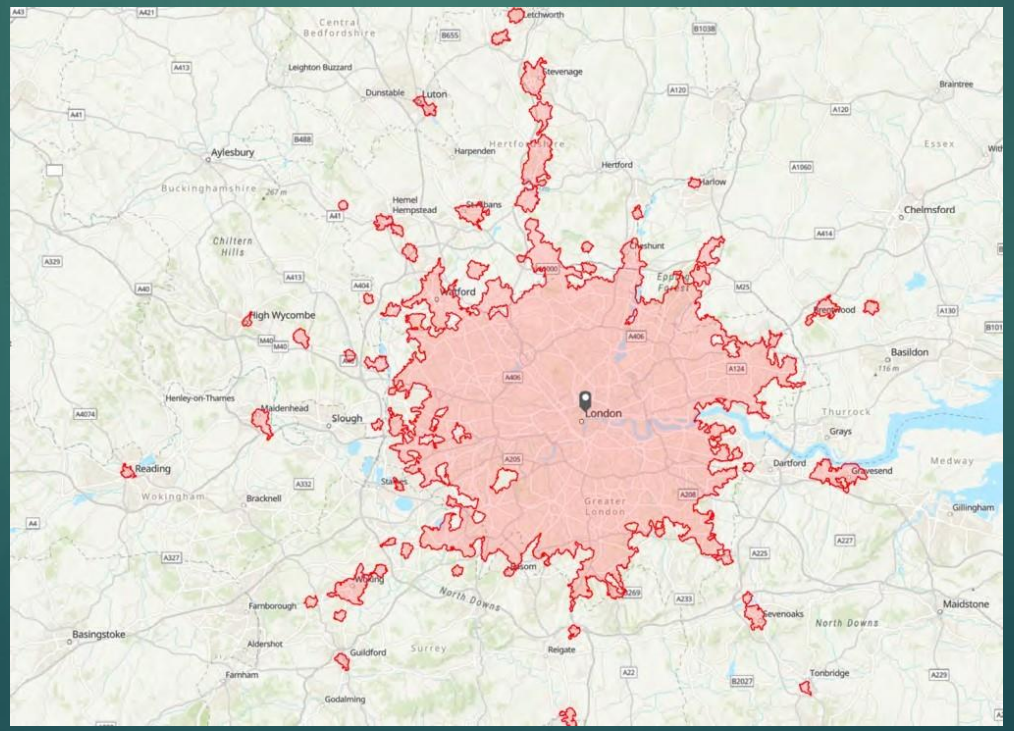
Distance or connectivity measures

- Relative accessibility: the degree to which two places or points are connected.
- Distance measures: maximum travel time or distance to a given location or to transport infrastructure.
- For multiple destinations, a ***contour or isochronic measure*** is derived

Isochrone maps

- In its simplest form, accessibility is represented as the area of reach within a certain time
- Isochrone maps (also known as *travel time maps)* - show all areas reachable within a specified limit by a specified mode of transport from a given location

See: https://traveltime.com/blog/what-is-an-isochrone

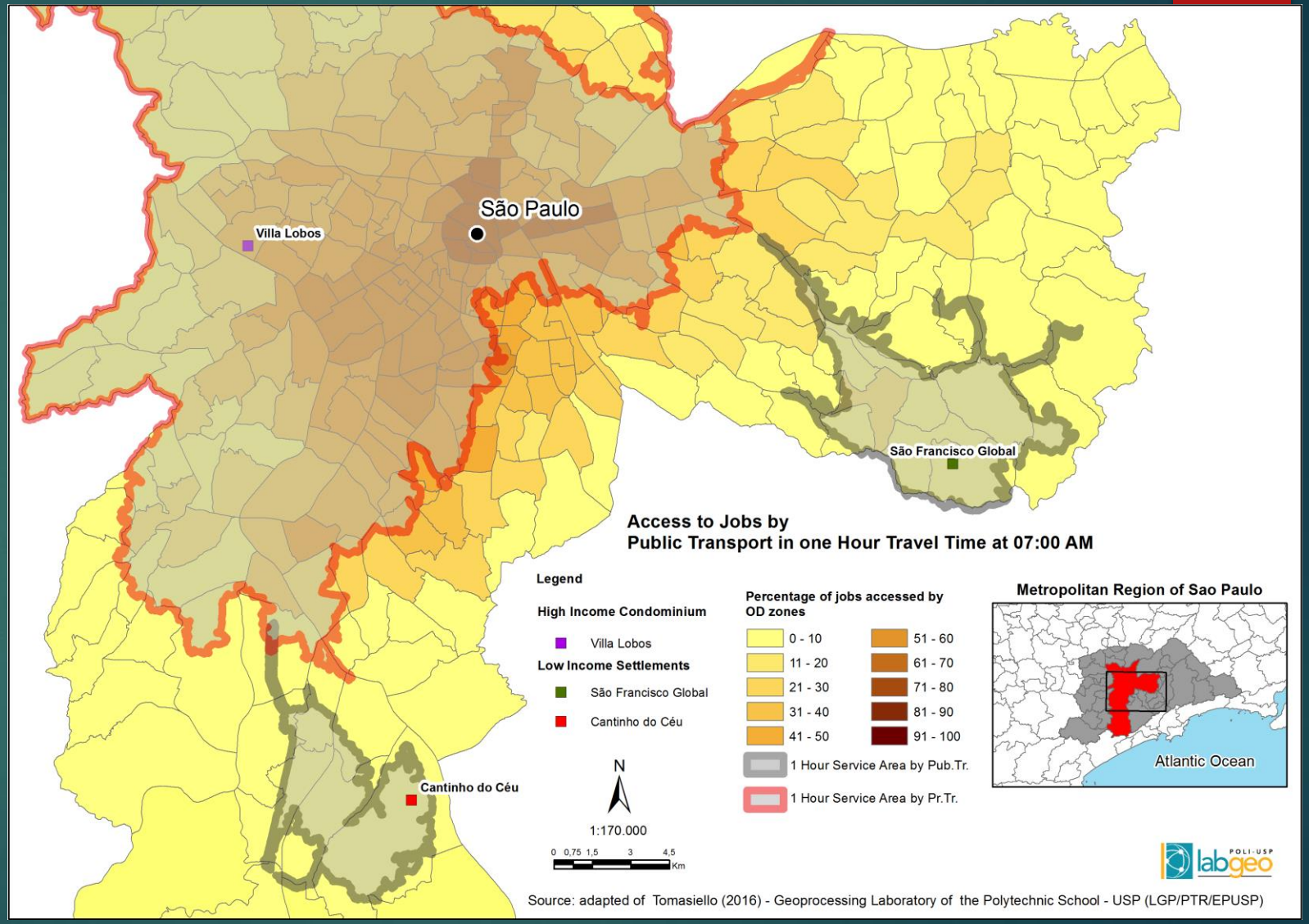


1-hour travel time by public transport from a starting point in Central London

Source: https://traveltime.com/blog/free-isochrone-map-generator

Isochrone maps

Inequality example



Isochrone maps

Understand centroids and boundaries: https://storymaps.arcgis.com/stories/41743d0d5364488fb51d795d65b40b37

- Usually used as a spatial representation of accessibility, but the area can be used as a way to quantify accessibility (metric).
- Consider transport network and travel time (as well as trip time) but **does not include land use**
- One can reach a large area that is empty
- Shows *mobility* rather than *accessibility*

  Note: term accessibility is used in the literature nevertheless!

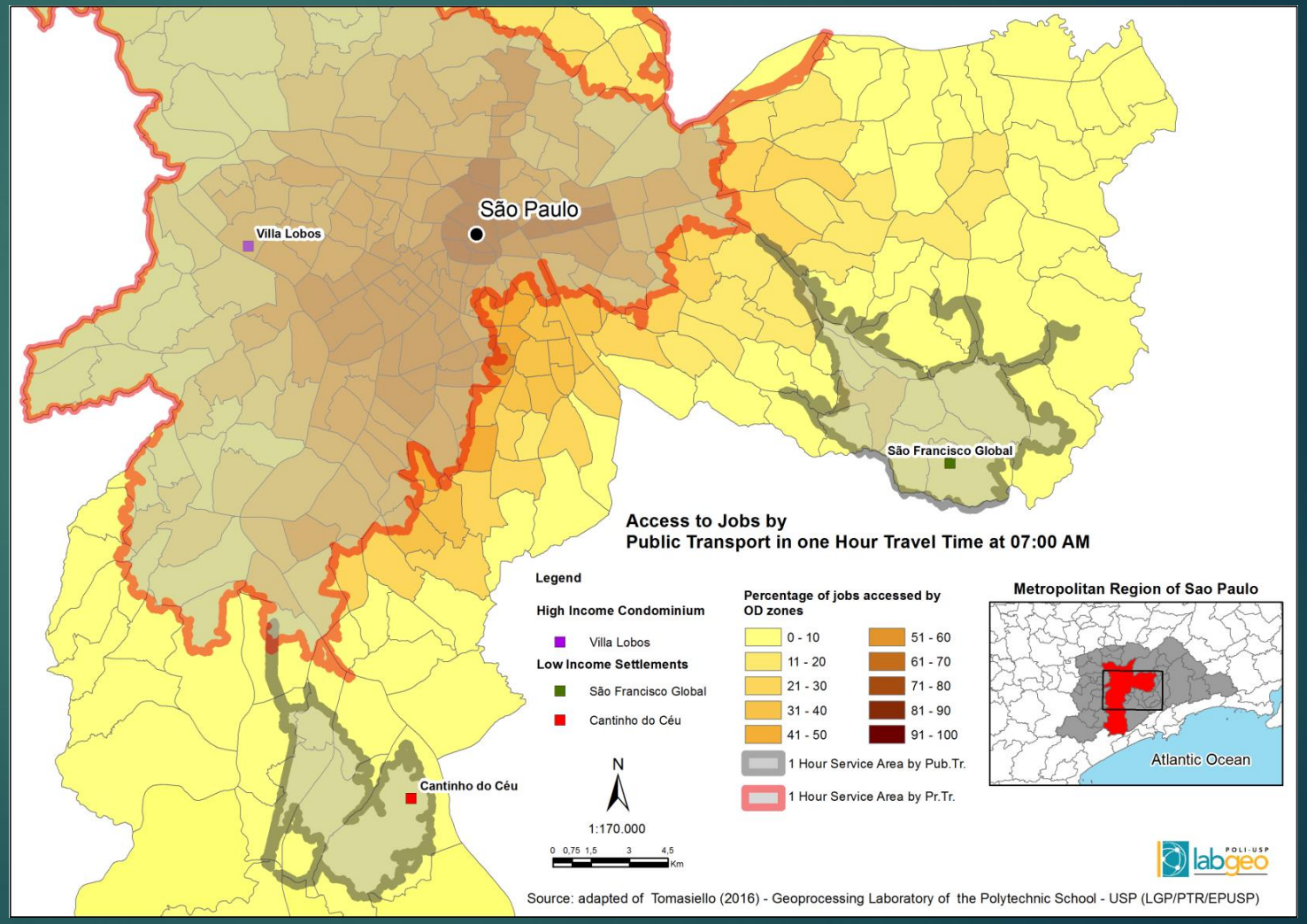
- Maps are built around points
  - Useful to portray mobility of individuals
  - Target housing areas (gated communities, informal settlements) as in the case of São Paulo, arbitrary like the case of London.
- Centroids of areal units can be used to represent areas.
  - Common approach to calculate accessibility (not only isochrone maps)

Cummulative Opportunities

- One of the simplest accessibility measures
- They count the number of opportunities reached within a given travel time
- Distance can also be used but less common
- The use of time instead of distance incorporates the effects of some aspects that make travel easier or more difficult – examples?
- Cut-off time is defined for each measurement: 30 min, 60 min, 90 min

Cummulative

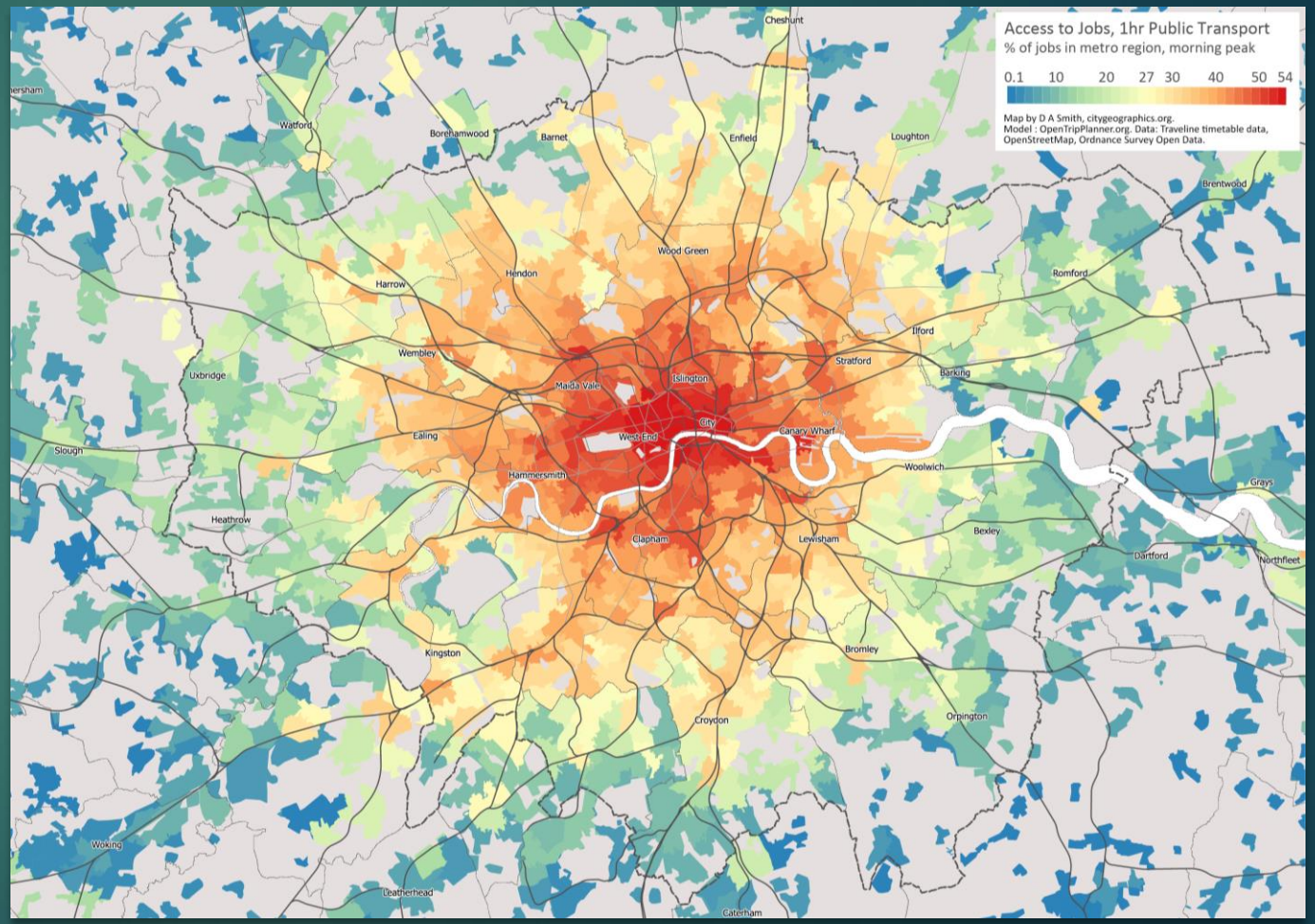
Inequality example



Cummulative Opportunities

- Cut-off time is defined for each measurement: 30 min, 60 min, 90 min
- All destinations within the cut-off time are weighted equally and ignores differences in travel time
- Emphasis on the number of potential destinations or opportunities rather than their distance
- This measure gives a sense of the range of choice available to residents
- For example:
  - the number of different stores from which they can choose
  - the number of jobs they can access within a certain time based on their home location
- Very widely adopted mainly due to the ease of interpreting it

Can you think of any limitations with this way of measuring accessibility?



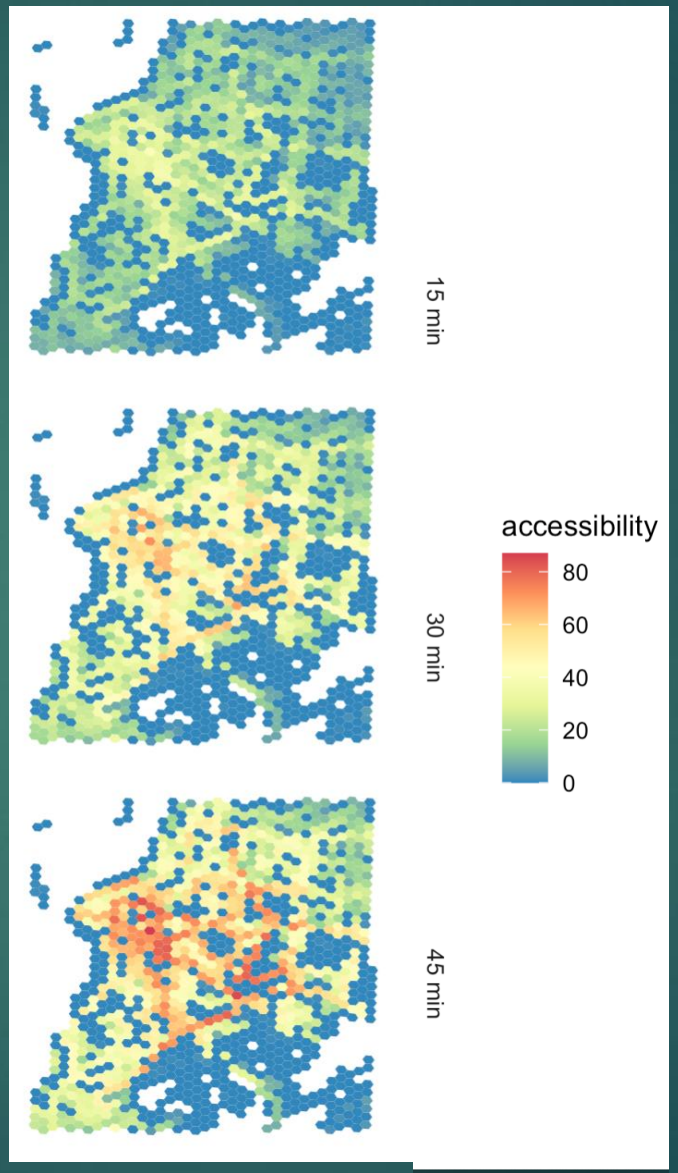
Map by Dr Duncan Smith

https://citygeographics.org/2016/09/02/open-source-public-transport-accessibility-modelling/

Accessibility to schools

Image of accessibility in Porto Alegre, Brazil by Dr Marcus Saraiva,

Source: https://github.com/ipeaGIT/r5r/issues/169



Potential (gravity-based) measures

- Potential accessibility measures are more complex
- Also called gravity-based measures, originates from the gravity model for trip distribution
- Principle is that the accessibility between two locations declines with increasing of distance, time, and cost between them, but is positively associated with the amount of activity at each location
- Incorporates notions of attraction and impedance
- These are translated in the measure by giving weights to opportunities (addressing a limitation of the cumulative accessibility metric)

Potential (gravity-based) measures

- Accessibility, A; for residents of zone i is then measured as

$$A_i = \sum_j a_j \mathrm{f}(t_{ij}) ,$$

- where aj is the activity in zone j, t is travel time, distance, or cost from zone i to zone j, and f (tij) is an impedance function.
- The closer the opportunity, the more it contributes to accessibility; the larger the opportunity, the more it contributes to accessibility.

Potential (gravity-based) measures

- Unlike the cumulative measure that counts the opportunities accessible within a given time, the potential measure does not require a pre-defined time limit
- It measures the quantity of opportunities as a function of travel time or travel cost
- Although theoretically more complete, the metric is more difficult to interpret because one cannot grasp the practical meaning of the accessibility figures

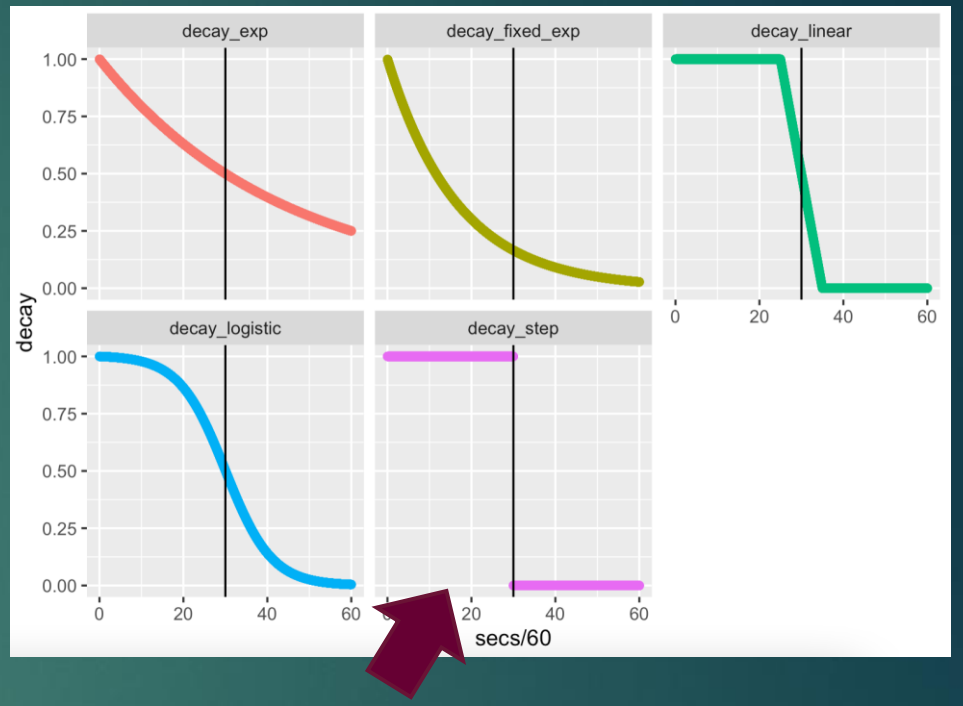
Impedance functions

Different decay functions are used to represent impedance

A good resource on decay functions for accessibility measures:

https://docs.conveyal.com/learn-more/decay-functions

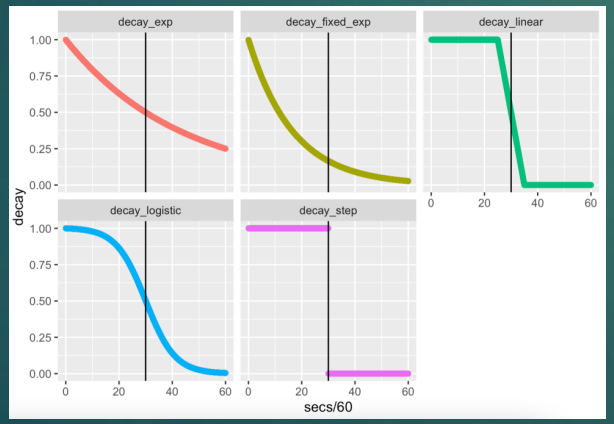
- The impedance function may take many forms
- The most used function is the negative exponential form due to its alignment to travel behaviour theory



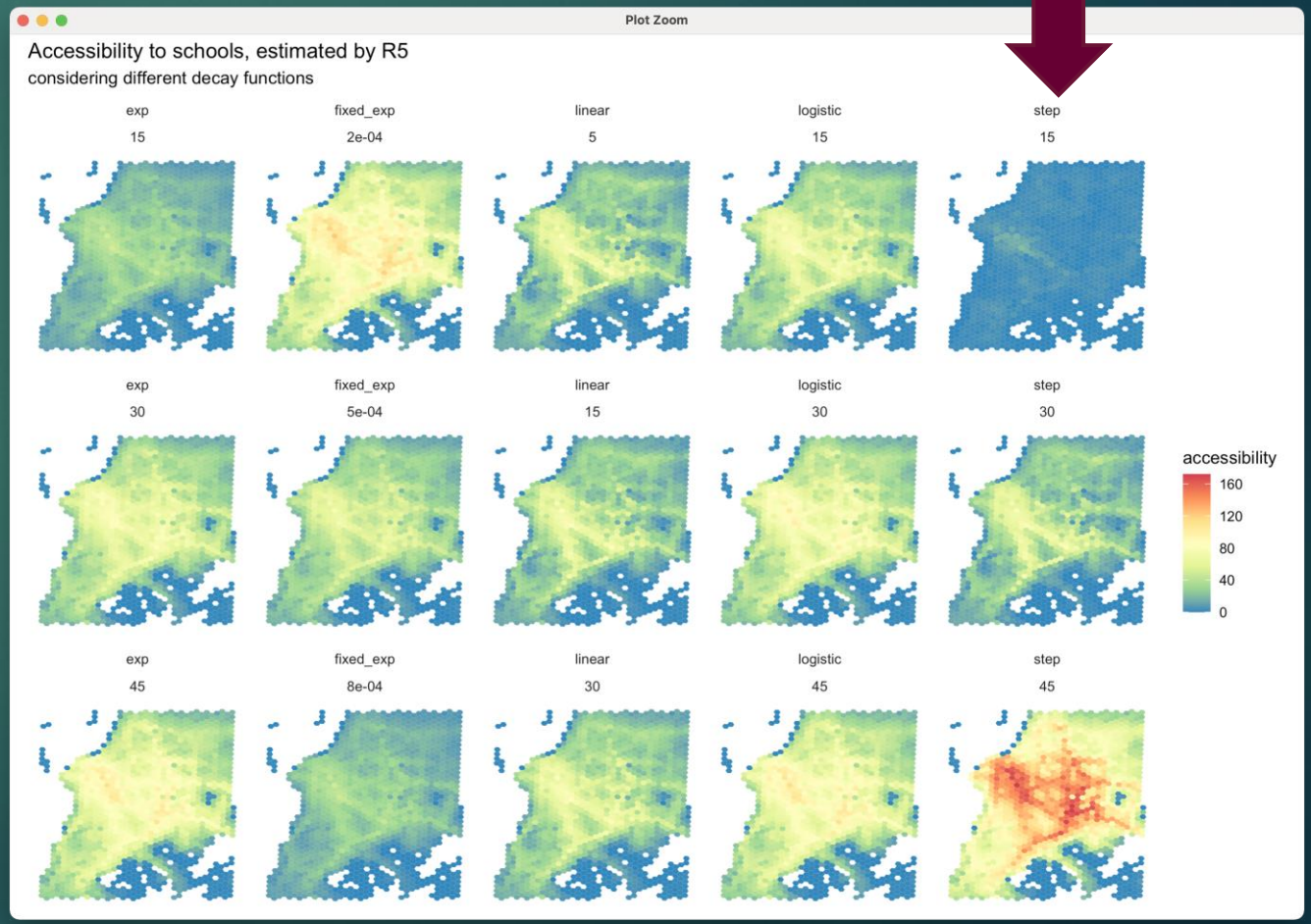
Note: A cumulative opportunities measure can be understood as a specific form of the potential (gravity-based) measure, with the impedance function equal to one if the opportunity is within the (pre-determined) travel time limit, and zero otherwise

Impedance function: effects on results

Images by Dr Marcus Saraiva, source: https://github.com/ipeaGIT/r5r/issues/169



Cummulative opportunities



Workshop Day 2

Measuring accessibility and assessing the feasibility of a 15-minute city

- Slides will be available in GitHub together with materials for tomorrow's practical
- If you are happy to use the computer labs [recommneded], then you don't need to worry about extra software
- If you plan to use your laptop run the analysis using your own computer, then you must install the following software:
  - R
  - Rstudio
  - Java Development Kit (JDK) 21
  - r5r package

Information on software at: https://github.com/ipeaGIT/r5r