Urban Accessibility: Perception, Measurement and Equitable Provision

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Defining the Strategic Objectives in Urban Transport Policy

- The objectives underlying Urban Transport policies are frequently defined on the basis of desirable saturation levels or speeds of car traffic or public transport,
  - with constraints related to emissions or atmospheric concentration of pollutants.
- This may be correct at the tactical level but is formally wrong as instrument-related variables are used to define the essential attributes of the policies. **Strategic objectives are required!**
- It is also inequitable because it fails to address the very significant differences of levels of access to jobs and urban facilities across the geographical and sociological spaces in the urban area
- Strategic Objectives must be defined in terms of those **levels of access**

The perception of accessibility to a single target

- Current language includes words that very neatly represent the ease of access to a specific destination:
  - **Near (close to) and far**

- We have made a survey to several hundred persons in Lisbon, asking them about their (travel time) thresholds for application of these terms for up to 6 types of facility

- Different thresholds for different types of facilities were found, and also for different modes of travel to the same type of facility

Some average values of “Near” and “Far” thresholds

(all modes)

Target	Average “Near" perception [minutes]	Average "Far" perception [minutes]	Average ratio betw. "Far" and “Near”	Total number of answers
Global Average	8,18	18,48	2,88	14882
Bus stop	6,04	14,91	3,04	1195
Subway station	7,60	16,67	2,74	1125
Train station	8,53	18,08	2,56	1177
ATM	5,78	14,22	3,12	1222
Grocery stores	6,78	15,96	2,82	898
Supermarkets	7,88	18,42	2,73	1101
Pharmacies	6,77	16,34	2,90	982
Health Centers	8,46	19,35	2,82	910
Public services (i.e. tax office)	9,63	21,15	2,73	582
Coffee houses	5,99	15,19	3,41	825
Restaurants	9,88	22,11	3,09	647
Bars and Clubs	13,99	27,48	2,67	305
Bookstores	10,51	23,10	2,82	324
Clothing stores	10,82	24,06	2,84	453
Retail stores (technology, entertainment and services)	11,02	24,06	2,80	336
Cinemas	11,15	24,82	2,90	400

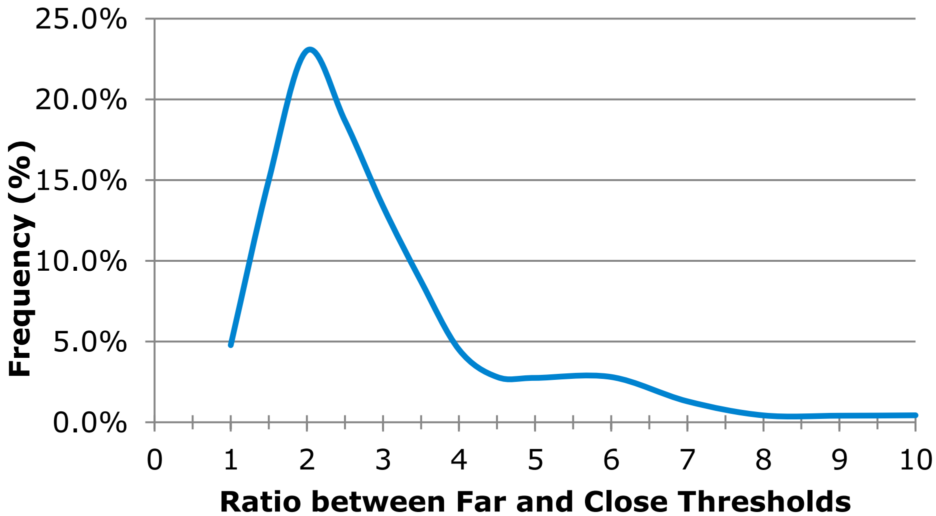
Some average values of “Near” and “Far” thresholds

(values by mode)

Land Uses	Walk: Average "Close" perception [minutes]	Walk: Average "Far" perception [minutes]	Private Car: Average "Close" perception [minutes]	Private Car: Average "Far" perception [minutes]	Public Transport: Average "Close" perception [minutes]	Public Transport: Average "Far" perception [minutes]
Grocery stores	5,93	14,49	7,80	18,21	15,18	25,18
Supermarkets	7,16	17,14	7,90	18,44	10,36	21,39
Pharmacies	6,43	15,87	6,88	16,55	10,71	19,44
Public services (i.e. tax office)	8,53	19,17	9,19	20,58	13,09	24,39
Coffee houses	5,03	13,31	9,35	21,64	12,58	25,54
Restaurants	6,70	15,90	11,57	22,75	11,86	27,57
Bars and Clubs	10,53	17,83	13,74	25,90	16,55	25,02
Clothing stores	8,54	19,42	10,88	23,43	13,12	25,62
Bookstores	7,89	19,09	10,53	22,20	14,17	27,90
Retail stores (technology, entertainment and services)	8,18	18,57	10,47	23,10	14,67	27,44

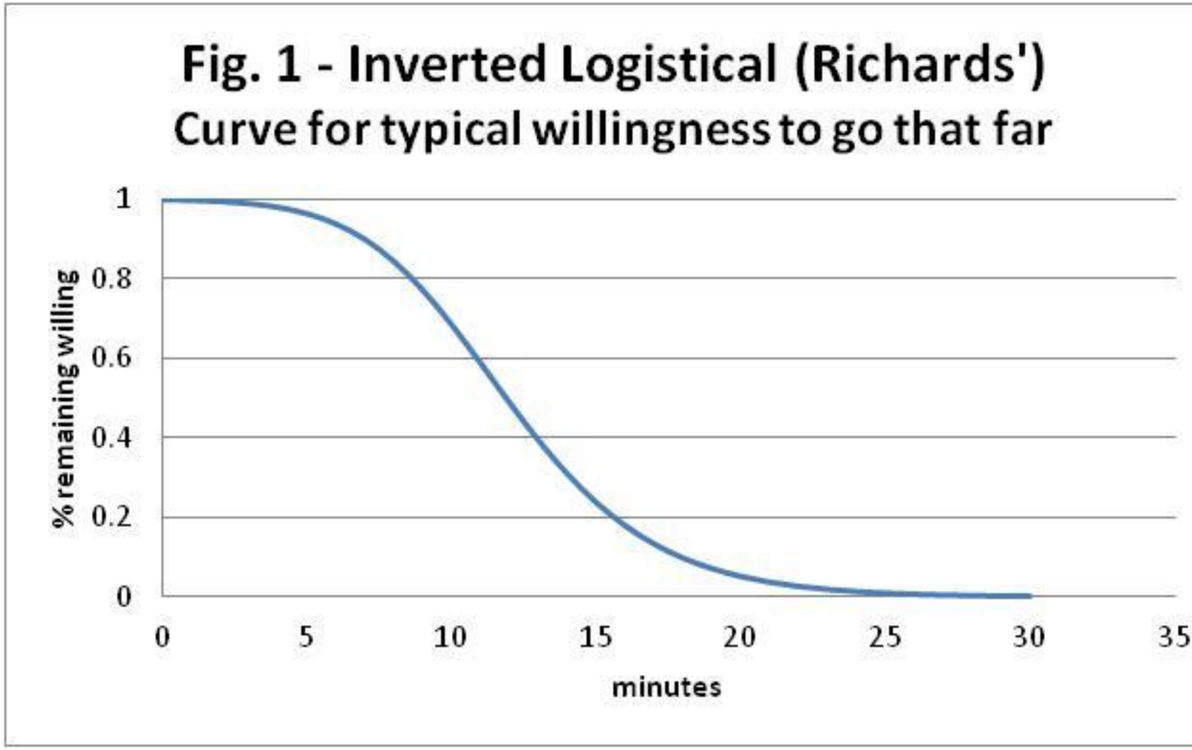
Interesting remarks

- The perceptions of these thresholds are always in growing values from walking to private car to public transport
- In average, almost the same ratio car / walk as public transport / car (in the range 1.15 – 1.35)
- There is a rather stable ratio between the “far” and the “near” thresholds, between 2 and 3 for the majority of people (average = 2.8)



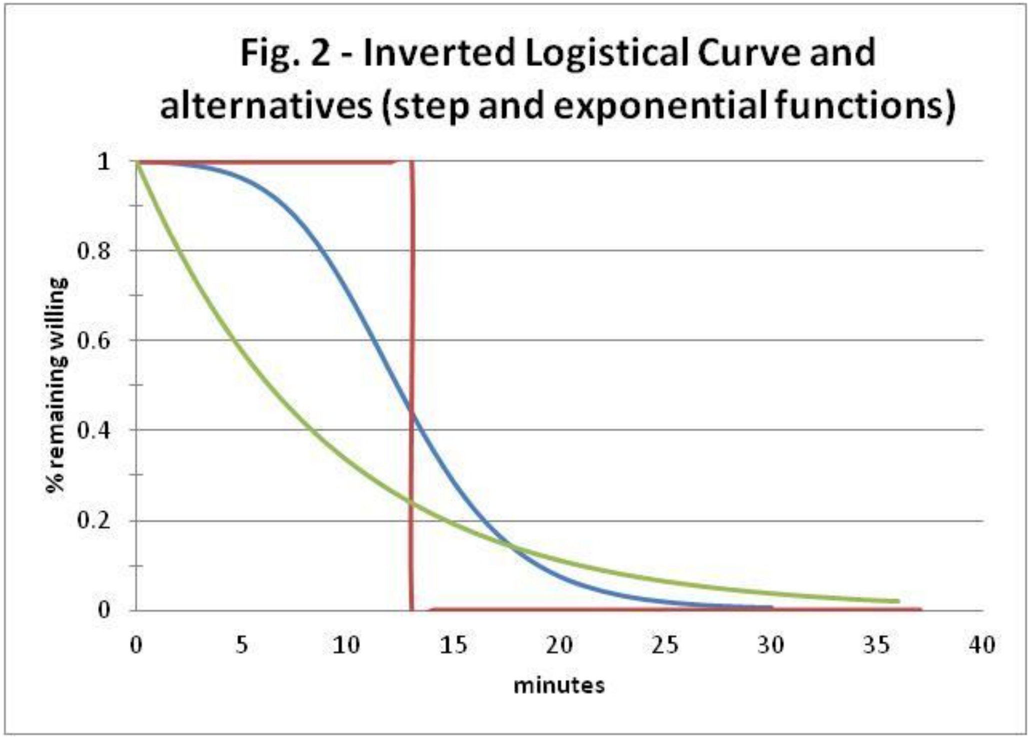
The distance decay curve

- The curve that best reproduces the decay (of attraction = perception of accessibility) with distance/travel time has a logistic shape
- We have systematically obtained better calibration results with this shape than with any other of those mentioned in the literature



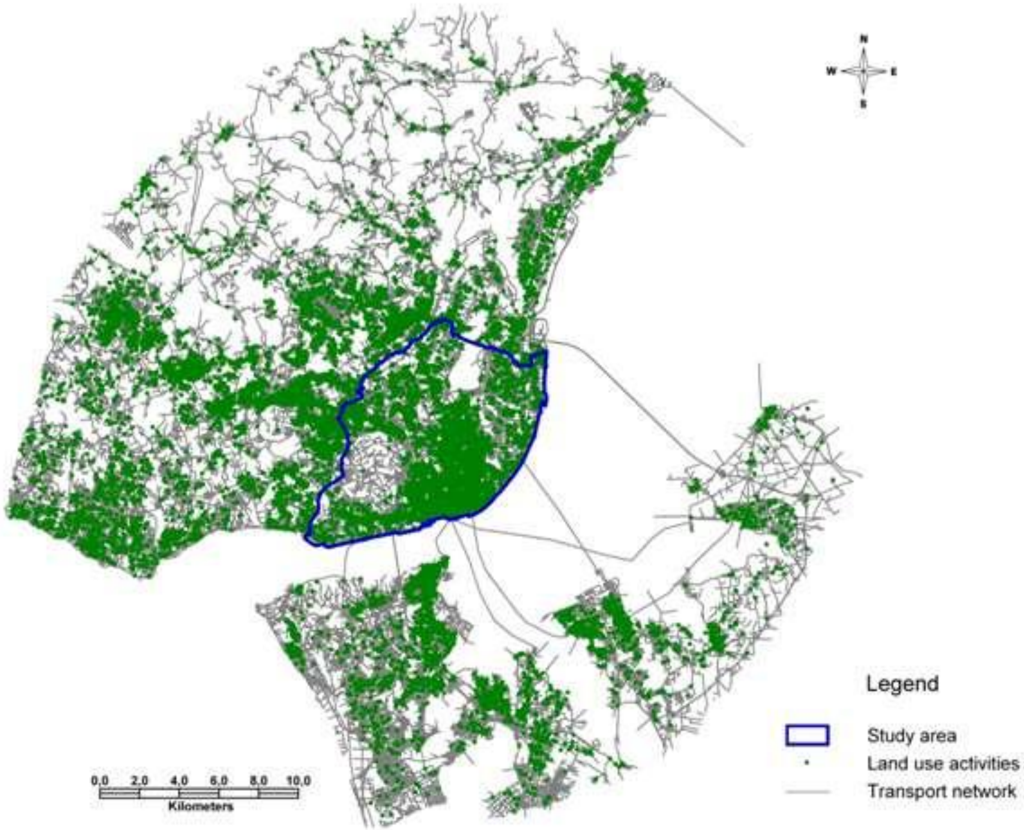
Inverted Logistic vs. Most Used Alternatives

- The two most used alternatives are the step function and the exponential
- The step function is an obvious simplification, no longer acceptable with the currently available computational power
- The systematic good results obtained with the exponential gross zoning can be explained because the intra-zonal trips are not modelled, and those are the ones where these two curves differ markedly.



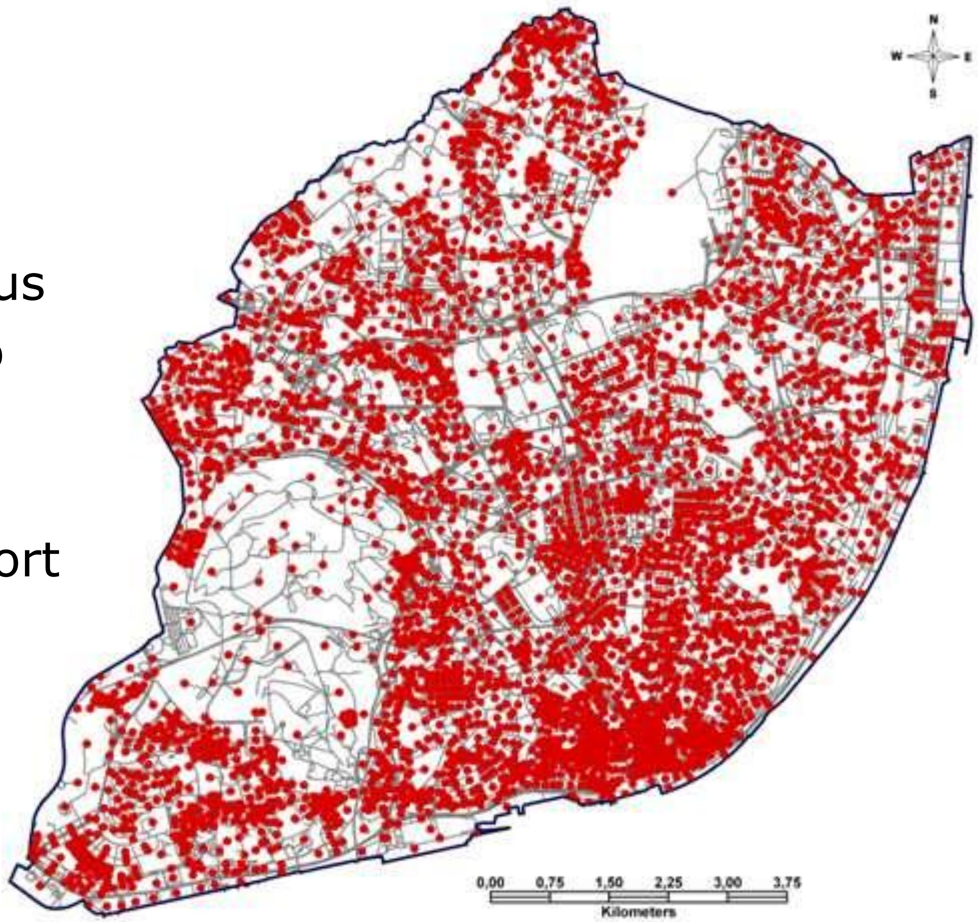
How to measure accessibility

- Use a geodatabase of all the activities in a study area (point data)
- Extend influence area outside the boundaries of the study area (city of Lisbon) to avoid border bias on the assessment



How to measure accessibility

- The unit of analysis is a census block
- The centroid of each census block is then connected to the immediately adjacent transport networks used (pedestrian, public transport and private car)



Measuring accessibility from one location to a set of similar destinations (same urban function)

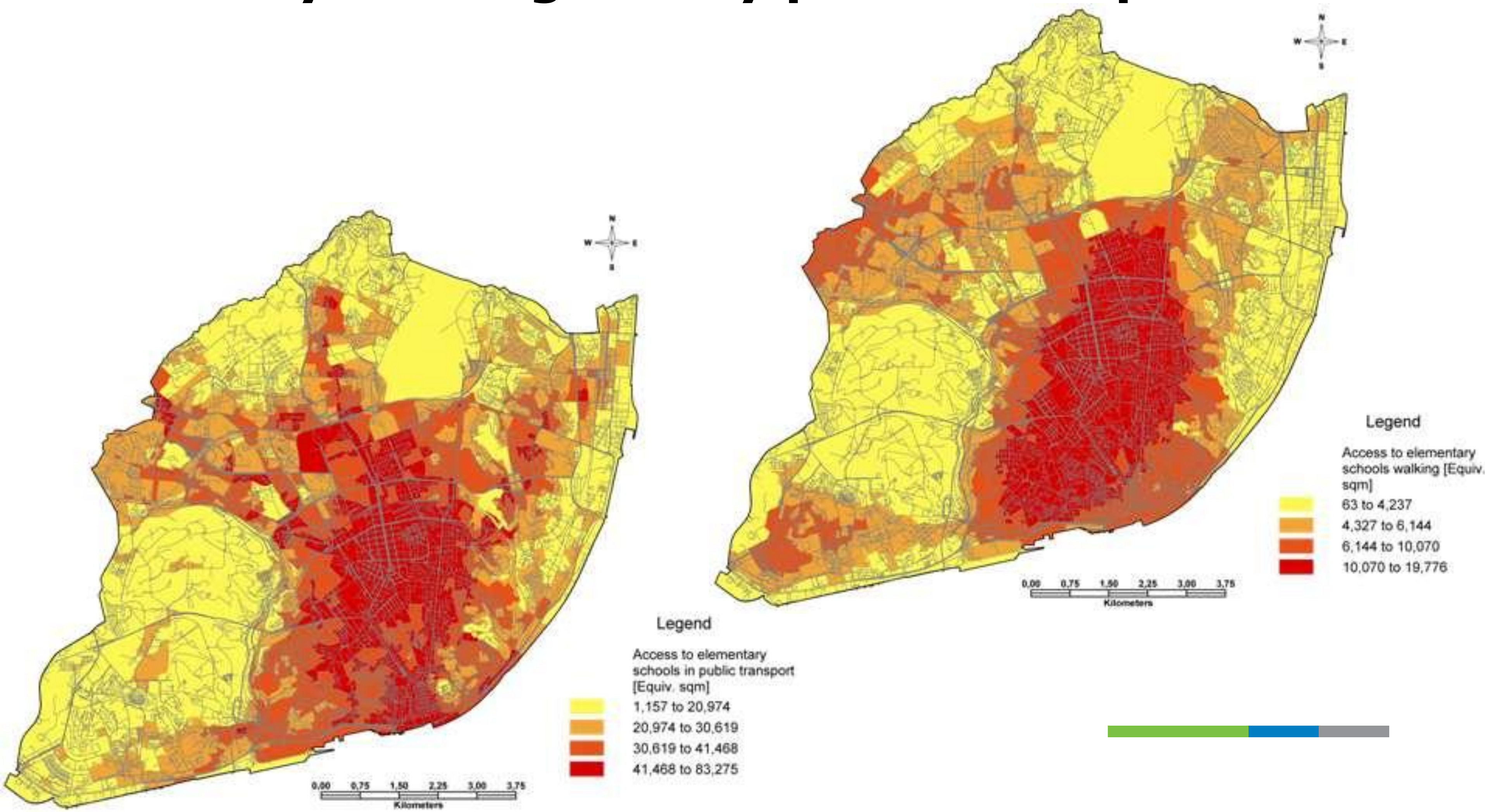
- We adopt the classic concept of accessibility as the potential of opportunities for interaction, but measuring the potential of (interaction) at each destination as the Y-value of this inverted logistical curve, starting from the base location and adopting a specific travel mode

$$A_i = M_j . R\left[T\left(i, j, m\right)\right]$$

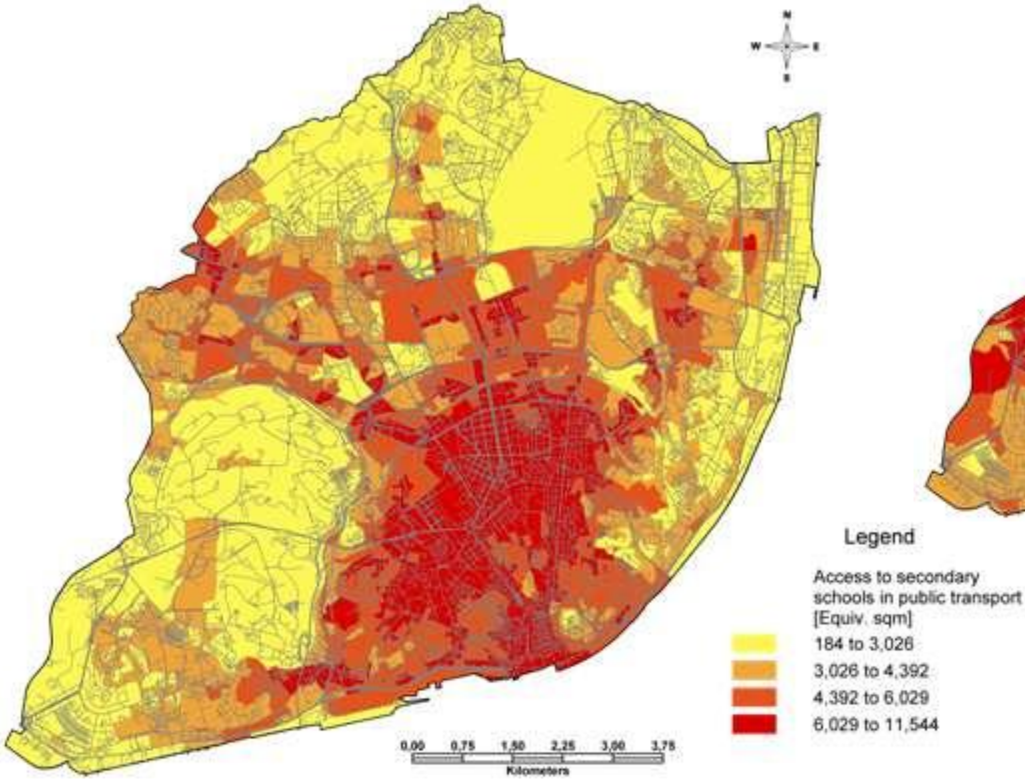
<u>Where</u>
M_j is the "mass" at destination j
T (*i, j, m*) is the travel time between city blocks *i* and *j*, using mode *m*
R (*x*) is the value of the Richards curve for the travel time *x*

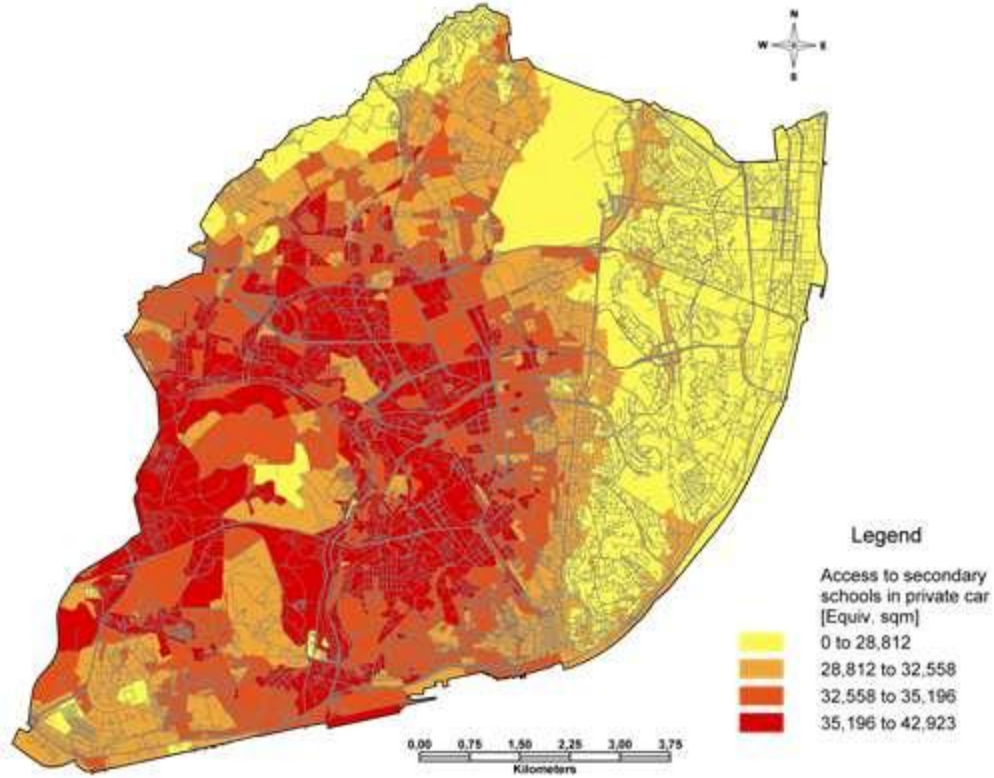
- Given the current wide availability of good urban land-use and transportation databases, our spatial analysis unit is the city block, and displacement times are computed on the networks available for each mode

Example: Accessibility to elementary schools, by walking and by public transport



Example: Accessibility to secondary schools, by public transport and by private car





Measuring inequality of access across space

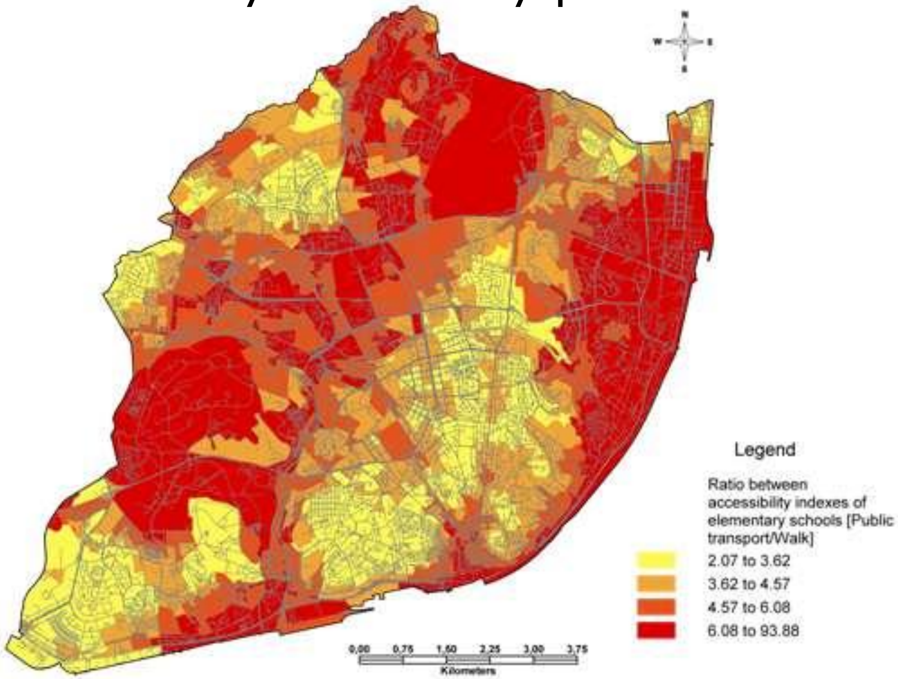
- Inequality of these indicators across space allows identification of poorly served areas. Interventions may be
  - Based on **location measures** (new sites or expansion of existing sites)
  - Based on ***transport measures*** (improve access to existing sites)
- Given the high number of units (city blocks), the Gini coefficient is a relevant measure for comparison of the overall inequality of access across modes and for policy evaluation

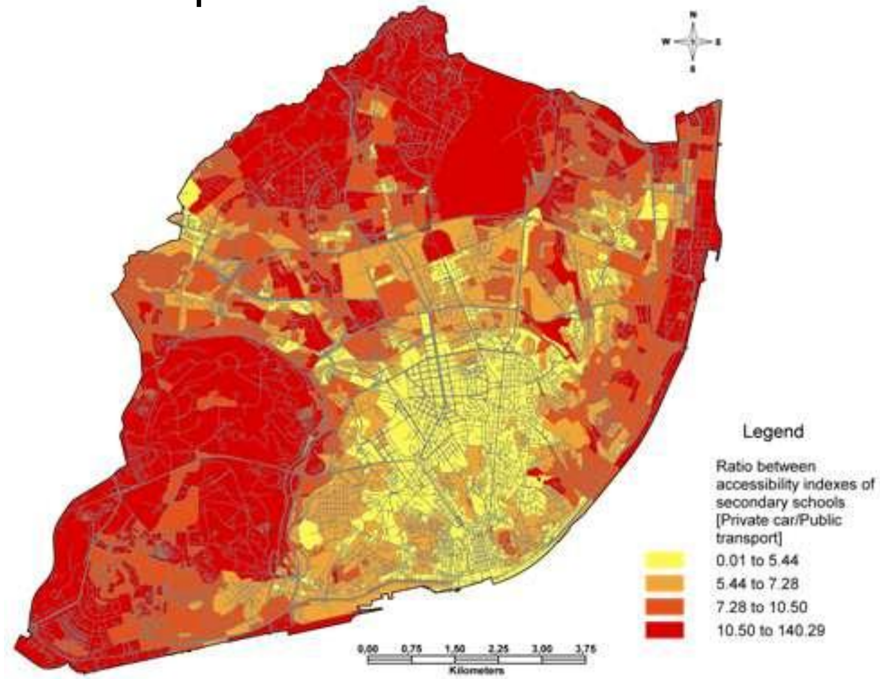
Measuring inequality of access across space

- In the previous example, the Gini coefficient for access to secondary schools is 0.24 by public transport and 0.08 by car. For access to elementary schools it is 0.31 by walking (very high!) and 0.23 by public transport
- Inequality of these indicators across space allows identification of poorly served areas. Interventions may be
  - based on **location measures** (new sites or expansion of existing sites)
    - The case of elementary schools is a clear demonstration: excessive concentration of schools for internal efficiency reasons leads to high inequality (and motorized transport as a remedy)
  - based on ***transport measures*** (improve access to existing sites)

Measuring inequality of access across modes

For inequality across modes, the ratios between accessibility indexes by modes are powerful indices, which can also be mapped. Two examples: access to elementary schools by public transport vs. Walking and to secondary schools by private car vs. Public transport





Urban accessibility in general
The value of functional diversity (1)

- The value of functional diversity for urban quality of life is widely recognized
- Cervero and Koppelman (1997) propose a measure of accessibility in which diversity is measured by an entropy index in the urban space

$$Entropy = \frac{-\sum_{f=1}^{k}\left[\mathrm{prop}(f) * \ln\left(\mathrm{prop}(f)\right)\right]}{\ln(k)}$$

<u>Where</u>
f represents one urban function
k represents the total number of functions
Prop (*f*) represents the proportion of function *f* (measured in area) in the total functional area

Urban accessibility in general
The value of functional diversity (2)

- This approach is interesting but it has two problems
  - It delivers the maximum value for equal proportions of all urban functions
  - It gives equal importance for all instances of the same function across the study area
- We propose a formulation that addresses these two problems
  - Identifying a “desirable” distribution of (proportions) of functions
  - Weighting the contribution of each location of a function to its total supply by the distance-decay factor

Urban accessibility in general
The value of functional diversity (3)

- The "desirable" mix of functions in a city is a concept that is little explored but this distribution can be estimated
  - Globally for a given city, assuming that the existing mix is a result of long societal interactions and thus not far from that goal
  - Specifically for a given social group (for instance defined by age and income ranges), this can be estimated through surveys
- Assuming that we can obtain such a desirable functional mix <u>Pr*</u>, the multifunctional accessibility index of city block *i* can be computed in three steps, as indicated next

Urban accessibility in general
The value of functional diversity (4)

1) The accessible mass of each function *f* at *i* [AM*(i,f)*] in terms of the overall accessibility of its locations to city block *i* is

- $$AM(i,f) = \sum_{j} M_j(f).R(i,j,m,f)$$

2) The real proportion of that function *f* in the set of all functions, as they are accessible from *i* is

$$\Pr(i,f) = AM(i,f) \Big/ \sum_{g=1}^{k} AM(i,g)$$

<u>Where</u>
Pr(*i*,*f*) is the real proportion of function *f* in the set of all functions accessible from *i*

Urban accessibility in general
The value of functional diversity (5)

3) The multi-functional accessibility at *i, MFA(i),* is a composite value of those accessible masses, corrected by an index that expresses the relative deficits and excesses of the various urban functions in the real mix versus what they would represent in the desirable mix

$$MFA(i) = \left[\sum_{f=1}^{k} AM(i, f) \right] . S(\mathrm{Pr}, \mathrm{Pr}^*)$$

with $$S(\mathrm{Pr}, \mathrm{Pr}^*) = \frac{1}{k} . \sum_{f=1}^{k} \left(1 + \ln \left[\mathrm{Pr}(f) / \mathrm{Pr}^*(f) \right] \right)$$

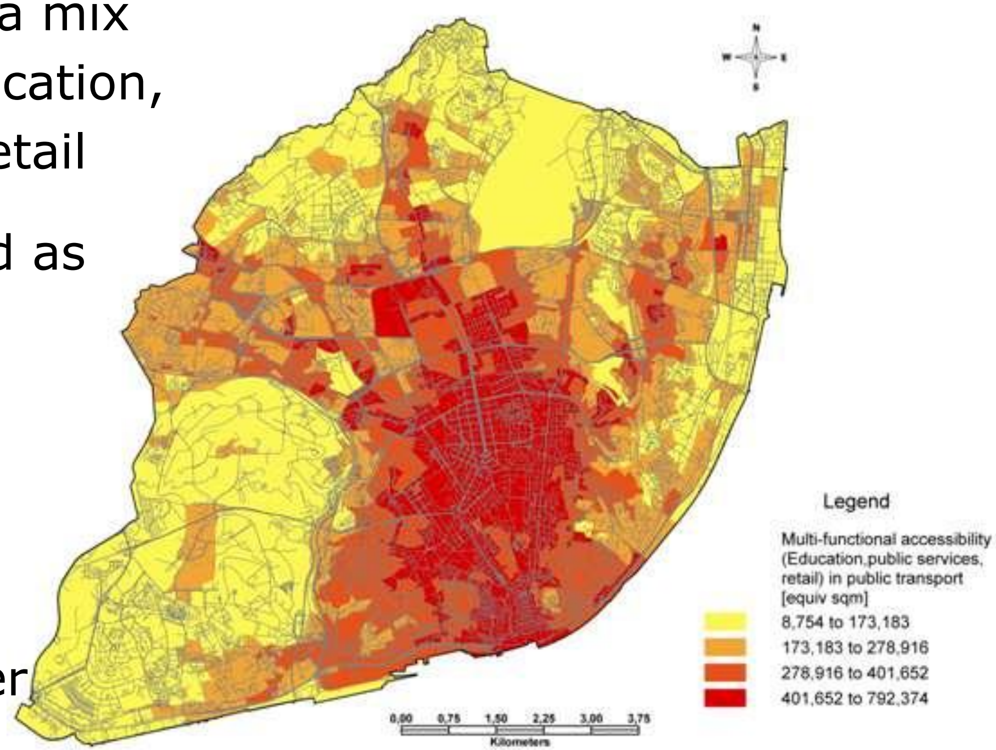
<u>Where</u>

*Pr and Pr** are the vectors of real and desirable proportions of accessible masses by function

S is an function producing an index (with values between 0 and 1) measuring the level of satisfaction with the relative accessibility of the various functions (real vs. desirable proportions)

Example for a mix of Education, Public Services and Retail, access by Public Transport

- This map shows the results for a mix of three types of functions: Education, Public (non-health) Services, Retail
- City wide proportions were used as proxy for the desirable ones:
  - Education: 27%
  - Public Services: 15%
  - Retail: 58%
- The satisfaction index has rather homogeneous values, between 61% and 74% (median at 68%)



From Indicators to Policy Guidelines

- Based on these and similar values, it is possible to identify what functions are insufficiently accessible from each urban area and conceive interventions to mitigate those problems
  - Through location and / or transport measures
  - Relatively simple computations allow evaluation of the impacts of different policy options

- Different social groups will have different desirable functional mixes, and the preferences of the same group of people will change along time as they age and tastes evolve in society
  - Avoid "sharp optimization" of the functional mix at a particular point in time, try to adopt a longer term perspective

Conclusions (1)

- We all have a good mental representation of what good access to a particular target means, and common language has the words for that
- An inverted logistical curve is a good fit for the "willingness to go that far"
  - Similar shape but different thresholds for different urban functions
- This allows an easy computation of the "accessible mass" of any function (e.g. urban facilities, jobs) at each location (city block)
- The value of functional diversity, and the preferences of different social groups in that respect can also be accounted for
- If travel times are computed realistically (i.e. taking account of congestion in traffic and headways in public transport) the strategic objectives of urban transport policy would preferably be expressed in terms of urban accessibility

Conclusions (2)

- This approach reflects concerns for
  - **Quality of life**, by jointly considering ease of access to multiple types of facilities / opportunities
  - **Social inclusion**, by allowing easy identification of urban areas of low accessibility in general, and also targeted analyses for the access to the types of facilities most desired by each social group

- Part of the urban motorized transport (and associated traffic congestion) is avoidable and constitutes a negative externality of bad land-use planning, without proper care for accessibility with walking or cycling

Thank You!

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