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MEASURING TRANSPORT-RELATED SOCIAL EXCLUSION AT THE MESO-LEVEL USING THE CONCEPT OF ISOLATED ISLANDS IN THE BIG CITIES

Summary. Using the notion of isolated urban islands, this paper discusses, from a theoretical point of view, three important but controversial issues related to the measurement of social exclusion in the big cities: (i) the extent to which social exclusion is likely to occur, (ii) accessibility indicators that are sensitive and relevant for the evaluation of social exclusion, and (iii) the geographical scale for evaluation. From an urban island point of view, two important issues have been raised: the distribution of jobs, basic facilities, and services within an urban island and the travels of people between urban islands. Therefore, social exclusion can be determined either by the affordability/acceptability of travel time/cost to access the minimum requirement of facilities/services or the number of facilities/services in reach of the individuals within acceptable/affordable travel time and cost. A person will be at risk of social exclusion if they belong to a minority group as opposed to the majority in the same society. Some levels of social exclusion risk have been proposed. The evaluation should be implemented at the meso-level (urban island). From the view of the urban islands, the issues of transport-related social exclusion are clearly understood, and measurements of social exclusion should be solved. We feel that a detailed survey/interview is needed for areas at high risk of social exclusion, followed by an evaluation at the micro-level to identify excluded people and the causes for their exclusion. It is expected that this paper will attract researchers to pay more attention to this issue.

1. INTRODUCTION

Though the notions of social exclusion and inequity have attracted the growing interest of academics and policymakers since the late 1990s, there is no consensus among researchers on how to measure social exclusion [11]. Generally, scientists agree that social exclusion is strongly related to accessibility and, therefore, that accessibility indicators can be used to measure social exclusion [12, 15]. However, there are still several important but controversial issues related to measuring social exclusion.

First, most societies or cities have no equality between groups in terms of accessibility to activities/services. The differences between them can be measured, but it is difficult to ascertain to what extent social exclusion will occur [12]. Second, it is unclear which accessibility indicators are sensitive and should be used to evaluate social exclusion [11]. Third, so far, most accessibility analyses involve evaluations at two levels. At the macro-level—for example, at national or regional scales, accessibility analysis is typically calculated based on large geographical units such as postcodes or transport analysis zones (TAZ) [5]. At this level, accessibility analysis is generalized and social exclusion may be

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overlooked or incorrect. At the micro-scale, many detailed characteristics of the three main components of a land-use transport system are taken into account in accessibility analyses, such as street design, walking and cycling facilities, bicycle racks on buses, parking availability times, sidewalk continuity, individual household income [10, 13]. At this level, such analyses require high-resolution detailed data, which are not easy to obtain and difficult to manage. Moreover, they are not suitable for providing a clear picture of a large region or a whole city. Therefore, it must be asked which scale is the most suitable for the evaluation of social exclusion.

This paper discusses these issues using the notion of isolated urban islands (see Section 2). Then, Section 3 will discuss the extent to which social exclusion is likely to occur. All accessibility indicators that have been developed in the literature so far will be summarized in Section 4. Based on that, indicators that are sensitive and suitable for the evaluation of social exclusion will be suggested. The paper will be closed with some brief conclusions.

2. THE BARRIERS OF TRAFFIC AND ISOLATED URBAN ISLANDS

According to the literature, it is recognized that both mobility and accessibility contribute to social exclusion. Mobility contributes to social exclusion in two aspects. First, individuals or groups of individuals may have trouble accessing basic social facilities/services and social activities/contacts due to a lack of access to adequate mobility transport modes. Hence, they are at risk of social exclusion if the distribution of land use (facilities/services) is poorly planned. Without being equipped or able to control a motorized vehicle, they will be at risk of being excluded from normal social activities [6]. Second, high-mobility roads (in terms of high speed and/or a high volume of motorized vehicles) can act as barriers and may cause social exclusion for some groups of local people [2].

In reality, urban roads have unique characteristics in terms of mobility (the ease of movement of vehicles between urban regions) and accessibility (the ease of access of people to their homes, services and other social activities at the local level), depending on their functions. The main function of high-mobility roads—for example, urban expressway, primary roads, and arterials roads—are to enable motorized vehicles to move freely and quickly between urban regions; accessibility to homes, services, and activities at the local level is not prioritized. These roads are usually wide and designed to enable motorized vehicles to travel at high speeds. The distances between intersections (at grade) are long to ensure the mobility of motorized vehicles.

Hence, there is a conflict between the movement of traffic moving along high-mobility roads and the accessibility of local people. Some groups—for example, pedestrians, young children, the elderly, or people with physical disabilities (who do not or cannot use motorized vehicles)—will face difficulties in accessing their homes, jobs, services, and social activities on the other side of high-mobility roads, and they may have to accept the risk of traffic accidents when crossing them, such as the accident that occurred in Hanoi City, Vietnam [14].

In this context, areas surrounded by wide roads with high traffic volumes travelling at high speeds or by other natural or human-made barriers like lakes, rivers, streams and railways become isolated urban islands within which people who do not use or cannot use motorized vehicles are trapped. The people who get trapped inside urban islands tend to be those who do not use or cannot use motorized vehicles due to their age, poor income, or disabilities, among other reasons. They are at high risk of exclusion from social activities and social contacts if the distribution of land use (facilities and services) inside the islands and public transport systems (for travel between urban islands) are not well organized.

As discussed above, transport-related social exclusion occurs at the urban island level (hereafter, we refer to this using the term *meso-level*), which is between the macro- and micro-level. Therefore, to evaluate social exclusion, we propose applying accessibility analysis for different groups at the meso-level.

Urban islands can be defined by traffic volume on roads and/or road functions in combination with other natural and human-made barriers such as rivers, canals, and railways. In addition to people who do not or cannot use motorized vehicles, people who use motorized vehicles could face social exclusion in cases where land use is poorly planned. Even some members of high-income households—for example, children and the elderly—may be trapped inside the urban islands. From an urban planning point of view, there are two important issues: the distribution of jobs, basic facilities, and services within an urban island and the travel of people within an urban island and between urban islands.

3. TO WHAT EXTENT IS SOCIAL EXCLUSION LIKELY TO OCCUR?

According to Lucas (2012) [11], an individual is considered as part of an excluded group if their disadvantages fall below a level of threshold in direct comparison to the normal relationships and activities of the majority in society. However, there is no consensus among scientists, either from a theoretical or empirical point of view, on the extent to which social exclusion is likely to occur [11] [12].

From the theoretical perspective, social exclusion is not due to a lack of social opportunities but a lack of access to those opportunities. Therefore, in order to avoid social exclusion, an individual requires a set of accessible facilities and social contacts. According to this theory, the facilities/contacts can be split into proximate facilities/contacts, in which transport expenditure (measured in time and cost) is immaterial, and distant facilities/contacts, where transport becomes a factor. Social inclusion can be achieved through either purely proximate facilities/contacts (to the right of point A on the horizontal axis of Fig. 1 below, with (near) zero transport expenditures), through purely distant facilities/contacts (above point B on the vertical axis, with a minimum transport expenditure of OB) or by some combination of these (the area above line AB). The area OAB is defined as an exclusion set. The idea is that there should be a mix of proximate and distant services/contacts that provide social inclusion. There is a trade-off between these services/contacts such that the excluded set forms a right-angled triangle, with two sides provided by the X and Y axes. In case the price of transport expenditure or travel time increases, individual C is deemed to be socially included until they can no longer afford to maintain the full set of distant contacts; therefore, individual C could be socially excluded (Fig. 1).

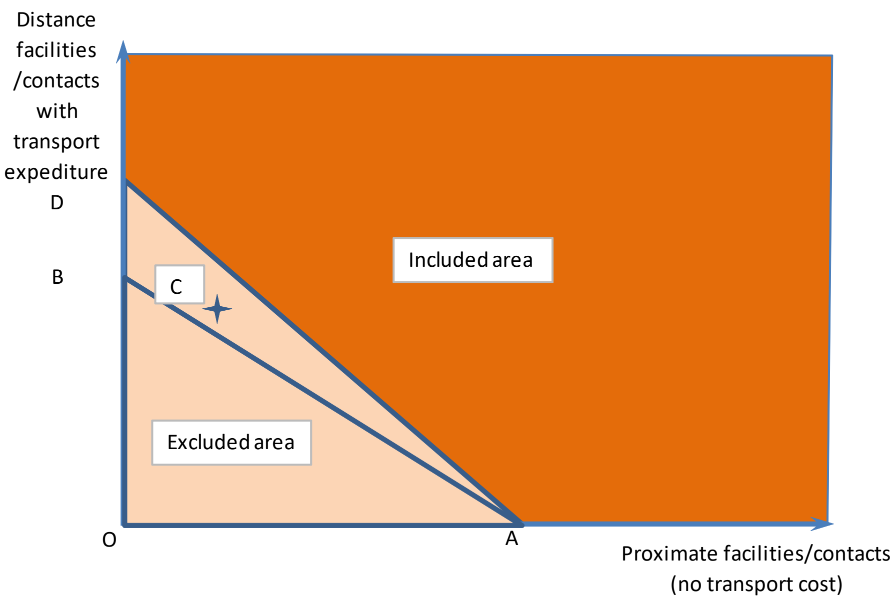

Fig. 1. A tentative concept of transport-related social exclusion

According to the theory, the idea of proximate contacts/facilities is quite broad and includes contacts/facilities that can be accessed via the internet or phones and facilities/services that can be accessed by walking or cycling (with near-zero cost).

From an urban planning (a land use and transport system-LUT) point of view, contacts/facilities that can be accessed via the internet and phones are ignored, while only facilities/services that people can access by walking or cycling are taken into consideration. Applying the notion of urban islands, it can be understood that a person can be included in society if they can access jobs and services within walking or cycling distance (with no or near-zero cost assumed) within an urban island and/or if they can access jobs and services at a further distance in other urban islands by a transport mode within an acceptable travel time and cost. A person will be excluded from social activities if there are not enough available jobs, basic facilities, and services in the vicinity of their home (within an urban island) or if the travel time or cost of a transport mode to access jobs or services at a further distance in other urban islands is unacceptable.

Generally, from a LUT point of view, it can be concluded that an individual or group of individuals can be excluded if the number of facilities and services that one can access within acceptable travel time by a transport mode is below a specified threshold or if the travel expenditure (in terms of time and cost) required to reach the minimum required number of facilities and services is unmanageable.

This means that social exclusion can be determined either by the affordability/acceptability of travel time/cost to access the minimum number of required facilities/services or the number of facilities/services within reach of an individual with acceptable/affordable travel time and cost. An individual can be excluded if the distribution of land use (jobs, facilities, and services) in an urban island does not meet their minimum requirements or if transportation expenditure (in terms of time and cost) for travel between urban islands is not affordable or acceptable. This can be the case for people living in poorly planned areas—for example, in rural areas—or for people who live very near facilities/services but whose income is not high enough to afford the transportation or access. For example, one cannot send their children to an international school that is very near their house if their income does not allow them to do so. In practice, there are still two difficult issues that need to be resolved: determining the minimum threshold of basic facilities/services and defining the perceptions of travel time or acceptable transport cost [11, 12][3].

3.1. Determining the minimum threshold of basic facilities/services

Metz [12] recognized that access and choice increase with the square of the speed of travel (mobility) because what is deemed accessible falls within a circle whose area is proportional to the travel speed. Over time, with improvements to transport modes (i.e. with higher mobility), most people have travelled further and have more choices related to the time they have available for travel (for example, one hour per day). On the other hand, the value of each extra element of choice for a given kind of destination may be expected to decline-this is the principle of diminishing marginal utility in general. Therefore, the combination of access and choice, which is increasing with the square of the speed and choice (which is subject to diminishing marginal utility), leads to the expectation that the demand for travel to routine destinations would cease to increase because people have sufficient choices. In other words, travel demand has saturated.

Metz [12] implied that a "natural" limit to daily travel has been reached for most people in developed economies who are relatively unconstrained in their personal mobility because they have sufficient access to a car or a good public transport system. According to Metz [12], some evidence about access that is consistent with the idea of travel demand saturation has been found in England. For example, the number of choices of family doctors within 15 minutes for people without a car in dense urban areas is commonly four or more, while it is five or more for people who drive a car. Another study on urban areas of Britain showed that about 80% of the population has the choice of three or more large supermarkets within 15 minutes by car. It is recognized that relatively high numbers of choices for employment, schools, hospitals, and other services were also found for most people.

It is suggested that the "natural" limit for daily travel in England can be used as a standard requirement for the basic needs of people in developed economies, and an individual can be considered excluded if this requirement is not met. Wee et al. [16] also proposed similar standard values – for example, the distance or travel time to the three nearest primary schools, supermarkets, or health care centres. However, these values are relevant to developed countries, such as England. It cannot be applied

[3] It is noted that the travel cost will not be discussed in this paper because we look at this issue from LUT point of view only.

to other urban contexts, especially in developing countries like Vietnam; if this standard value were applied in Vietnam (for example, the minimum requirement of four schools or hospitals within 15 minutes by car), there may be almost citizen in a city who will be excluded from social activities, which is not realistic. In our opinion, the minimum requirement of facilities/services and minimum requirement of transport expenditure may vary in different contexts and times.

Moreover, excluded people are considered a minority group in society [12]. Therefore, it is better to find a minority group of people in comparison with the majority in any given society or city. Hence, the standard values should relate to the majority of cases in any given context. For example, in Hanoi City, where motorcycles have become predominant in society [9], a person who has no motorcycle or cannot use a motorcycle may have greater difficulties in accessing jobs and other social activities than people who use motorcycles. Therefore, social exclusion should be evaluated for groups who do not use or cannot use motorcycles in comparison with people groups who use motorcycles.

Furthermore, people with private motorized vehicles—for example, MC—may also be at risk of social exclusion if they live in a poorly planned area—for example, if a person lives in an area that has few jobs or where job centres are very far from their home. In such a case, the travel time to their job would be far beyond an acceptable daily journey, or the number of jobs/services they can reach within acceptable travel time/cost is far below that of people living in other areas. Therefore, to evaluate social exclusion, s comparison should be made for both groups who use different transport modes (e.g. those who use private motorized vehicles and who use NMT and PT) and people who use the same transport modes. Since excluded people belong to the minority, they are considered excluded if the number of facilities/services is below 50% of the standard value. The thresholds and levels of social exclusion are proposed in Tab. 1 and Fig. 2.

Table 1

Proposed classifications of social exclusion risk based on the number of accessible acilities/services

No.	Number of facilities/services within reach compared with the standard value	Level of social exclusion risk
1	<=10%	Very high risk
2	10-30%	High risk
3	30-50%	Low risk

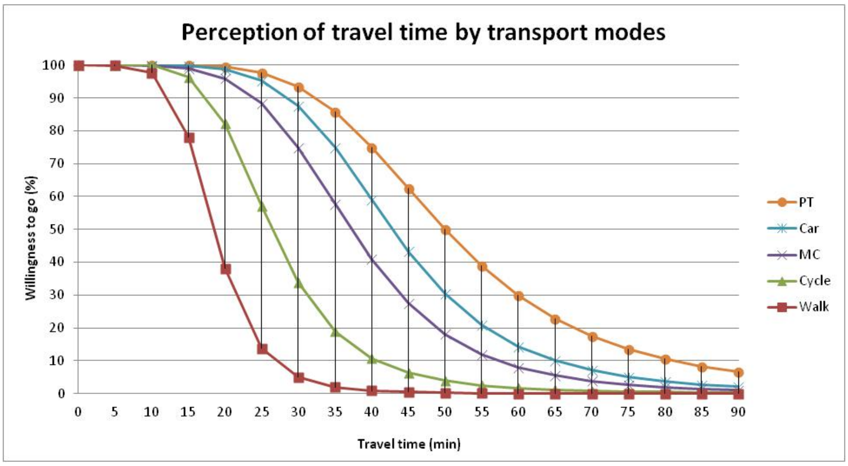

Fig. 2. Illustration of perceptions of travel time by transport modes for daily journeys to jobs/services

3.2. Perception curves of travel time

Travel time to jobs/services can be used to evaluate social exclusion [16]. As discussed above, the travel time required to reach a minimum number of facilities/services is an important indicator to evaluate social exclusion and make comparisons with people's perceptions. Based on the idea of travel time budget, Ha et al. (2016) [8] constructed the perception curves of travel time. An example of travel time perception to different transport modes for daily journeys to jobs/services is illustrated in Fig. 2. the perception of travel time can vary depending on the local urban context, geographical conditions, transport policy, trip purposes, individual characteristics, and the nature of the activities performed at destinations [5]. The real travel time by a transport mode (or revealed behaviour) is usually different from the perception of travel time (or preferred behaviour). Thus, a perception curve of travel time should be applied to calculate the number of facilities/services when evaluating social exclusion.

3.3. Defining social exclusion based on travel time

As discussed, a city consists of several urban islands, and travel is the result of socio-economic interactions between urban islands [1]. People from one urban island travel to other urban islands in order to access services/activities or seek jobs. The daily travel time to jobs/services of an individual or a group in an urban island reflects their quality of life. The risk of the social exclusion of (a group of) individuals living in an urban island can be evaluated by comparing their real travel time to jobs/services with the perception curve of travel time, which is considered the standard measure in society. In practice, it is difficult to know the exact value at which an individual or group will be excluded, but we can evaluate the risk of social exclusion that a group is facing. An individual is considered at risk of social exclusion if he belongs to a minority group (less than 50%) (Fig. 3). The risk of social exclusion can be evaluated if the travel time of people groups living in urban areas is categorized according to the perception of travel time. The values of the risk of social exclusion are proposed in Tab. 2 and Fig. 3.

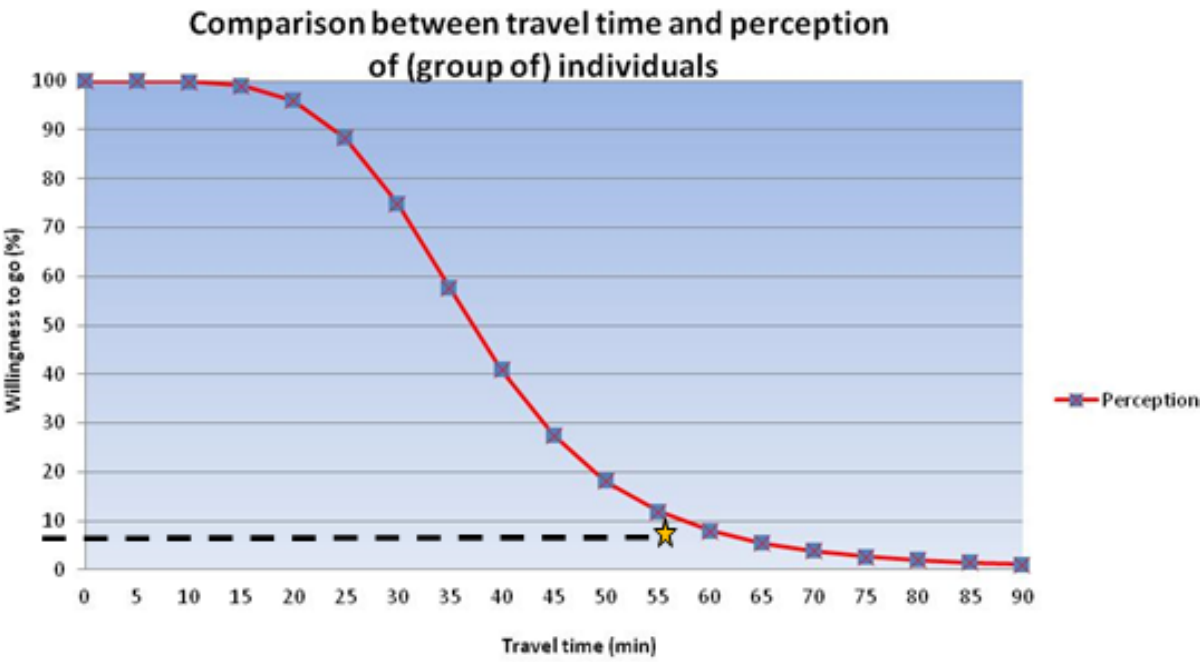

Fig. 3. Real travel time against the perception curve of travel time

Table 2

Classification of social exclusion risk based on travel time

No	Perception of travel time	Level of social exclusion risk
1	<=10%	Very high risk
2	10-30%	High risk
3	30-50%	Low risk

4. ACCESSIBILITY INDICATORS THAT CAN BE USED TO EVALUATE SOCIAL EXCLUSION

It is widely agreed among researchers that social exclusion is strongly related to accessibility and, therefore, that accessibility indicators can be used to measure social exclusion [12, 15]. However, it remains unknown which accessibility indicators are sensitive and suitable for the evaluation of social exclusion. A number of accessibility measures have been developed and used in the literature and can be categorized into three main groups [3, 5]:

(1) Infrastructure-based measures describe the level of service of transport infrastructure. Typical indicators are congestion levels, travel time, and average speeds on a road network.

(2) Activity-based measures describe the level of access to spatially distributed activities. Activity-based measures can be subdivided into (a) location-based measures, for which accessibility is analysed at the macro-level, and (b) person-based measures, for which accessibility is analyzed at the micro-level.

(3) Utility-based measures focus on the (economic) benefits people derive from access to spatially distributed activities.

Among the above-mentioned measures, infrastructure-based measures do not have a land use component and are typically used only in the transport planning field. Person-based and utility-based measures typically focus on the individual component [5]. They require intensive data, which is very difficult to obtain for a large urban area in practice [8]. Therefore, these accessibility groups may be suitable for the evaluation of transport-related social exclusion at the micro-level but not at the meso-level. Location-based measures are advantageous since they take into account both land use and the transport system [5]. In practice, location-based measures have a balance between required data and the quality of results. Therefore, they are preferable and widely used in urban planning and geographical studies. Furthermore, in general, they can be computed easily using existing land use, transport data, and/or models traditionally employed as input for estimating infrastructure-based measures [8]. The location-based measures are again subdivided into [3] the following:

- *The contour accessibility indicator* (also known as the isochronic or cumulative opportunity measure) indicates the number of opportunities reachable within a given travel time or distance from a specific point of origin. This indicator indicates that accessibility increases as more opportunities can be reached within a given travel time or distance. The result depends on the transport component and the distribution of land use/activities in space—for example, the number of jobs. The formula of cumulative opportunity measure becomes $A_{im} = \sum_{j=1}^{n} O_j$ if c_{ij} <= predefined threshold.
- *The potential accessibility indicator (A_i)* discounts the opportunities over the distance. As a consequence, the level of accessibility of a point of origin increases relative to the number of opportunities and is corrected for impedance. The general form is as follows:

$$A_{im} = \sum_{j=1}^{n} O_j * f(c_{ij}) \quad (1)$$

In which

A_{im}: the accessibility of zone i to the relevant type of opportunities using mode m. A_{im} can be measured, for example, by the number of available jobs or employees, depending on the unit of the selected O_j.

O_j: the number of opportunities of a specific type in zone j (e.g., number of jobs or employees).

$f(c_{ij})$: distance decay function.

c_{ij}: generalized (or actual) time or cost for a trip from i to j using mode m.

Among all accessibility measures, potential accessibility measures are the most popular accessibility measures and have been widely used in urban and geographical studies [5]. So far, some modified accessibility indicators have been developed from the traditional potential accessibility measure introduced below.

- *Average travel time of a zone (T_i)*: This indicator was proposed and used by Geertman and Van Eck [4] and Guttiérrez [7]. This indicator is easily interpreted and is meaningful for policymaking. The potential average travel time from location (i) is calculated as follows:

$$T_i = \frac{\sum_{j=1}^{n}(A_{ij} * t_{ij})}{\sum_{j=1}^{n} A_{ij}} = \frac{\sum_{j=1}^{n}(t_{ij} * O_j * f(c_{ij}))}{\sum_{j=1}^{n}(O_j * f(c_{ij}))} \quad (2)$$

In the above equation, t_{ij} is the travel time from zone i to zone j. When comparing different transport modes, it is assumed that people have the same travel behaviour. Therefore, in this case, $f(c_{ij})=1$ should be applied, and the formula becomes the same as the formula proposed by Guttiérrez [7]. Other indicators are the *network efficiency indicator (E_i)*, *accessibility with competition,* and *accessibility with balancing factor*.

As discussed in the previous section, by applying the notion of urban islands, social exclusion can be evaluated based on either the number of facilities/services within reach in an acceptable travel time or the average travel time required to reach a specified number of facilities/services. Among the accessibility indicators that have been developed in the literature, it is recognized that the following indicators can be selected for evaluating social exclusion: potential accessibility (A_i) and potential average travel time (T_i). This selection is in line with the suggestions of Wee et al. [16], who proposed adding to the currently used accessibility indicators some more accessibility indicators that relate to the minimum distance, travel time, or generalized transport costs from residential locations to activity locations.

These indicators can also include the nearest choice options, as well as a minimum number of choice options – for example, the distance or travel time to the three nearest primary schools, supermarkets, or health care centres. They also propose reporting the part of the population that is at risk of social exclusion according to the predefined minimum levels of access below which a person is considered socially excluded. Further, the potential accessibility (A_i) can be corrected with a competition factor or with a singly-constrained balance factor (or a combination of the two) to make the values of indicators more realistic.

5. CASE STUDY IN HANOI CITY OF VIETNAM

As discussed above, there is a conflict between the movement of motorized traffic and the accessibility of local people. Some groups of people, especially those who do not or cannot use motorized vehicles, might be trapped inside an urban island surrounded by roads with high-mobility traffic. These groups of people are at risk of being excluded from normal social activities since they have more difficulties accessing jobs, social activities, and services than people who use motorized vehicles and who do not face traffic barriers.

However, several questions have been raised related to the difference in accessibility between groups who use and do not use motorized vehicles, the difference in the accessibility of groups in cases of the existence of a traffic barrier compared to when there is no such barrier, and under what conditions exclusion is likely to occur. To explore these matters, we conducted a case study in Hanoi City.

Hanoi, the capital city of Vietnam, is witnessing rapid urbanization and motorization as the result of accelerated economic growth. Hanoi's population has increased from 5.3 million in 2002 to about 7.68 million by the end of 2017 (Hanoi Statistical Bureau). Hanoi's transportation is characterized by the predominance of motorcycles (MCs) on the streets. Motorcycles account for more than 80% of total daily passenger trips, and most households have at least two motorcycles.

In late 2021, the first UMRT line (line 2A) was put into operation. However, the number of passengers is still very low. Therefore, public transport still comprises conventional buses only and covers only about 10% of the total travel demand [9]. The rapid urbanization and development of motorized vehicles have caused many transport-related problems, including traffic congestion, pollution, and traffic accidents. The quick development of motorized vehicles might also lead to social exclusion for people who do not or cannot use motorized vehicles.

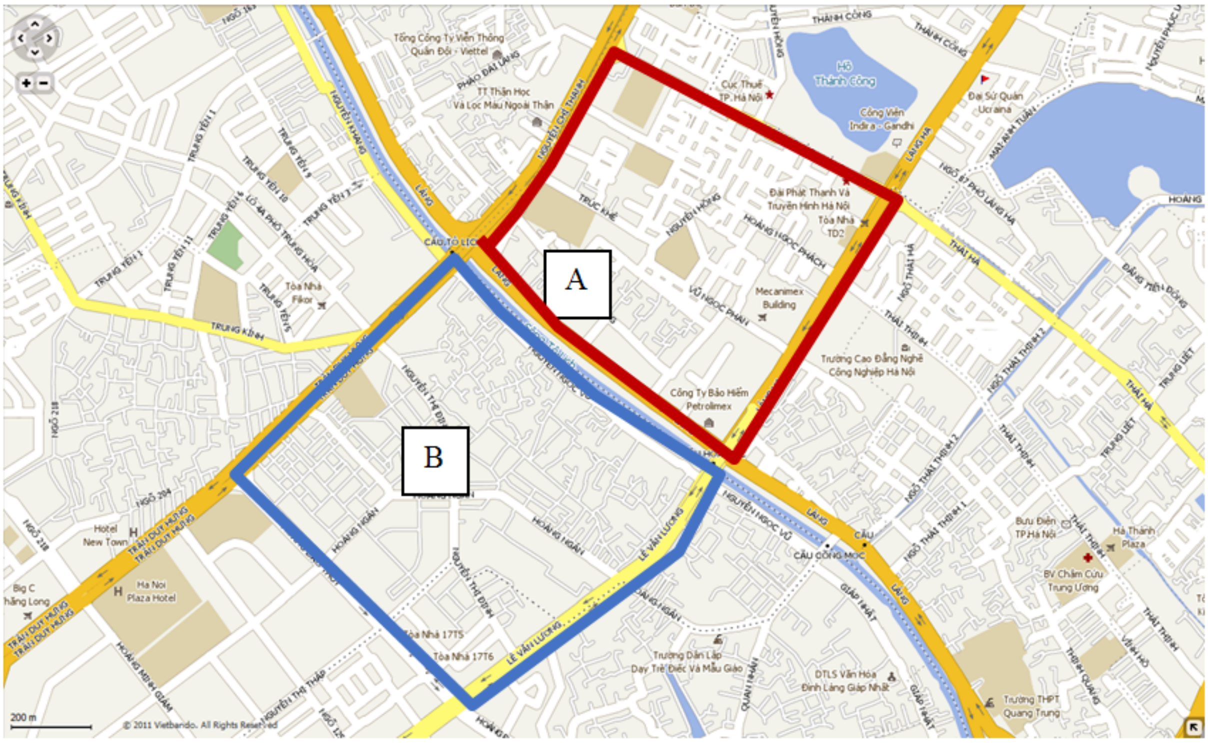

Fig. 4. Two selected study areas in Hanoi city of Vietnam (source: http://www.vietbando.com/)

Table 3

Possibility of crossing for selected roads in afternoon peak times in the Lang Ha study area

No.	Street name	Road width (m)	Median width (m)	Road width/direction (m)	Real traffic volume afternoon peak by ALMEC, 2005 (pcu/h)		Crossing time (seconds)	No. of traffic blocked during crossing time (pcu)		Possibility of corssing a road
					(Way-in)	(Way-out)		(Way-in)	(Way-out)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	Lang Ha street	21	3	9	1765	2585	9	5 (20)	7 (28)	Not possible
2	Nguyen Chi Thanh street	21	7	7	3029	1293	7	6 (24)	3 (12)	Not possible
3	Huynh Thuc Khang street	14	0.5	6.5	2312	1491	7	4 (16)	3 (12)	Not possible
4	Lang street	11	No	5.5	Facing river. Cannot crossing.					

Note: The number in bracket is converted number of motorcycles (1 pcu is equal to 4 motorcycles-MOC, 2007).

Two urban areas were selected for study (see Tab. 3 and Fig. 4):

(1) Site A is in the Lang Ha ward, which is surrounded by three main roads (the Lang, Lang Ha, and Nguyen Chi Thanh roads) and one secondary road (the Huynh Thuc Khang road). The size of the selected area is about 700-800 meters each size. This urban area is known for having quite good living conditions. In this area, there is one primary cum secondary school, one high school, one sports centre, and one market. Thanh Cong Park and many social facilities, such as other schools, hospitals, and markets, are also located nearby in the neighbourhood. Using road and traffic data surveyed in 2005 by Almec cooperation of Japan under the HAIDEP project [9], we calculated the number of motorized vehicles that were blocked by people crossing the road. The result showed that a quite high number of

motorized vehicles were blocked during crossing times or that people had no chance to cross the roads if the movement of motorized vehicles was prioritized. Obviously, with such a high volume of traffic, people living within the selected area have few chances to cross the roads safely to join activities in the neighbouring urban areas unless they use motorized vehicles.

(2) Site B is the same size as Site A but is on the other side of the To Lich River. It is surrounded by two main roads (the Tran Duy Hung and Le Van Luong roads), one secondary road (the Hoang Dao Thuy road), and the To Lich River. Unlike Site A, half of site B is an urban village, and half is a newly developed urban area. The social facilities are not as good as those of in Site A. There is one primary cum secondary school, one sports centre, and one market. There are almost no social facilities in the urban village area, while most of the land in the newly developed urban area is reserved for offices, commercial and residential high-rise buildings, villas, or businesses. Very little land was used for social facilities/services. There was no traffic data for those roads as of 2005, but the traffic conditions are similar to those of the roads surrounding Site A.

To evaluate the risk of social exclusion of people who do not or cannot use motorized vehicles, we compared the accessibility in three situations: (1) The best case represents a situation in which it is assumed that the movement of motorized vehicles is not prioritized and people can cross the roads wherever they want. (2) The worst case represents a possible scenario in the future in which the movement of motorized vehicles is absolutely prioritized. In this situation, people can cross the roads only at major intersections. (3) The normal situation represents the current situation in which people can cross roads officially at specific intersections. This situation has a balance between the movement of traffic and access of people at the local level.

Some researchers [11, 12, 16] propose using accessibility measures such as the number of jobs/services accessible within a specified travel time and the average travel time required to access a specified number of activities/services, such as the number of available jobs, hospitals, or schools, to evaluate social exclusion. The specified number of activities/services is considered a minimum requirement for the quality of one's standard of living.

Thus, in this case study, we used both accessibility to jobs and the average travel time to evaluate social exclusion. We compared the number of accessible jobs between two groups (i.e. those who use motorized vehicles and who do not). We also compared the average travel time to services for people who do not use motorized vehicles with their preferred travel times to see whether people can access activities/services.

5.1. Preferred travel time in Hanoi City

Preferred travel time is an important factor to determine whether a group is excluded. Preferred travel time differs across different urban contexts. We conducted an online survey from October 2018 to February 2019 using SurveyMonkey. The survey form was distributed through friend networks via email and Facebook. The survey included about ten short questions, including questions asking about particiapnts' demographic information, such as their age, sex, career, income, and the city they are living in, as well as information about their daily travel, such as the transport mode they use every day, average travel time from to work and home (revealed travel time), and the maximum travel time they preferred or expected. In four months, we collected 824 responses, 529 of which were from respondents living in Hanoi City, Vietnam. The analysis result is presented below.

It is recognized that there are three groups of curves. The first group is the preferred travel time of pedestrians and cyclists. The second group is the preferred travel time of people who use motorized vehicles (MCs, cars). The third group is the preferred travel time of people who use buses as a daily transport mode to get to work. People who use motorized vehicles are willing to travel for slightly longer than people who use NMT transport modes; people who use public transport modes accept the longest travel times. In Hanoi, most people (80%) prefer to join activities if the travel time is less than 20 minutes, 25 minutes, or 30 minutes by walking or cycling, by motorcycle, and by bus, respectively. Nobody wants to join activities or use services if the travel time is longer than 30 minutes by walking, 40 minutes by MC or bicycle, or 70 minutes by bus (Tab. 4 and Fig. 5).

Table 4

Number of responses per mode

No	Item	Walking	Cycling	MC	Car	Bus	Total
1	No. of responses	39	39	356	30	65	529
2	Percentage	7.4%	7.4%	67.3%	5.7%	12.3%	100%

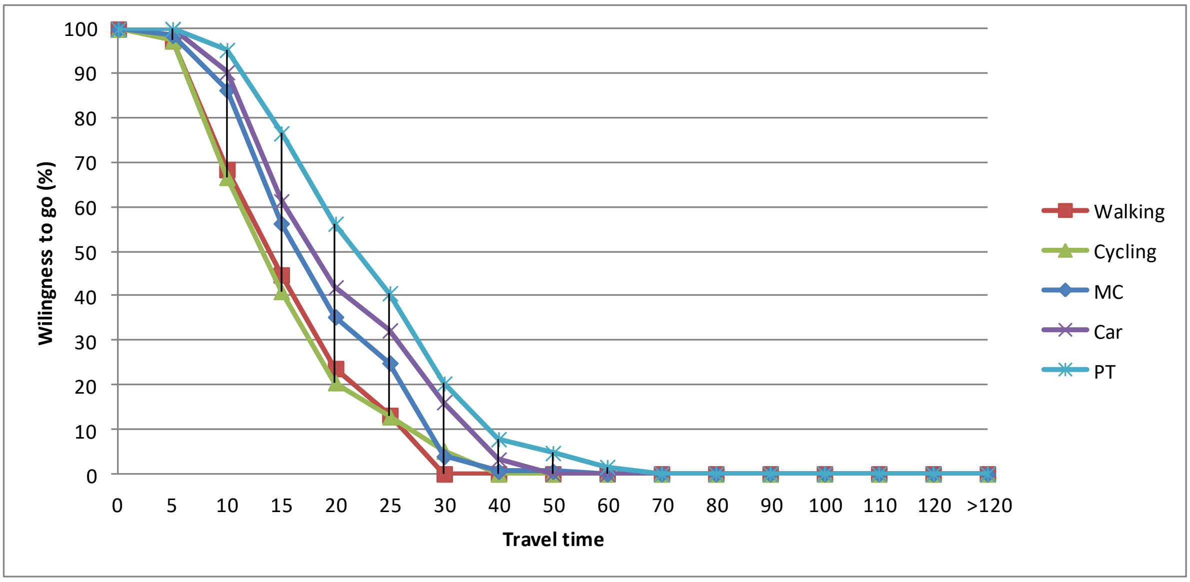

Fig. 5. Preferred travel time from home to work in Hanoi city

5.2. Job accessibility

A GIS model was built using the network analysis extension of ArcGIS software of ESRI. We divided the residential area in the selected sites by a net of a hexagon with a 20-m width, assuming people will travel from the centroids of the hexagons. We prepared for modelling by converting the road network for 2005 into ArcGIS shapefiles from MicroStation format. The 2005 bus network was imported from the BusIS 2.0 program developed by VIDAGIS in GIS format in 2004. The average speeds of MCs and cars were assigned based on the survey data collected by the study team of Haidep in 2005 [9] in combination with local knowledge. The average speed of buses was calculated based on the theory of urban traffic, depending on the distance between bus stops (Fig. 6).

6. CONCLUSIONS AND RECOMMENDATIONS

By applying the notion of urban islands, some important issues related to measuring social exclusion were resolved. These issues were discussed from a LUT point of view. Some main conclusions are summarized as follows:

- Social exclusion should be evaluated at the urban island level (meso-scale). The barrier of traffic can be identified by traffic volume, road width, and road function (which relates to the mobility or speed of transport means), such as expressways, highways, and primary roads, in combination with natural and human-made barriers such as rivers, lakes, streams, walls, and railways.

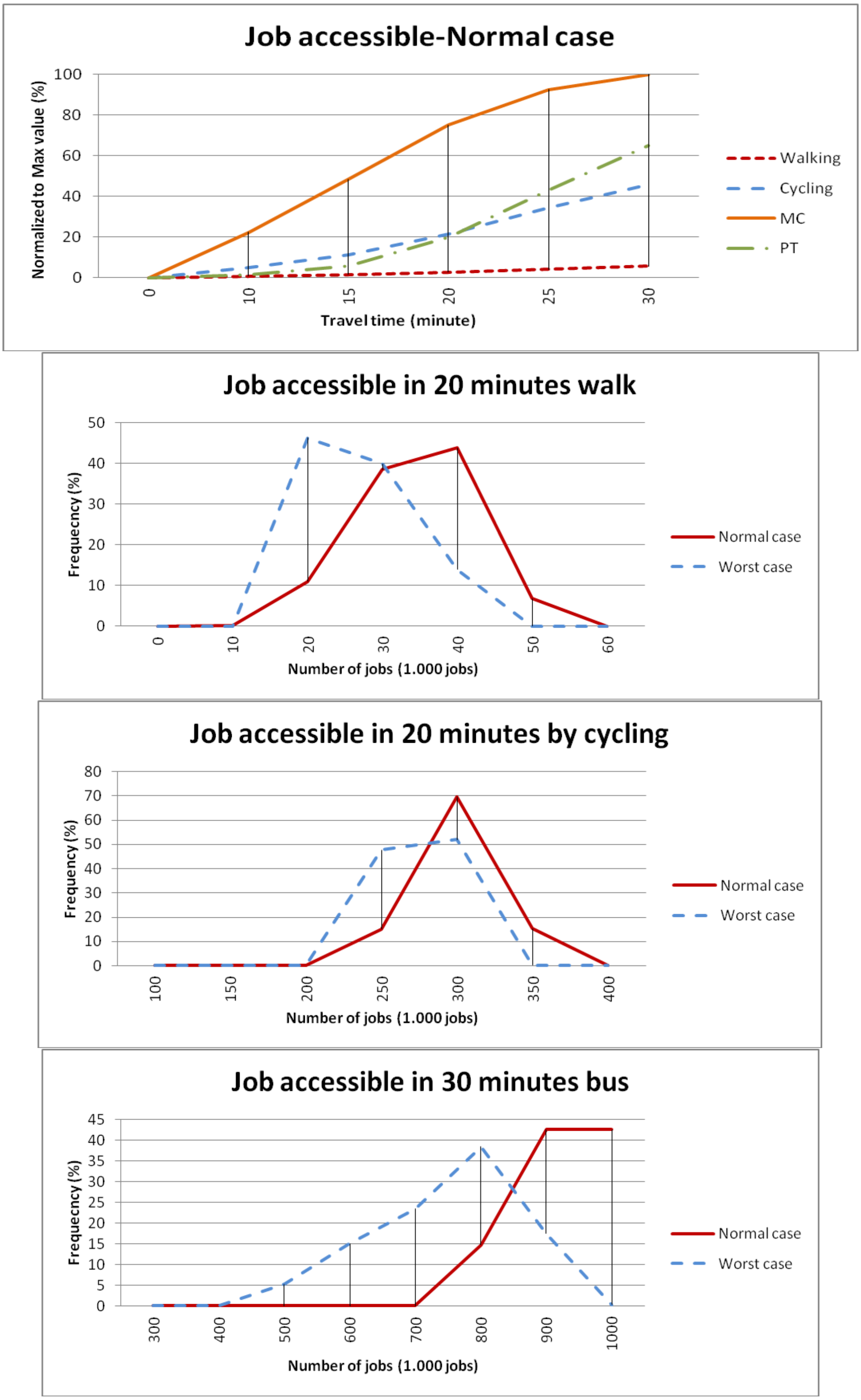

Fig. 6. Job accessible

- The standard values for the evaluation of social exclusion can be defined by comparing the minority with the majority in the same society. It can also be defined by selecting a number of typical islands within the study area (or a city). The standard values can be the number of jobs, services, or facilities that people can access within acceptable travel time or the average travel time by different transportation modes to the minimum required numbers of jobs and services. Some thresholds and classifications of the risk of social exclusion have been proposed.
- Potential accessibility (Ai) and potential average travel time (Ti) can be used as indicators for the evaluation of social exclusion. To make the values of these indicators more realistic, the potential accessibility (A_i) can be corrected with a competition factor, a singly-constrained balance factor, or a combination of the two.

17A low accessibility level does not mean individuals are excluded from society, but it does mean they are at risk of social exclusion. In this paper, we proposed a method for identifying areas that have a high risk of social exclusion at the meso-level geographically using the notion of urban islands. We suggest applying a detailed survey/interview for areas at high risk of social exclusion, followed by an evaluation at the micro-level to identify excluded people and the causes for their exclusion. It is expected that this paper will encourage researchers to pay more attention to this issue.

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