

# **Measuring accessibility**

## **(Indicateurs d'accès pour une mobilité durable)**

Project A11 of the  
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'Transport and Environment'

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## Summary

Within the framework of the National Research Program 41 " Transport and Environment ", the Istituto di Ricerche Economiche (IRE) of Università della Svizzera Italiana and the Observatoire Universitaire de la Mobilité (OUM) of the department of Geography of the University of Geneva were elected for the realisation of a research entitled "*Indicateurs d'accès pour une mobilité durable*" (module A11).

It is devoted to build methods and indicators allowing the best taken into account of the access of the population to various opportunities (such to work, leisure, etc.) by taking into account the localisation (in the centre town, in suburbs, in the countryside) and the socio-economic characteristics (age, income, activity). The aims of this search is the prospect for a sustainable policy of transport, reconciling the request for mobility - present and future - with the requirements of economic efficiency, social justice and environmental protection (cf. Himanen and alii. 1993, Sadler-Jacobs 1990); this objective is part of the new strategy of the DETEC (the Swiss Ministry of Transport).

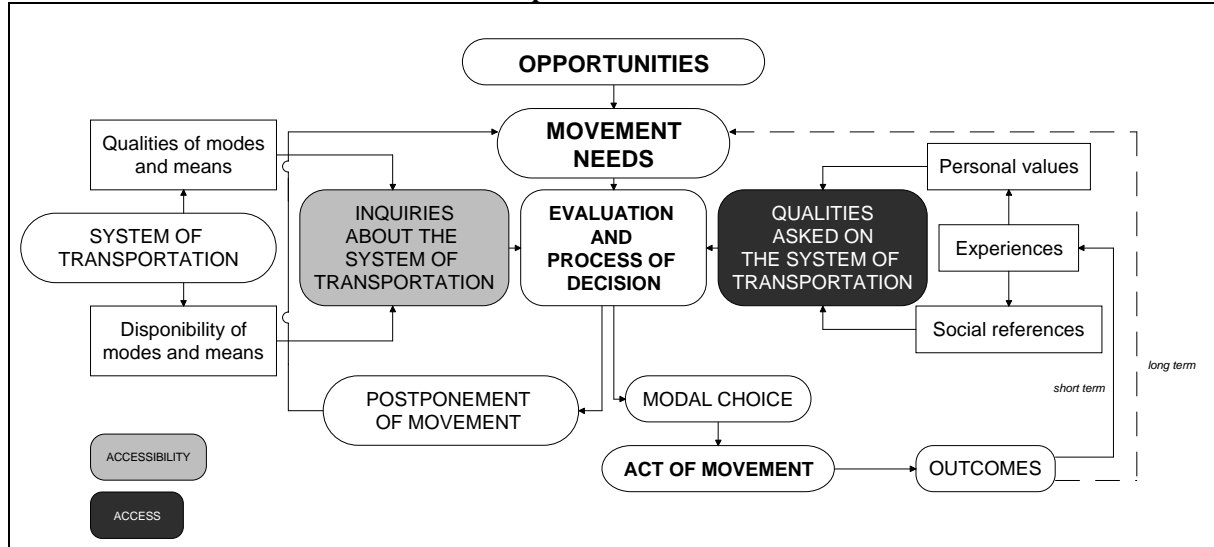
Research was carried out in four stages:

- In the first, we posed the methodological bases of the measurement of the access and looks further into the theoretical aspects related to these questionings;
- In the second stage, we validated our step with the design and the realisation of an investigation near the households of the canton of Vaud. The initial intention was the realisation of a national investigation relating the access to three various opportunities (work/formation, shopping, leisure). Because of the costs of realisation of the investigation, the scale had to be adapted to the financial availability. With the agreement of the management of the program, the investigation was carried out on 540 households of the canton of Vaud and explored the requests of access to the leisure and places of work. This investigation leads us to know the sensitivities of the users towards access and to collect the data necessary to the realisation of the indicators of access;
- The third stage consisted of the construction and the experimentation of the pilot indicators of access, potentially usable in the implementation of local, regional or national policies of transport;
- Lastly, in the fourth stage, various aspects relating to the modal choice criteria were analysed through a qualitative investigation probing the stated preferences towards access on a subsample of households resulting from the first investigation.

### **Access and accessibility: two components of a same system**

Spatial mobility indicates at the same time the propensity and the facility of a person to move and the realisation of this propensity in the form of movement ; a movement being understood as an act aiming at cancelling the distance separating two places within the framework of a given activity. Propensity to move depends on opportunities which each individual has the knowledge for the satisfaction of his needs (for example, to buy goods and services, to learn, to work, have fun, etc). Thus, we consider spatial mobility from the broader point of view than that for displacement, by the fact that it considers the causalities and the consequences related to movements (Reichman 1983).

To be interested in mobility, from such a point of view, means thus to wonder about the request and the offer of transport, the needs of the persons, their waiting in terms of quality of movement, and also their motivations and their choices upstream of the act of movement. That implies to consider the qualities offered by the system of transport and the user's perception of the movement. We claim that each individual, consciously or unconsciously, sets qualitative and quantitative levels of satisfaction for the movement to be made according to the needs to which it must answer (Figure 1).

**Process of modal choice from the individual's point of view**

To consider at the same time causalities, the realisation and the consequences of a movement appears very complex for the transport planners and, so the latter more privileged the study of only one item, the transport supply. From this point of view, the facility of a place (where an opportunity is localised) to be joined by an actor, a customer, an information or a service and the transport supply were often regarded as the only indicators, gathered under the various concepts of accessibility (cf. chapter 3).

However, according to our observations, these indicators do not consider sufficiently the request for transport and postulate a very strong sensitivity of the individuals to the modifications of the system of transport. Thus, to improve these indicators and to integrate the demand, we formulated the concept of access, defined as the whole of the qualities requested from the system of transport by an actor or a user to join a localisation where the places of work are, where goods and services are offered and where the places of leisure are localised, which satisfy its waiting and its needs.

Access and accessibility are the two sides of the same medal : access expresses a request – derived from the request for transport - while accessibility expresses the supply's level of the system of the transport (or communication), which allows the realisation of a need for the common life.

In this research, access and accessibility are formulated in a spatial context, because we were interested in the activities implying a spatial change (movement).

The process of modal choice constitutes a central point of the realisation of each displacement. The modal choice (the manner in which it is realised) reveals the quality required by the individuals to reach principal opportunities (work, purchases, leisure, friends or parents, etc.) causing the majority of daily movements within a regional space. The choice is carried out according to criteria dictated by the nature of opportunity: the access to work expresses a request differentiated in terms of qualities than the access to leisure destinations. It is also function of age or income or other variables like the sensitivities and the standards systems to which each one is identified. Moreover, the modal split is also strongly influenced by the offer of the system of transport.

Our methodology consisted in clarifying the role of the modal choice criteria according to the spatial localisation, the socio-economic characteristics and the type of activities to be realised, in order to allow the development of a specific policy of mobility according to spatial and socio-economic contexts. We thus highlighted the importance attached to the modal choice criteria and the hierarchy of these criteria that everyone carries out before moving in order to reach an opportunity. Our research leads to the knowledge of the latter, which is of primary importance, because it will give the essential indications in the setting up of a mobility policy, whose goal is the management of mobility (regional, urban or metropolitan) in a sustainable policy.

## The investigation and principal results

The access to work and leisure places was the subject of a sample survey (by phone), on the basis of sample representative of the households, according to its geographical distribution in the canton of Vaud (urban centre, commune of agglomeration, nonurban commune). Three topics were discussed :

- the practices of movement to reach these opportunities ;
- the satisfaction towards these displacements ;
- the decisive factors of the modal choice in an open way (referring to last movement) and in an indirect way by a cross appreciation of the importance of four factors: time, cost, conditions of displacement (or comfort) and environmental sensitivity.

The results reveal a "demanding" request on behalf of a population which counts " less and less " its money to move. In a brief way, the principal lessons are :

- the predominance of the use of individual transport (65% of residence-work displacements, 77% of leisure's displacements). The public transport and soft means of transport are more used to go to work, than to reach the leisure place ;
- the time is generally lower than 20 minutes (66% for work and 68% for leisure), consequently the distances are relatively short (lower than 10 km for 58% of movements for the work and 64% for leisure) ;
- 50% of the workers have a car at disposal even if they don't use it versus 42% of the people moving to practise leisure; the assets of the other means of transport were thus dominating the modal choice ;
- More than half of the sample declare access costs to work lower than 150 CHF, the highest costs (from 100 CHF/month) are especially supported by the car users. For leisure, costs are generally lower than 10 CHF by movement (63% of sample) ;
- General conditions of the displacement (which includes security, reliability, physical comfort, etc.) represent the principal modal choice factor for 38% of work displacements and 42% of displacements related to the leisure. This result is relatively surprising for pendular displacements where one could expect a greater part of people privileging the time of displacement (19% work and 16% leisure) or the cost of displacement (3% work and 2% leisure);
- Two thirds of the pendular using car do not have parking fee on their place of work, more than 90% of the practise of leisure also do not declare any cost of parking;
- A lot of persons considered themselves "captive" of their means of transport (30% of work displacements and 34% of leisure displacements);
- More than half of the people interviewed is declared satisfied, partially or entirely with access conditions (58% give an evaluation equal or higher than 7/10 for work and 63% for the leisure);
- The possibilities of teleworking are weak but are not excluded (less than 3% have the theoretical possibility of working at home; 14% could achieve part of their work).

After this first analysis of the data, it appears that the cost of movement is not (or no more) the determining criterion of the access. That could mean that part of the captive people would be laid out to pay more for a valid alternative in terms of comfort and time (especially to go to working places); however, this assumption must be moderated because of the high general level of satisfaction declared.

If we now consider the answers according to the characteristics of the sample (localisation, income), it is possible to give more precise details while moderating certain preceding reports. By considering the localisation of people questioned, the quality of accessibility is better in centre communes, where the supply of transport is more significant:

- the percentage of the use of the car grows while moving away from the centres of the agglomerations (from 54% (67%) in centres communes to 81% (84%) in nonurban zone for displacements towards the place of work (leisure));
- in the centres of the agglomerations, the percentage of "captive" is the lowest (for work 21% versus 25 % respectively 49% in the communes of the agglomerations or in nonurban zones; for leisure, the values are similar) and the ecological sensitivity is mentioned as a factor of choice primarily for work (16%, but that must be also interpreted according to the proximity of the places of work which facilitates a displacement by foot or bicycle).
- in the centres of the agglomerations also live the majority of people questioned (3% only for work access) declaring the cost like deciding factor, while, in the other zones, this factor is practically not quoted ;
- it is still in urban environment and more in the centres that the factor time is significant (25% for work in the centres versus 19% on average).
- in the centres finally, the judgement of the conditions of the access is slightly better.

The most significant differences are obviously established according to the geographical position of the people questioned (centres of the agglomerations, communes of the agglomerations and nonurban communes), while the differences of income or type of household do not distinguish the mobility's behaviours; that can explain the weak interest accorded to the factor " cost " in the modal choice.

### Relative importance of the modal choice criteria

The purpose of the sample survey was also to highlight the hierarchy of the access factors, in particular, the importance of the modal choice criterion according to the localisation, by comparing two to two the following criteria:

- the general conditions of displacement;
- the time of displacement;
- the cost of displacement;
- the environmental sensitivity.

The comparison between couples of criteria showed that time is the criterion collecting the greatest number of points of importance, whatever the geographical area, except for the inhabitants of the centres communes in the case of leisure displacements, where the conditions of displacement are the most significant.

#### Importance of the modal choice criteria according to the geographical area

	Centres		Agglomerations		Non-urban		Total	
	Work	Leisure	Work	Leisure	Work	Leisure	Work	Leisure
Time	18 pts	17 pts	21 pts	20 pts	21 pts	20 pts	21 pts	19 pts
Conditions	17 pts	21 pts	14 pts	14 pts	12 pts	16 pts	14 pts	17 pts
Cost	12 pts	13 pts	14 pts	15 pts	15 pts	13 pts	13 pts	15 pts
Sensitivity	13 pts	9 pts	11 pts	11 pts	12 pts	11 pts	12 pts	9 pts

The environmental sensitivity is almost always the criterion to which it is granted the least importance, with however less difference compared to the conditions and the cost within the framework of work displacements. We also note that the cost is only privileged compared to the conditions by the inhabitants of the nonurban communes within the framework of work displacements and by the residents of the peripherals communes of agglomeration during leisure's displacements.

It should also be noted that towards the question " why this modal choice ? ", relating to the last movement, people questioned stressed in priority the conditions of displacement (38% work, 42%

leisure), then the time of displacement (19% and 16%), the environmental sensitivity (11% and 5%) and the cost (3% and 2%).

On the other hand, to the question "compare the selection criteria", referred to work access, the people clearly privileged time, then quoted the conditions of displacement, followed by the cost and the environmental sensitivity; this hierarchy of the factors is also found for the access to leisure (with however a stronger preponderance, in the centres, for the environmental sensitivity to the detriment of the cost).

The hierarchy of the criterion of modal choice appears thus different according to the manner of asking the question.

This difference is explained by the shift between the needs for the everyday life (to move to work, to slacken, etc.) and personal values of each one. Even if the questions related to last movement to join the leisure and place of work, it is probable that the people questioned integrated a more global dimension during the cross estimations of the criteria. Thus, during the indirect questions, surveyed privilege initially the criterion of the general conditions of displacement and then the time of displacement. The cost of displacement is even often regarded as being less significant than the environmental criterion, which means that the individuals perhaps perceive their pendular movement as being more frequent, therefore requiring a greater "comfort" and involving a greater environmental sensitivity within sight of the generated effects. On the other hand, for leisure displacements, the environmental criterion becomes marginal, contrary to the cost of displacement, which takes more importance, while remaining relatively slightly evoked. That means that the individuals always grant much importance to the time and the conditions of displacement, with a glance more marked on the costs of displacement and a relative disinterest of the environmental effects, as if the pleasure of going to practise a leisure took advantage over the environmental protection.

Thus, we find two types of hierarchy of the modal choice criteria :

- the "hierarchy of the needs", where individuals are subject to a concatenation of events and constraints of the daily life ;
- the "hierarchy of the values" which reflects the values and the normative's structure in which individuals identify and which, according to certain cases, can privilege other criteria than those quoted previously.

### **The indicator of access**

The formulation of an indicator of access was a top priority of the research. Indeed, in spite of the many studies carried out in this field, it does not seem to exist indicator integrating the economic, social and environmental factors (cf. OFS, 1999; Basler&Partner 1998). It was a question of formulating an indicator of access answering at least partly this challenge. The following elements were considered:

- *the concept of actor/user*. The access is expressed by a person, an actor and user of the system of transport. The investigation carried out shows that the characteristics of displacements to work/leisure are significantly related to socio-economic variables characterising the people questioned;
- *the needs and waiting of actor/user*. To consider needs and waiting of the user means to take into account qualities of opportunity, but also qualities of movement to reach this opportunity. To cancel the distance separating from opportunity, an individual is obliged to spend a certain quantity of four types of resources: time, money, the availability with discomfort and environmental care. The resources represent the factors of access enabling us to appreciate the characteristics of the access and the process of modal split.

- *the localisation of opportunity*. It is necessary to consider real situations, in order to appreciate the needs according to the friction for the distance between the place for residence and the leisure/work places.

The adopted approach is not directly interested in the value of time or comfort, but sets a hierarchy of the factors of access and, thereafter, determines coefficients balancing the various resources necessary to the access. The indicator of access is logically composed by the four factors of access, each one balanced by a coefficient of importance.

#### Indicator of access

$$A_{ado} = \text{time} * IT + \text{cost} * IC + \text{incomfort} * Ico + \text{impacts} * ISe$$

$$A_{ado} = t_{do} * IT + (d_{do} * ck_m) * IC + (1/dc_{do}) * ICo + i_m * Ise$$

$A_{ado}$	access of the individual(A) to opportunity (O) on the basis of the place of residence (d)
IT	importance of time (coefficient)
IC	importance of cost (coefficient)
ICo	importance of the conditions of displacement (coefficient)
ISe	importance of the environment (coefficient)
$T_{do}$	time used by the individual(A) to reach opportunity (O) from the residence (d)
$D_{do}$	distance covered by the individual(A) to reach opportunity (O) from the residence (d)
$ck_m$	cost per km of the mode (m) borrowed
$dc_{do}$	average cumulated density of the commune of residence (d) and the commune where opportunity (O) is localised
$I_m$	environmental impacts

The indicator of access is composite and considers at the same time the objective and subjective friction separating the place from residence to the place where opportunity is localised.

#### Results for movement towards work places

The cantonal mean corresponds to a value of 1.1630. This level can be used as reference for the analyses carried out according to the social groups and to the geographical distribution. On one side, this value reflects the average characteristics of work movement and on the other side, it expresses the mean importance allotted to the resources necessary to move. For the analyses, the values below the cantonal mean will be interpreted like an easier access; on the contrary, higher values will be interpreted like a more difficult access.

##### The access according to the sex

There is a difference between the values of the indicator of access for men and women. The indicator of access of men is higher than the sample mean (+3%), while the women one is lower (-4%). This difference is explained by the higher cost of movement for men and longer time used to go to work places.

##### The access according to the households income

The higher the income is and the more the indicator of access takes high values. Thus, more the income is significant, more the resources used to move are consequent (time and money). The coefficients of importance contribute to widen the gaps between the classes ; indeed, the higher the income is raised, the more the consideration for the factor time increases (time is money).

##### The access according to the geographical area

The indicator of access presents values very contrasted according to the geographical area : the value is lower in the centres communes (-27%) and the communes of agglomeration (-6%) that the mean of the sample, whereas it is higher in the nonurban communes (+40%).

The time and the cost devoted to movement present the highest values in the communes of agglomeration. Concerning the coefficients, the one relating to time is most significant in the three categories selected. The ecological coefficient of sensitivity is in second position in the centres communes and the communes of agglomeration, while it is in last position for the nonurban communes, which constitutes a very interesting result from the point of view of a strategy of sustainable policy of transport. One can think that inside the urban zone, the people are more incline to modify their behaviour of transport if the objective is a better environmental protection, contrary to the inhabitants to the nonurban communes.

### **Results for displacement towards the place of leisure**

The cantonal mean of the access to the places of leisure is equal to 1.3135.

#### **The access according to the age**

The quality of the access to the places of leisure varies considerably according to age : good for the people less than 25 years old, for whom time and cost present the lowest values and poor for people more than 65 years old, which attach an importance particular to comfort and the environmental protection.

#### **The access according to the size of the household**

The value of the indicator of access for the people living in a household of two people is definitely higher than the mean (+15%), while for the households made up of 3 people or more shows values below the mean (-7% and -4%).

These differences are explained by the characteristics of movements (longer and more expensive for the people living alone or in couple). Thus, more the size of the household is large, more people will be ready to devote resources for their movement. However, it should be noted that the coefficients of importance tend to resemble each other, because the people moving at shorter distances also have the highest time coefficient (5-6 persons).

#### **The access according to the geographical area**

The value of the indicator of access for the inhabitants of centres communes and of the communes of agglomeration is lower than the mean of the sample (-28% and -6% respectively). On the contrary, the value for the residents of the nonurban communes is much higher than the mean (+ 46%).

This difference is explained by the stronger density of infrastructures of leisure in urban zone (centres communes and communes of agglomeration). In addition, the importance attached by people questioned to the environmental protection is higher for the urban residents.

### **The qualitative investigation**

The deepening analysis of the sensitivity of the individuals, in particular the one of car users, with qualities of the access was carried out in the form of a qualitative phone investigation on a restricted sample (19 persons). That enabled us to appreciate the thresholds of satisfaction, which the individuals set in the process of modal choice, by attaching a great importance to the role played by the cost.

### **Results**

Many studies showed that having a parking place near its place of work does not encourage the individuals to use public transport. In our sample, only one person affirms to pay its parking fee (parking meters) without having permanently the availability of it. Thus, the great majority of our sample has, at any time, the disposal of a company place offered by its employer or a private place.

To have a company place does not always mean paying nothing to use it. However, the amounts devoted to the parking fee are relatively low and do not constitute a barrier to the use of the car to go to the place of work. That is confirmed by the fact that six persons out of thirteen would be ready to take out a subscription if the permanent availability of a place could not be obtained.



In addition, two persons only would be been willing to change means of transport and three would plan to use the P+R. All the persons having a parking place are said to be ready to pay if they can be ensured of the availability of a parking place at work. The recourse to other means of transport or a combination of means (P+R) seems to intervene only if it would not be possible to obtain the insurance of the permanent availability of a place.

People questioned perceive the alternative to the use of their private car as being complicated (11 quotations), slow (9 q.) and not very comfortable (5 q.). Moreover, the public transport schedules are considered to be unsuited to the temporal constraints of people questioned. However, it is not inevitably the people having to use several means of transport which evoke more the complexity of the ways or the schedules badly co-ordinated.

Concerning the reasons to choose the car, the practical sense (13 q.) and the speed (10 q.) are the most quoted factors. We could add the terms "independence" (7 q.) and "flexibility" (6 q.) with "practical sense", even if these two terms are respectively to be understood like a certain degree of autonomy and a relative flexibility towards public transport schedules.

For a better appreciation of our people questioned sensitivities towards public transport use, we asked them to indicate the level of performance (in terms of time) that a new offer has to propose so that they use them instead of their car.

On the fourteen people declaring themselves willing to use public transport, some of them are ready to devote a relatively significant share of their time in comparison with time currently devoted (between 17% and 150% of current time). If the introduction of the new offer were coupled with parking restrictions at work, eight people out of fourteen would not change anything compared to the preceding situation. On the other hand, six people would modify their behaviour by using public transport and by increasing their time of displacement from 20% to 100% of current time.

That means strong sensitivity of people questioned to the modifications of the offer, if it is coupled with parking restrictions.

### **Preferences towards public transport supply**

Under which conditions people questioned would agree to use public transport, either on the assumption of an improvement of a current line or the realisation of a project interesting them, or on the assumption of a future new public transport supply (undetermined) ? The improvements of public transport supply are both presented to people questioned as being coupled with parking restrictions in the city centre.

Only three persons would be interested by an offer of the type P+R, whereas they would be fifteen interested by a public transport line.

To access to their work places, a strong majority of persons are ready to devote eight minutes and more for their movement by foot, which corresponds to distances varying between 500 and 650 meters. These values seem excessive if one compares them with the usual distances considered by the planners (in urban zone, 300m between the bus stops). Two persons would even agree to move longer distance to join the place of work than to join the stop starting from the place of residence.

Nevertheless, seven people declare themselves very demanding towards public transport. They agree to spend the same time, or even shorter, than actually, which does not seem easily realisable actually.

Concerning the bus change and the comfort of the vehicle, ten people out of nineteen wish to have one change to do and the nine others are willing to change means of transport twice. The people questioned are relatively demanding from the point of view of the comfort of displacement, which could be explained by the practice they have to move in their own car, without promiscuity and the disadvantages of public transport.

Eight people questioned out of the nineteen would accept a frequency of passage of the public transport from 10 to 12 minutes at the peak hour to use them, which is relatively possible, in urban environment.

For better appreciation of the user's sensitivity to costs of movement, we asked the questioned people with which level should be the daily cost of parking and the price of the litre of gasoline so that they will use public transport.

Ten users say to consider changing means of transport if the parking fee lies between five and eight francs per day. Thus, the parking fee seems to be a significant leverage for our questioned people.

Only two people declare themselves sensitive to the price of the gasoline for their modal choice. Nevertheless, four persons would start more seriously to think about the question of a modal change starting from a price of 1.50 francs the litre, that is to say the price, which we currently meet in Switzerland<sup>1</sup>. Let us note that the psychological threshold of the 2 francs seems to be very significant, since six people would use TC with this tariff.

## Conclusions

At the end of this research, several major lessons can be drawn; they concern :

*theoretical contributions.* Access represent a field of search still little explored; in all the cases it is located well beyond the transformation into money values of the components of the request for movement. To measure the access presupposes taking into account " objective " elements (transport supply at one time and in a space given, types of opportunities) and " subjective " elements (like the importance allotted by the user to the opportunities to reach or qualities requested for the movement).

*methodological contributions.* The indicator of access build in this search is a measuring instrument which combines the resources necessary to movement with the frictions (objective and subjective) acting on a same displacement. The formulation suggested is interesting while it considers needs and waitings of the users, in terms of transport, with the importance allotted to the factors the such *cost*, *conditions* (comfort), *time* and environmental effects.

*empirical contributions.* The investigation highlighted two hierarchies of the modal choice criteria : the "hierarchy of the needs" resulting from a concatenation for events and constraints, and the " hierarchy of the values" reflecting the normative structures, the beliefs and the values in which individuals identify. This differentiation of the importance of the factors of choice lets appear many questionings : all could not be detailed in this research (cf. next point). The qualitative investigation showed the existence of allowance's thresholds of the resources to be devoted for the realisation of movements.

*Further developments.* The concept of access and the process of modal choice constitute rich topics, because they allow not only the description of the mobility's behaviour, but they also clarify their "objective" and "subjective" reasons. Many questionings remain evidently unanswered and Further developments are necessary as well from the point of view of the opportunities considered, of the indicator of access and of the qualitative investigation. In particular, the double hierarchy of the factors of choice constitutes the starting point for the best taken into account of the transport demand in the development of local and regional policies of transport.

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<sup>1</sup> At the time of the investigation, the price of the litre of unleaded gas was of Fr.1.30.