CIVITAS
Sustainable and smart mobility for all
2030

CIVITAS indicators

Accessibility index – Version 2 (TRA_FC_AC2)

DOMAIN

Transport	Environment	Energy	Society	Economy

TOPIC	**Functionality of the transport system**	
IMPACT	**Accessibility** *Increasing the accessibility in the urban area*	**TRA_FC**

Category

Key indicator	Supplementary indicator	State indicator

CONTEXT AND RELEVANCE

Accessibility in urban areas refers to how easily individuals can reach services, amenities, and opportunities. Achieving accessibility requires well-designed infrastructure, efficient transportation systems, and inclusive public spaces that support all modes of urban mobility. By prioritizing accessibility, cities foster inclusivity and equity, ensuring residents can fully participate in urban life—whether accessing jobs, education, services, or recreation. Additionally, improved accessibility strengthens community bonds and reduces social isolation.

This indicator provides a measure of the level of accessibility in the experiment area. **It is a relevant indicator when the policy action is aimed at improving the role of the transport system as support of trips needed for individual activities. A successful action is reflected in a <u>HIGHER</u> value of the indicator.**

DESCRIPTION

This indicator is an index obtained as function of the variation of **potential accessibility indicators** computed for several zones. Potential accessibility indicators are functions of two elements:

- The attractiveness of zones
- The effort required to reach one zone from another zone.

For this indicator, the attractiveness of one zone is measured building on the **number of different city functions** located in the zone itself. The effort required to move between two zones is measured by a function of the **generalised cost (out of pocket cost plus monetary equivalent of travel time**) of the movement by car, public transport and bicycle.

The city functions considered for the quantification of the indicators are:

- **Population**
- **Schools**
- **Administrative offices** (e.g. public administration, post, bank)
- **Hospitals**
- **Other health services** (doctors, etc.)**.**
- **Grocery shops**
- **Recreational facilities** (e.g. sport facilities, cinemas, theatres)

These functions are significant destinations of several trips for personal reasons or even for working.

METHOD OF CALCULATION AND INPUTS

The indicator is calculated by means of mathematical equations, **within the supporting tool, building on a set of required inputs**. There are two methods for computing the indicator. The difference between the two methods is in the source of the generalised cost. If a multimodal urban transport model representing cars, public transport and bicycles is available, it can be the source for generalised cost. This option reduces the complexity of the quantification of this element, but is relying on theoretical values, therefore less significant. If a multimodal transport model is not available or it does cover only some modes, generalised costs can be quantified building on measurements made by online route search engines. This option is much more complex but provides more representative values, therefore is more significant.

METHOD 1	METHOD 2
Generalised costs extracted from a multimodal transport model	**Generalised costs quantified on route search engines**
It is based on theoretical values.	It is based on more realistic values
Complexity	Complexity
Significance	Significance

Method	
Generalised costs extracted from a multimodal transport model	Significance: **0.50**

METHOD OF CALCULATION

The indicator is computed according to several steps. Some initial activities are required to produce the inputs for the calculation:

- **Quantification of the number of city functions by type located in each zone**.
- **For each origin-destination pair, quantification of travel time for travelling by car, public transport and bicycle in the before-experiment condition, in the BAU condition and in the after-experiment condition.**
- **For each origin-destination pair, quantification of travel cost for travelling by car, public transport and bicycle in the before-experiment condition, in the BAU condition and in the after-experiment condition.**

After these initial steps, the computation of the indicator is managed **within the supporting tool**, according to the following steps:

- **Calculation of an attractor value for each zone** based on the number of functions located in each zone.
- **Calculation of the generalised travel cost** for each mode of transport and each origin-destination pair in the before-experiment condition, in the BAU condition and in the after-experiment condition**.**
- **Calculation of the average generalised cost across modes of transport** for each origin-destination pair in the before-experiment condition, in the BAU condition and in the after-experiment condition**.**
- **Calculation of potential accessibility for each zone** in the before-experiment condition, in the BAU condition and in the after-experiment condition

- **Calculation of the variation of the potential accessibility in each zone** in the after-experiment condition compared to the before-experiment condition and the BAU condition.
- **Estimation of the index (within the supporting tool)**.

INPUTS

The following information should be coded in the supporting tool to compute the indicator:

a) $FunctNum_j^f$. **Number of city functions of type *f* located in zone j.** This number should be obtained by overlapping GIS layers reporting the location of different functions on a layer reporting the boundaries of the zones. If zones are based on some administrative classification, population should be available from census or city statistics. If the transport model already uses some measure of zonal attractiveness, this measure can be used.

b) ${}^{m}TravTime_{ij}$. **Travel time between zone *i* and zone *j* by mode *m*.** origin-destination times are a common output of a transport model.

c) ${}^{m}TravCost_{ij}$. **Travel cost between zone *i* and zone *j* by mode *m*.** origin-destination costs are a common output of a transport model.

d) VOT. **Value of travel time**. Value of travel time is a measure of monetary value attached by individuals to travel time. The supporting tool provides initial values, which can be adapted by evaluators based on previous studies, recommended values by national or regional practice, literature, dedicated surveys, etc.

The experiment would be reflected in the indicator by changing the matrices of travel times $\boldsymbol{{}^{m}TravTime_{ij}}$ and travel costs $\boldsymbol{{}^{m}TravCost_{ij}}$. Basically, the difference between the before-experiment condition, the BAU condition and the after-experiment condition should be represented by different matrices. The differences between BAU and after-experiment condition should be the result of modifications due to the experiment. **The number of city functions** in each zone **should remain unchanged**, unless a modification of this number can be considered an impact of the experiment. Identically, **the value of time should remain unchanged**.

EQUATIONS

The equations, **computed within the supporting tool**, to manage the calculation of the indicator, building on the provision of the inputs mentioned above, are the followings:

Calculation of the attractor value by zone:

$$AttrZone_j = \sum_f \left(FunctNum_j^f * FunctWght^f * \frac{J}{\sum_j FunctNum_j^f} \right) * 10$$

Where:

$FunctWght^f$ = relative weight associate to function type *f*. These weights are predetermined within the tool, with the following values:

- Population: $FunctWght^f = 0.10$
- Schools: $FunctWght^f = 0.15$
- Administrative offices: $FunctWght^f = 0.15$
- Hospitals: $FunctWght^f = 0.15$
- Other health services: $FunctWght^f = 0.10$
- Grocery shops: $FunctWght^f = 0.20$
- Recreational facilities: $FunctWght^f = 0.15$

J = Number of zones

Calculation of the average time and average cost across transport modes:

$$TravTime_{ij} = \frac{\sum_m {}^{m}TravTime_{ij}}{3}$$

$$TravCost_{ij} = \frac{\sum_m {}^{m}TravCost_{ij}}{3}$$

Where *m* = car, public transport, bicycle

Calculation of the average generalised cost:

$$TravGenCost_{ij} = TravCost_{ij} + TravTime_{ij} * VOT$$

Calculation of the potential accessibility by zone:

$$PotAcc_i = \sum_j \left(\alpha * AttrZone_j * exp^{-\beta * TravGenCost_{ij}}\right)$$

Where α and β are two parameters predefined in the model.

Calculation of the variation of the potential accessibility by zone between the BAU and the after-experiment condition and between the before-experiment and the after-experiment condition:

$$PoTAcc\_AEBAU\_Chng_i = \frac{PotAcc_i[AE]}{PotAcc_i[BAU]}$$

$$PoTAcc\_AEBE\_Chng_i = \frac{PotAcc_i[AE]}{PotAcc_i[BE]}$$

Calculation of the accessibility index (indicator value) in terms of average variations:

$$\boldsymbol{AccIndex = \sum_i \left(PoTAcc\_AEBAU\_Chng_i * \frac{Pop_i}{\sum_i Pop_i}\right)}$$

$$\boldsymbol{AccIndex = \sum_i \left(PoTAcc\_AEBE\_Chng_i * \frac{Pop_i}{\sum_i Pop_i}\right)}$$

Where Pop_i is the population of zone *i* (already available as one of the $FunctNum_j^f$ variables)

Method 2

Generalised costs quantified on route search engines	Significance: **1.00**

METHOD OF CALCULATION

A preliminary step is required:

- **Partitioning the experiment area in zones.** The zones should correspond to meaningful portions of the experiment area. It could be convenient basing the zones on administrative spatial classifications (e.g., census zones or aggregations of census zones, neighbourhoods) as information might be available for these administrative classes. The number of zones should be large enough to assume that a significant share of activities in the experiment area imply a trip between two different zones, but not larger.

After this preliminary step, the method of calculation is the same as for Method 1 (see above).

INPUTS

The inputs required as the same as for method 1 (see above).

The difference with respect to method 1 is that **travel times and travel costs by origin-destination and mode** cannot be extracted from a transport model but **need to be quantified using some route search engine** like, e.g. Google Maps.

In order to use the route search engine, a representative point need to be defined for each zone. This point should be defined in the geographical middle of the zone or, better, in the middle of the populated area. The query sent to the engine should be for the route between two representative points.

The route search engines always provide travel time, usually referred to the traffic conditions existing when the query is made. It is therefore recommended to concentrate queries in the same period of the day. Peak time is the preferable period, if possible.

Some route search engines provide travel cost by car. Usually, this cost includes charges if the route involves charged roads. Parking costs, instead, are hardly considered. Evaluators should assess whether parking costs should be added – as a significant part of those arriving in a certain zone should pay for parking their car – or not – as regulated parking are used only by a minority of motorists. It should be taken into account that this aspect might be changed by the experiment (e.g., if one measure is the conversion of all or most parking places in some zones in regulated parking).

Public transport costs are not necessarily provided by route search engines. In many cases, origin-destination costs for using public transport between two urban zones can be easily defined given the fare system applied.

The experiment would be reflected in the indicator by changing the matrices of travel times $^{m}TravTime_{ij}$ and travel costs $^{m}TravCost_{ij}$. Basically, the difference between the before-experiment condition, the BAU condition and the after-experiment condition should be represented by different matrices. The differences between BAU and after-experiment condition should be the result of modifications due to the experiment. **The number of city functions** in each zone **should remain unchanged**, unless a modification of this number can be considered an impact of the experiment. Identically, **the value of time should remain unchanged**.

EQUATIONS

See method 1

ALTERNATIVE INDICATORS

This indicator evaluates accessibility by considering the attractiveness of different zones based on key urban functions such as housing, schools, offices, healthcare, and recreation. It incorporates a generalized cost function that accounts for transport costs and travel time across various modes, including cars, public transport, and bicycles. By integrating both transport infrastructure and supply and the spatial distribution of services, this approach offers a comprehensive view of accessibility.

In contrast, **TR_FC_AC1** provides a simpler alternative, focusing primarily on transport accessibility. It combines measures of public transport connectivity, bike lane networks, and congestion levels. While this makes it easier to compute, it does not account for the broader urban environment or the availability of essential services. As a result, it may overlook areas where transportation is well-developed but access to key city functions remains limited due to their unavailability.