COST Action TU1209 - Transport Equity Analysis (TEA):
assessment and integration of equity criteria in transportation planning

Guidelines & Roadmap for EU equity planning

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This publication is based upon work from COST Action "TU1209 – Transport Equity Analysis (TEA): assessment and integration of equity criteria in transportation planning", supported by COST (European Cooperation in Science and Technology).

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Funded by the Horizon 2020 Framework Programme of the European Union

To cite this report:

Di Ciommo, F. (ed.) (2018) Guidelines & Roadmap for equity planning. Dissemination Report, TU 1209 TEA COST Action (http://www.teacost.eu)

Cover photo:

LNEC - Laboratório Nacional de Engenharia Civil (National Laboratory for Civil Engineering). http://www.lnec.pt/en/

GUIDELINES & ROADMAP FOR EU EQUITY PLANNING

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This document includes Transport and Equity guidelines and the related roadmap for implementing them. The aim of these guidelines is to provide to practitioners and urban planners a step by step process for assessing transportation project/policy behind an equity point of view.

DEVELOPING AND IMPLEMENTING AN EQUITABLE URBAN MOBILITY PLAN

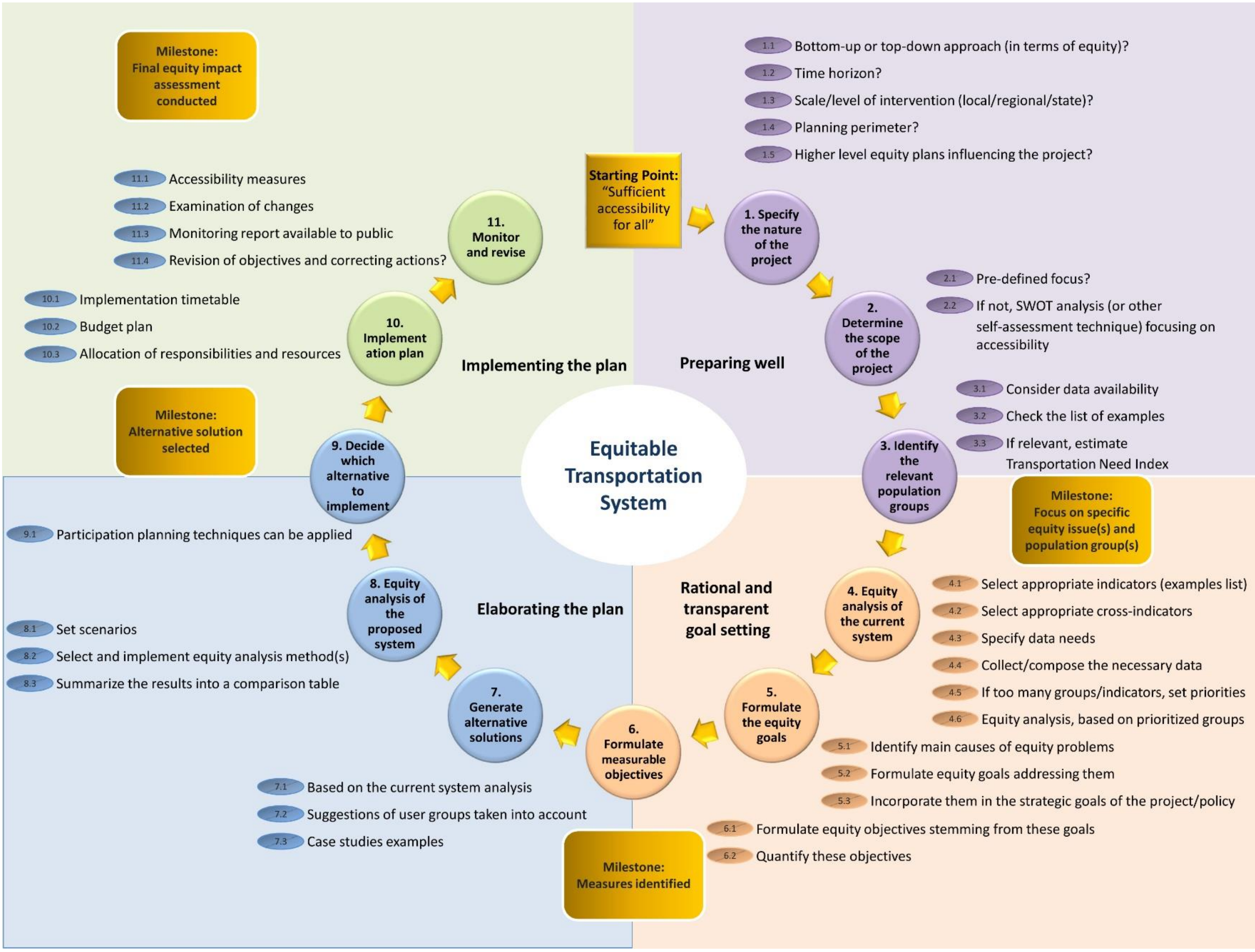
The guidelines for equity in transport focus on the process of assessing equity for transportation project/policy.
How equity is defined and measured can significantly influence analysis results. A specific alternative solution may seem equitable when evaluated one way but inequitable when evaluated another. It is advised to consider various perspectives and impacts. There is no single correct methodology. A planning process should reflect each community's concerns and priorities, so public engagement is important for equity analysis (Litman, 2002).

Equity goals:

- Fair allocation of transport resources
- Equal opportunity to be mobile and have access to key `life chance` activities
- Reducing adverse effects of transport system – including pollution, accidents and social exclusion

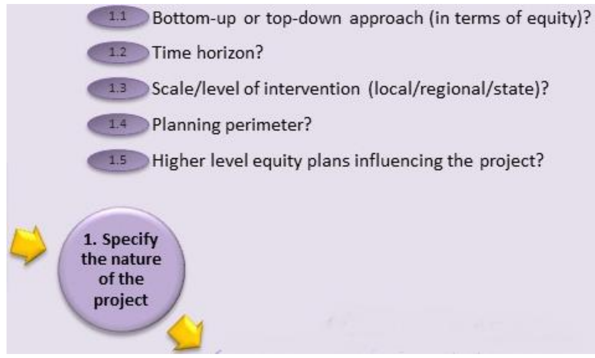
The below diagram will show what it could be considered in an equitable planning policy. TEA Cost team adopted the used framework for the Sustainable Urban Mobility Plans (i.e. SUMP), but with completely different contents. The idea is to use a familiar framework for European Transport planners for implementing Transport equity guidelines.

PLANNING CYCLE FOR AN EQUITABLE URBAN MOBILITY PLAN



STEP 1: SPECIFY THE NATURE OF THE PROJECT/POLICY

ACTIVITY 1.1: BOTTOM-UP OR TOP-DOWN APPROACH IS FOLLOWED?



- Bottom-up approach: Process usually followed when there is an already defined project/policy addressing a specific problem (e.g. congestion in a specific area). Equity analysis is then conducted as an additional element of the appraisal procedure of this project.
- Top-down approach: In this case, the fundamental goal is the development of an equitable transportation system, providing everybody a fair level of enough service. Therefore, the main target is the design of fair projects/policies and equity analysis is in the core of the appraisal procedure. A differentiation between programmatic (targeting specific disadvantaged groups) and structural solutions (affecting overall policies and planning activities) can be made.

Checklist: The approach followed in this project/policy is clarified.

ACTIVITY 1.2: WHICH IS THE TIME HORIZON OF THE PROJECT/POLICY?

It is important to specify the time horizon of the project/policy, because this influences directly the following steps of goal setting, equity analysis, etc.

Checklist: The time horizon of this project/policy is clarified.

ACTIVITY 1.3: WHICH IS THE SCALE/LEVEL OF INTERVENTION (LOCAL/REGIONAL/STATE)?

It is important to specify the scale of the project/policy, because this influences directly the following steps of goal setting, equity analysis, etc. The complexity of the project/policy is also affected, as well as the required level of detail of the collected data.

Checklist: The intervention area is specified in detail.

ACTIVITY 1.4: DEFINE THE PLANNING PERIMETER

Apart from the area that will be directly affected (area of intervention), are there other surrounding areas that will be indirectly affected)? Multiple levels of influence can be identified, by taking into account the complex interdependencies between functional spatial structures and traffic flows. The planning perimeter of a project/policy can directly influence the self-assessment process (step 2), the goal setting, etc.

Checklist: The planning perimeter of the project/policy is identified.

ACTIVITY 1.5: ARE THERE HIGHER LEVEL EQUITY PLANS INFLUENCING THE PROJECT/POLICY?

Check whether there are higher level equity plans, strategies and objectives that might influence the project/policy. Identify whether specific requirements or initiatives for coordination and integration of different policies are needed (SUMP guidelines).

GAP ANALYSIS

The most demanding element is to compare the present situation with the one described in the bench-mark. The purpose is to describe the existing collected plans, strategies, actions, and targets of the city and the gap between them and the SUMP benchmark. The description in the benchmark is called a 'gap analyses'. It explains the differences between the current practise in the city and the SUMP benchmark.

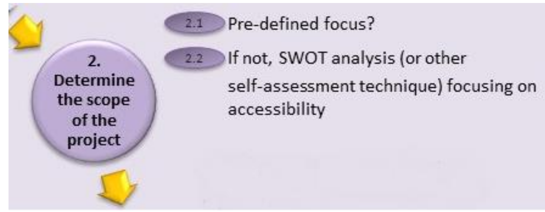
The first part of the benchmark invites the city to describe the processes that have been used in preparing their plans, strategies, actions, and targets. This description is made against the 'ideal' characteristics of the benchmark for preparing SUT planning.

The second part of this benchmark invites the city to describe the cumulative content of their plans, strategies, actions, and targets. This description is contrast against the 'ideal' characteristics of the SUTP benchmark.

Checklist: Higher level equity plans influencing the project/policy identified (if any) and taken into account. Coordination and integration needs specified.

STEP 2: DETERMINE THE PROJECT/POLICY SCOPE

ACTIVITY 2.1: IS THERE A PRE-DEFINED FOCUS?



Is there a focus on a specific benefit/burden of the intervention area in terms of equity (e.g. job accessibility)? If so, then the analysis of the current system focuses on it. However, the procedure suggested for the top-down approach (SWOT analysis, etc.) can also be followed in this case, in order to identify equity problems in the intervention area and the planning perimeter and try to adjust the solution alternatives in such a way that these equity issues can also be addressed.

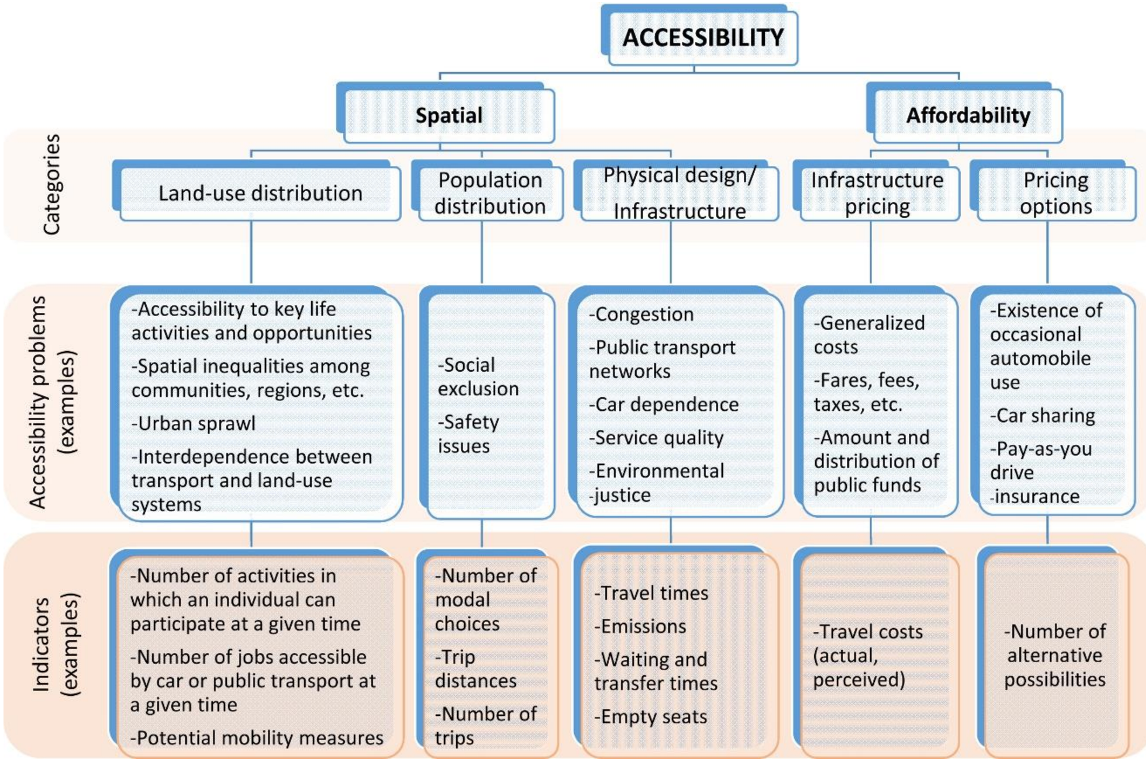
Checklist: If there is a pre-defined scope, identify it and decide whether SWOT analysis is needed.

ACTIVITY 2.2: IF NOT, CONDUCT A SWOT ANALYSIS (OR OTHER SELF-ASSESSMENT TECHNIQUE) FOCUSING ON ACCESSIBILITY

The main goal of this activity is to identify the major problems on which the project/policy can pay particular attention. Data availability should also be taken into account when taking this decision. Receiving early feedback from the relevant user groups is also advised.

Identify which are the strengths/weaknesses/opportunities/threats of the urban transport system in terms of equity. Specifically, this analysis focuses on equality of opportunities in the intervention area (social and distributional impacts considered) and the accessibility of public and private transport systems. Specifically, accessibility can be regarded as dynamic, due to changes in congestion, provided services, etc. during the course of the day/week.

The following aspects of accessibility can be considered: spatial and financial. Spatial accessibility can be related to the land-use distribution of the destinations, the population densities and the physical design of the transportation system. Financial accessibility (affordability) is related to infrastructure pricing, as well as the availability of various pricing options. The following diagram summarizes the main aspects of accessibility that can be considered during the self-assessment process. It also includes examples of equity problems stemming from lack of accessibility, as well as relevant indicators that can be considered during the next steps of equity analysis.



Accessibility categories, relevant problems that can be considered during the SWOT analysis. Examples of corresponding indicators are also included in the diagram.

One of the spatial aspects of accessibility is related to the spatial distribution of key life activities and opportunities (housing, work, personal business, education, healthcare, (non-)daily shopping, social interaction, leisure, etc.). Specifically, the density, mix and connectivity of the locations of various activities can be considered during the self-assessment process. Additionally, spatial inequalities among different urban/suburban/rural communities, regions or member states (depending on the scale of the project/policy) is advised to be identified. Additionally, the number of jobs and educational opportunities for the residents of these areas, the attractiveness of the areas as residential locations, the existence of urban sprawl phenomena of workplaces and residences, as well as the existence of blighted and deprived areas within the urban tissue (degrees of disadvantage for these areas can also be identified, with e.g. five levels of severity) can be taken into account. Moreover, the interdependence between transport and land-use system should be taken into account, since transport supports agglomerations and provides access to labor markets. Finally, the productivity and profitability of local companies, the economic opportunities and the socioeconomic strength of these areas can be examined. The attractiveness of these areas for companies/labor market is also an important factor and can be investigated by examining whether transport-related measures facilitate employment and support the development of an inclusive labor market.

Another spatial aspect of accessibility is related to population densities and socio-economic characteristics of people and their distribution in space and time. Social exclusion phenomena and safety issues can be examined in order to investigate the existence of this type of inequalities. Potentially vulnerable groups and areas (usually related to women, minorities, etc.) can be identified.

Finally, the physical design of the transportation system is also related to the spatial accessibility. This includes the set of infrastructures, facilities and services. For instance, road configuration, roadway quality (traffic speeds, delay, safety, physical condition, etc.), the form of the public transport networks, the existence of non-motorized transport opportunities (walking, cycling), car dependence phenomena, barrier effect (delay that roads and railroads cause to nonmotorized travel), congestion, (disabled) parking and infrastructure aesthetic impacts are issues related to this category of spatial accessibility. In addition, service provision quality can be considered: average distance to closest public transport stations/stops, synchronization of transfers for transit systems, intermodality and door-to-door mobility opportunities, frequency of service, punctuality, information provision, etc.. Furthermore, environmental justice and health impacts of transport (e.g. noise and air quality, hazardous materials and waste, active travel opportunities, etc.) can be taken into account.

The main financial aspect of accessibility (affordability) is related to infrastructure pricing (generalized costs, money and time budgets spent on travel) (Flamma & Kaufmann, 2006). The financial design of the transportation system mainly includes the pricing of transportation infrastructures, facilities and services, fare structures and discounts, fees and taxes. The criteria mentioned in Nuworsoo et al. (2009) about pricing can be taken into account: i. The benefit criterion asserts that people should pay for services in proportion to the benefits they receive from them. ii. The cost criterion states that people should be charged for the use of transit services in proportion to the cost of providing the service to them. iii. The ability-to-pay criterion holds that people should be charged for the use of transit in proportion to their wealth. Issues related to the amount and distribution of public funds for transport facilities and services, vehicle ownership and operating expenses, vehicle taxes and government fees, fuel taxes (polluter-pays principle is considered an equitable approach), road tolls and parking fees (including exemptions and discounts), public transportation fares (including exemptions and discounts), regulation of transport industries (public transportation, trucking, taxis, etc.), as well as traffic and parking regulation and enforcement can be examined.

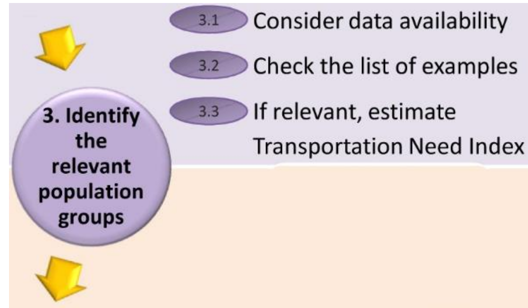
The second aspect of financial accessibility, is related to the existence of alternative pricing options. For instance, the existence of car-sharing, occasional automobile use, pay-as-you-drive insurance and other programs and pricing options that make occasional automobile use more affordable.

Example: A Transportation SWOT Analysis of Vancouver

Duxbury (2012) conducted a SWOT analysis on public transport network in Vancouver after completion of the Winter Olympics held in Canada, Vancouver in 2010. The purpose of the research was to identify issues related to public transport that has served both domestic passengers and tourists. The final aim of the study was the development of a general guidance plan which will be *used for future organization of high importance events by different cities. Equity considerations are included in the SWOT analysis, however equity is not the main focal point of this analysis (livability, ecology and economy were also taken into account).*

Checklist: Based on the SWOT analysis (or other self-assessment technique) and data availability, identify the main equity issue(s) that this project/policy will tackle.

STEP 3: IDENTIFY THE RELEVANT POPULATION GROUPS



ACTIVITY 3.1: CONSIDER DATA AVAILABILITY

Since the issues on which the project/policy is going to focus are identified, data availability should be examined in detail. This is an important factor for the selection of the relevant population groups. Due to data availability (census data are usually useful for identifying the size of these groups) and/or privacy concerns, the specification of population groups becomes more problematic the more detailed the spatial scale of analysis.

Checklist: Clarify data availabilities and constraints for the equity issues on which the project/policy will focus.

ACTIVITY 3.2: CHECK THE LIST OF EXAMPLES

Identify the groups of people who would be most sensitive to the project/policy implications, based on theoretical and practical considerations. The equity analysis will not only focus on the ability to pay, but also on the needs of these socioeconomic groups. Identify the relevant criteria of defining these groups/population segments. The following list of criteria can be considered:

1) Gender
2) Age and lifecycle stage (e.g. children, elderly)
3) Health and well-being
4) Special needs groups (mobility, physical, cognitive difficulties, etc.)
5) Ethnicity – cultural context – language barriers (e.g. not speaking the local language)
6) Educational level
7) Employment status – work-hour flexibility
8) Financial security
9) Personal income (quintiles, poverty line, lower income areas)
10) Household income
11) Household composition (e.g. single parents, caregivers: responsible for dependent child or disabled adult, etc.)
12) Housing security (tenure)
13) Mode availability
14) Car ownership
15) Driving license ownership
16) Size of social capital network (Di Ciommo et al., 2014)
17) Residential location with specific characteristics/urbanization levels (level depends on the project/policy scale: e.g. jurisdictions, neighborhood and street, urban/suburban/rural level).

For instance, specific areas identified during the SWOT analysis, such as areas next to a railway line/next to a national roads, areas in the periphery of a country/city, low walkability areas (very steep, usually bad weather conditions, etc.), isolated areas (in an inaccessible location), etc..

Example: Amsterdam case study

Population groups distinguished based on:

- *persons' residential location (the postal zones for which data were available on accessibility by car and public transport),*
- *mode availability (persons with access to a car and persons with access to public transport services) → based on income quintiles, with a distinction between the lowest and the four highest income quintiles),*
- *income level (Persons belonging to the lowest income quintile (as determined at a national basis for the Netherlands as a whole) are assumed to rely solely on public transport services, while all other persons are assumed to be able to take advantage of car-based accessibility).*

Checklist: Population groups identified.

ACTIVITY 3.3: IF RELEVANT, ESTIMATE TRANSPORTATION NEED INDEX

If relevant to the project/issue, after the identification of the relevant population groups, the Transportation Need Index value can be estimated. The Transportation Need Index is defined as the number of people in a given geographic area who are likely to require a public transport service. The measure is the index of transportation social needs related to transport disadvantages for each of the transportation analysis zones (TAZ) of the intervention area. In Currie (2010), the overall index is calculated as the weighted sum of the transport and social disadvantage indicators within each TAZ. Relatively disadvantaged areas are those with higher index. The method requires demographic data. The following table includes the weighting used for each socioeconomic population group (transport need indicator) for an application in Melbourne, Australia, presented in that paper (Currie, 2010):

Need indicator	Weight
Adults without cars	0.19
Persons aged over 60 years	0.14
Persons on a disability pension	0.12
Low income households	0.10
Adults not in the labour force	0.09
Students	0.09
Persons 5-9 years	0.12

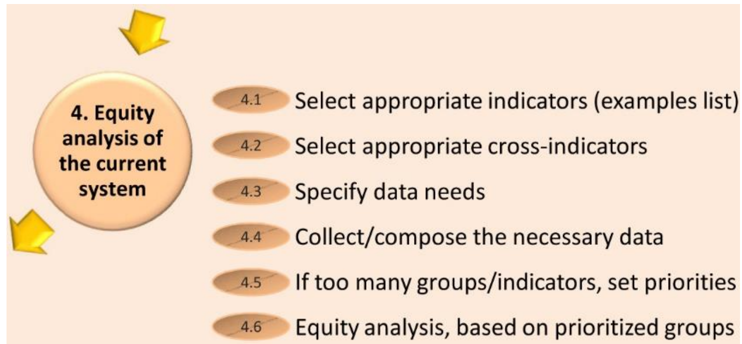
<u>Example: Accessibility and Social Equity in Tel-Aviv Metropolitan Area - examination of the current conditions and development scenarios</u>

1) *Identified Population groups:*
   a) *adults without cars (expressed by the difference between the number of adults and the number of cars in the TAZ),*
   b) *persons aged over 65,*
   c) *persons with disabilities,*
   d) *low income households (below median income),*
   e) *unemployed persons (as defined by the CBS - aged over 15 without a job),*
   f) *students,*
   g) *persons aged 10-18.*
2) *For calculating the Transportation Need Index, weighting was applied in the following way: 25% for adults without cars, with the balance divided equally among the other groups (13%).*

<u>Checklist</u>: Transportation need index calculated, if relevant.

STEP 4: EQUITY ANALYSIS OF THE CURRENT SYSTEM

ACTIVITY 4.1: SELECT APPROPRIATE INDICATORS



Decide/select the appropriate indicators (horizontal equity measures) (Miller et al., 2013). Various gravity-based or cumulative opportunity measures can be considered. Firstly, the appropriate measurement level(s) can be decided, for instance (Litman, 2002):

1) Per capita
   a) Per adult
   b) Per commuter or peak period travel
   c) Per household
2) Per Unit of travel
   a) Per vehicle-km
   b) Per passenger-km
   c) Per trip
   d) Per commute or peak period trip
3) Per euro
   a) Per euro user fees
   b) Per euro of subsidy
   c) Cost recovery

Indicators are accessibility measures, which can also be regarded as multi-dimensional: various periods of the day and week can be identified, as accessibility typically varies across time due to congestion effects and variations in service provision (Geurs & van Wee, 2004).

Examples of indicators (following the structure of accessibility issues mentioned in step 2):

1) <u>Spatial</u>:
   a) Land-use-based accessibility:
      i) the number of activities in which an individual can participate at a given time.
      ii) the number of jobs accessible by car or public transport within a 20, 30 and 45 minutes travel time threshold.
      iii) the number of schools, specific service locations, retail stores, health-care centers, etc. within specific travel distance.
      iv) potential mobility measures, such as the potential mobility index (Martens, 2007): the quotient of the aerial distance and the travel times between that origin and that

destination. The PMI for each origin location I is the average of the PMI values for all relevant origin-destination pairs for origin i. PMI can be applied to zones of any spatial scale.

b) Population-based accessibility:
   i) number of trips (can also be per activity type).
   ii) trip purposes.
   iii) trip distances.
   iv) trip durations.
   v) trip costs (relative to income).
   vi) modal choices.
c) Infrastructure-based accessibility:
   i) the average travel speed on the road network.
   ii) exposure to accident risk.
   iii) travel times / travel time thresholds by car, public transport, etc..
      (1) travel time thresholds of e.g. 15, 30, 45 minutes, reflecting the various spatial scales at which persons may engage in out-of-home activities (which may also differ between activities).
      (2) travel time ratio between public transport and car.
      Example: Kwan (1998) uses 20-, 30-, and 40-minute trips as cumulative opportunity/accessibility indicators.
   iv) emissions/other ecological impact indicators.
   v) public transport availability/ quality of the provided service:
      i. number of empty seats per trip for a specific line of public transport
      ii. waiting and transfer times.
      iii. Proportion of individuals in the population who are within X minutes walking distance of a bus/train/other public transport service.
      Example: A cut-off value of 400m is used by Church et al (2000) as a buffer to measure the accessibility to a transport system.

2) Financial:
   a) Infrastructure pricing:
      i) the welfare loss or the economic benefits that people derive from access to specific destinations.
      ii) travel costs (actual, perceived).
   b) Pricing options:
      i) number car-sharing services
      ii) number of pay-as-you-drive insurance options
   c) Affordability measures

Example: Accessibility and Social Equity in Tel-Aviv Metropolitan Area - examination of the current conditions and development scenarios

(1) Number of destinations of interest that are available for a person, within a reasonable time frame (between 30 minutes to an hour) using different transportation modes (usually private car and public transport, but it could be done also for bicycles and pedestrian movement).
(2) Number of jobs throughout the metropolitan area accessible by car from the city of Tel-Aviv departing at 7:15 am, and taking 15, 30, 45 minutes.
(3) Number of jobs accessible by bus throughout the metropolitan area and originating in Tel-Aviv starting out at 7:15 am and taking 15, 30, 45 minutes, before the bus reform of 2011.
(4) Number of jobs accessible by PT throughout the metropolitan area, originating in Tel-Aviv at 7:15am and taking 15, 30, 45 minutes - after the 2011 bus reform.
(5) Relative accessibility to jobs in the metropolitan area originating in Tel-Aviv at 7:15 am on the new bus network.
(6) Relative accessibility to jobs between public transport and car in the same 15-minute intervals.

Example: Strategic plan for the National railway network of Israel

Percentage of population within x minutes to Tel Aviv/another metropolitan center by public transport.

Example: Planning practice in Malmo, Sweden

Use of the following indices:

- *Accessibility index (accessibility for different age, gender, etc.)*
- *PAC: Perceived Accessibility*
- *Habitability index (attractiveness of a public space-pedestrians)*
  - *Ergonomic parameters*
    - *Distribution of public space*
    - *Accessibility*
    - *Spatiality*
  - *Psychological parameters*
    - *Diversity of activities*
    - *Attractive activities*
    - *Greenery*
  - *Physiological parameters*
    - *Sonorous level*
    - *Air quality*
    - *Thermal comfort*
  - *Proximity*
    - *Sustainable transport*
    - *Daily activities*
    - *Culture and service*
  - *City*
    - *Comfort*

    - *safety*
- *Gender budgeting*
- *Social Impact Assessment (SIA)*
- *Child Impact Analysis (CIA)*
- *Affordability measures*
- *Mobility management*

Checklist: Indicators selected.

ACTIVITY 4.2: SELECT APPROPRIATE CROSS-INDICATORS

Decide/select the appropriate cross-indicators, by combining the indicators with the relevant socio-economic groups (vertical equity measures). Examples of cross-indicators follow:

1) Travel time thresholds of e.g. 15, 30, 45 minutes, reflecting the various spatial scales at which persons may engage in out-of-home activities (these thresholds may also differ between activities), combined with the limitations persons may have to spend time or monetary resources for traveling (e.g., because of dependent children and related care tasks or because of a low (disposable) income).
2) Percentage of young people having access to school within x minutes by public transport.
3) Percentage of jobs accessible by public transport within x minutes for low income people in peripheral areas of the city.
4) Percentage of households without car having an access within x minutes to the nearest metropolis by public transport.
5) Average monthly cost spent by the households of a specific area/of a specific income category for using the transport system.

Example: Strategic plan for the National railway network of Israel

1) *Percentage of population living in the periphery of the country within x minutes to Tel Aviv/another metropolitan center by public transport.*
2) *Percentage of low-income population within x minutes to Tel Aviv/another metropolitan center by public transport.*
3) *Percentage of jobs within x minutes ride from low income population living in the periphery of the country.*
4) *Percentage of jobs within x minutes ride from the nearest metropolitan center.*

Checklist: Cross-indicators selected.

ACTIVITY 4.3: SPECIFY DATA NEEDS

Specify the appropriate data for measuring these (cross-) indicators. Make decisions over the following aspects:

1) Qualitative vs Quantitative
2) Scale:
    a) Land use data (increasingly available around the world - derived from geographical information systems).
    b) Data on the total population, population by income quintile, regional survey data, postal code area level, urbanization levels, etc..
    c) Individualized travel survey data
        i) Big data approaches → more scalable.
        ii) Smart data (smartphone panel surveys, etc.).
3) Time horizon:
    a) Panel data.
    b) Cross-sectional data.
4) Focus:
    a) Car ownership data (However, it might be problematic to rely on these data in order to estimate mode availability and access to a car. Income can be a better indicator.)
    b) Income, education, employment, other socioeconomic data.
    c) Travel times to all surrounding postal code areas (for morning peak hours, off-peak hours, etc.).
5) There might be a need to generate the necessary data. For example:
    a) Accessibility levels: in combination with data on land use, the data on travel times can be used to calculate accessibility levels for population groups.
    b) Potential Mobility Index: travel time data generated by travel demand models (typically separately for car and public transport, and typically between relatively large transport activity zones (TAZs)). Based on these travel time data and easily obtainable data (by GIS software) on the aerial distance between centroids of these TAZs, it is possible to calculate mode-based PMI (Potential Mobility Index)-scores for each TAZ (It is suggested to take the 'here and now' as starting point, not a long planning horizon).
    c) Activity-based travel demand models offer opportunities for generating the needed data for an equity analysis. They can allow a more fine-grained classification of persons and they can also account for multi-modal travel. The spatial scale is, however, often in line with more traditional models.
    d) Need-based models can be an alternative to the paternalistic approaches

Checklist: Data needs identified.

ACTIVITY 4.4: COLLECT/ COMPOSE THE NECESSARY DATA

It is often possible to collect data for transportation equity analysis in surveys performed for other purposes, by including questions concerning income and mobility constraints in regular travel surveys and by including transportation questions in surveys related to other issues (Schmocker, et al. 2005). Examples of potential data sources follow (Litman, 2002):

1) Government agency budgets and reports that indicate public expenditures by jurisdiction and mode, and on facilities and programs targeted to serve particular groups.
2) Census and surveys may provide data like the ones mentioned below, disaggregated by geographic, demographic, and income category:
   a) People's level of mobility (e.g. person-trips and person-miles of travel during an average day, week or year).
   b) The portion of the population with disadvantaged status (low income, physical disability, elderly, single parents, etc.) (Schmocker, et al. 2005).
   c) The portion of their time and financial budgets devoted to travel.
   d) The problems people face using transportation facilities and services.
   e) The degree to which people lack basic access.
   f) Residents' desire for transportation options.
3) Traffic accident injury and assault rates for various groups.
4) Audits of the ability of transport facilities and services to accommodate people with disabilities and other special needs.
5) Analysis of the degree to which disadvantaged people are considered and involved in transport planning.
6) Reports on the frequency of special problems by disadvantaged travelers (faulty equipment, inaccurate information, inconsiderate treatment by staff, etc.), the frequency of complaints by disadvantaged travelers, and the responsiveness of service providers to such complaints.

Example: Accessibility and Social Equity in Tel-Aviv Metropolitan Area - examination of the current conditions and development scenarios

The following data have been composed:

(a) Mode Access Area (MAAO(t)): all the destinations that could be reached using a particular mode (M) from origin (O) within a particular time frame (t):
-Public Transport Access Area PAAO(t)
-Private Car Access Area CAAO(t)

(b) Mode Service Area (MSAD(t)): all the area that is served by a particular destination (D) using a particular mode (M) within a particular time frame (t):
-Public Transport Service Area PSAD(t)
-Private Car Service Area CSAD(t)

(c) Relative accessibility between private car and public transportation:
-Access areas ratio: AAO(t) = PAAO(t)/CAAO(t)
-Service areas ratio: SAD(t) = PSAD(t)/CSAD(t)

Example: Accessibility and Social Equity in Tel-Aviv Metropolitan Area - examination of the current conditions and development scenarios

Data generation was based on CityGraph, a program developed within a GIS environment. It is a 3rd generation application based on the previous Urban.Access and AccessCity applications. It works at the resolution of individual buildings, bus stops and lines.

Example: Amsterdam case study (Karel Martens Book)

The measurement of potential mobility and accessibility was based on travel demand models. Accessibility to employment was mainly addressed. Three travel time thresholds (20, 30 and 45 minutes), for two periods of the day (peak and off-peak). Two types of accessibility measures:

a) *Cumulative opportunity measure (i.e., adding up all jobs that can be reached within a 30 minutes total travel time).*
b) *Gravity-based measure.*

Therefore, twelve different analyses have been conducted for car-based accessibility and six different analyses for public transport-based accessibility (due to lack of data on public transport travel time in off-peak hours).

Example: Planning practice in Malmo, Sweden

Data collected: GIS, KPI, census data, travel data

Checklist: Data needs identified.

ACTIVITY 4.5: IF TOO MANY GROUPS/INDICATORS, SET PRIORITIES

In case of too many population groups/cross-indicators, the following process can be followed, in order to set priorities:

1) Calculate the accessibility (based on the (cross-)indicator(s) that have been selected) and potential mobility index (see above) of each population group.
2) Position all population groups vis-à-vis a coordinate system of accessibility and potential mobility. The dots in the diagram represent the population groups that have been distinguished. This will have to be repeated for the different ways (indicators) in which accessibility is measured.

Example: Amsterdam case study

The results of each of the analyses were put in the coordinate system of potential mobility and accessibility. The average potential mobility and accessibility enabled by the car system *during peak hours, weighted by the population size of the zones, was used to establish the origin of the coordinate system. The dots in the diagram represented the 380 population groups, based on residential location of the groups and mode availability. The population groups with access to a car (the four highest income quintiles) are depicted twice in the diagram, reflecting their situation in peak respectively off-peak hours. The population groups who have only access to the public transport system are depicted only once, for the peak hour situation.*

3) Establishment of an accessibility sufficiency threshold. Real-life agents may agree on it. A range of thresholds may also be determined. The pragmatic approach can be followed (common in the domain of income), according to which the average or median level of income is the starting point, while the poverty line is a percentage of this income level. Then, the accessibility sufficiency threshold (based on the income poverty line concept) AP_r: Accessibility poverty in region r (Karel Martens Book) -> an overall score of accessibility poverty for an entire region, enabling the comparison between regions and socioeconomic groups. The assessment of the intensity of the accessibility poverty experienced by a person is also possible. This intensity is determined by the distance between a person's accessibility level and the accessibility poverty line. The larger the distance between a person's accessibility level and the poverty line, the stronger the intensity of the accessibility poverty experienced by that person.
4) Demarcate the level of potential mobility of sub-standard quality. Differentiation in the sufficiency threshold across cities or regions is also possible. Potential Mobility Index can also give a guidance to this process

Example: Accessibility and Social Equity in Tel-Aviv Metropolitan Area - examination of the current conditions and development scenarios

The first step in the assessment of accessibility poverty in the Tel-Aviv region consisted of the demarcation of the accessibility poverty line (in a pragmatic way). The poverty line was defined in a pragmatic way as a percentage of the average car-based accessibility (e.g., 20%, 30% or 60% of the average car-based accessibility level). Two poverty lines have been derived from these average car-based accessibility levels. A 'compassionate' poverty line of 50% of average car-based accessibility and a 'harsh' threshold of 20% of the average were distinguished.

Example: Amsterdam case study Following the pragmatic approach: the average level of accessibility experienced by persons with access to a car during peak hours threshold was used as the basis for setting a range of sufficiency thresholds. The sufficiency threshold was defined as a particular percentage of the average accessibility level (e.g., 40% or 60% of the average (or median) accessibility level). A range of sufficiency thresholds is set (10%, 20%, 30%, 40%, and 50% of the average level of car-based accessibility during peak hours) and the pattern of accessibility deficiencies across the thresholds is compared

5) Identify the population groups entitled to accessibility improvements. Identify the groups having an accessibility level below the sufficiency threshold(s) and experience a sub-standard level of potential mobility (PMI) or somewhat above the average.
6) Assess the severity of accessibility deficiency. This assessment takes into account the prevalence and the intensity of accessibility shortfalls. The analysis is carried out separately for each population group that is entitled to accessibility improvements and for each defined accessibility sufficiency threshold. Finally, assessment of accessibility deficiency across all population groups (this results in an understanding of the overall patterns of accessibility deficiency across the region, as well as in the relatively contribution of each of these population groups)
7) Set priorities: identify the population groups that suffer most from the unfairness of the urban/transportation system (a ranking is also possible). Add up each group's accessibility shortfall for each way of measuring accessibility. This is the measure of total accessibility shortfall. The size of the groups can also be taken into account, by adding up, for each group, the contribution to overall accessibility poverty for each way of measuring accessibility. These analyses are carried out separately for each accessibility threshold. The Accessibility Fairness Index combines the size of the accessibility shortfall and the size of the population group in one composite index

Example: Amsterdam case study

The average contribution to accessibility deficiency by population group was calculated by adding up the contribution for each group for each type of accessibility measurement, divided by the number of accessibility measurements. Of all transit-dependent population groups, only three end up in the 'top ten' for each sufficiency threshold. These population groups are particularly entitled to improvements in their accessibility level.

Checklist: If needed, the population groups on which the equity analysis will focus, are prioritized.

ACTIVITY 4.6: CONDUCT THE EQUITY ANALYSIS, BASED ON THE PRIORITIZED POPULATION GROUPS

According to the scope of the project/policy, data availability, etc., there are various possibilities:

1) Lorenz curve: a graphical representation of the cumulative distribution function of wealth across the population (Lorenz, 1905). Lorenz Curve does not imply that perfect equity is possible or even desirable. Weighted average can be used to account for daily variation.
2) Gini coefficient: a statistical measure of the distribution of an attribute (e.g. income) (Gini, 1912). Graphically, it is a ratio of the area between the line of equality and the Lorenz curve, divided by the total area under the line of equality. In this way, the distribution of two different Lorenz curves can be mathematically compared. Statistically, Gini is a measure of equity variance, computed as half of the "Relative Mean Difference" of the value of an attribute between two randomly chosen objects. The Gini index is always between 0 and 1. A value of 0

implies complete equality whereas a value of 1 suggests complete inequality. The lower the value the more equal is the distribution in question. Weighted average can be used to account for daily variation. Gini coefficient measures only how the resource is distributed among the population; it is not able to show how it is distributed among different individuals and groups or who benefits more and who less or how. However, it is possible to calculate the Gini index for e.g. disposal income before and after a policy change to evaluate whether it contributed to a more equal distribution of income or not.

Example: Case Study of Transit Fare Change in Haifa

The Gini index was used only to measure whether the change in fare was equally distributed among the population. Using the data from the on-board survey, the Lorenz curve was used to plot the distribution of the change in fare. The Gini index was then calculated both graphically and numerically by using numerical approximations (offering the advantage of providing a standard error for the index). Specifically, the method proposed by Ogwang (2000) was used for calculating the value of the Gini index.

Example: Accessibility and Social Equity in Tel-Aviv Metropolitan Area - examination of the current conditions and development scenarios

Lorenz Curve and Gini Index have been used in order to examine the old and new bus systems and their impact on relative job accessibility in the city of Tel-Aviv.

3) Magnitude of inequity measures (See "Accessibility and Social Equity in Tel-Aviv Metropolitan Area - examination of the current conditions and development scenarios (Martens, 2015)" on how to calculate them):
   a) Relative accessibility loss: allows ranking regions and population groups by their accessibility.
   b) Absolute accessibility loss: L depends on the size of the public transport users' population PB and, thus, allows comparison between the outcomes of essential PT improvement that is available to a few passengers and the minor PT improvement that is available to many passengers. Weighting can be applied in both these measures in order to account for time-of-day dependency.

Example: Accessibility and Social Equity in Tel-Aviv Metropolitan Area - examination of the current conditions and development scenarios

These measures have been used to calculate the relative and absolute accessibility losses in Tel-Aviv due to public transportation dependence.

4) Use of a generalized cost measure of accessibility (capturing both travel times and costs), disaggregated according to the relevant socioeconomic groups.
5) The degree to which non-drivers are disadvantaged relative to drivers can be measured using mobility gap analysis (LSC 2001), which measures the difference in motorized travel

(automobile, public transit, taxi, etc.) between households with and without automobiles (called “zero-vehicle households”). This can be determined using travel survey data to compare the average daily trips generated by different types of households, taking into account factors such as the smaller average size and lower employment rates of zerovehicle households.

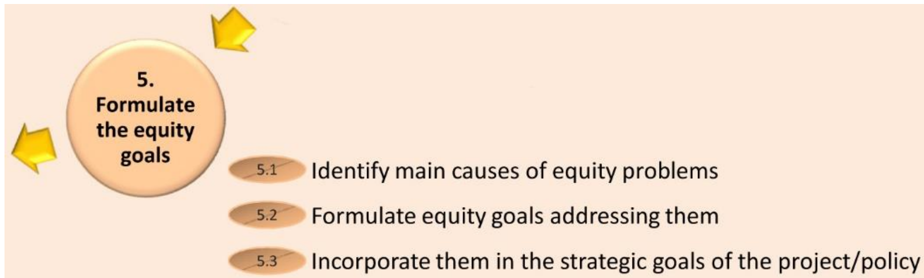
6) Theil Coefficient and the Coefficient of Variation
7) Qualitative data analysis
8) Use of custom ArcGIS tools (they facilitate geographic analysis of impacts) (see for example: Farber et al., 2014)

Checklist: Equity analysis of the current system conducted.

STEP 5: FORMULATE THE EQUITY GOALS

ACTIVITY 5.1: IDENTIFY MAIN CAUSES OF EQUITY PROBLEMS

Based on the equity analysis of the current system, identify the main causes of the inequalities in the current system.



Checklist: Main causes of the equity problems in the intervention area identified.

ACTIVITY 5.2: FORMULATE EQUITY GOALS

Formulate the goals addressing these causes of inequality, identified in the previous activity. Goals on household level and/or on community level (e.g. increased attractiveness of the community for business) can be set, depending on the scope and the scale of the project.

Move away from the current mobility-oriented to more accessibility-oriented goals for urban transport systems (Straatemeier, 2007). Examples of equity goals set in various projects/policies follow:

1) Improved well-being for all
2) Reduced regional imbalance
3) Strengthening of peripheral areas (on state/regional/city level)
4) Fair allocation of transport resources
5) Social inclusion
6) Social justice
7) Equal motility/ Equality in opportunities (to be mobile and have access to key "life chance" activities)
8) Accessibility to work, education, health
9) Improved safety

Example: Strategic plan for the National railway network of Israel (Goals)

1) *Enhance of social justice.*
2) *Strengthen the access to peripheral areas of the country (accessibility to Tel Aviv, metropolitan accessibility, regional accessibility).*

Example: Planning practice in Malmo, Sweden

Vision statements about equity:

Political visions at the national level

- *All women and men shall have the same power to shape society and their own lives.*
- *Evenly distributed power and influence, economic equality, welfare state – equal rights and possibilities for everyone.*

Local vision

- *By the year 2020 Malmö is a city with equal activities aimed at all women and men, girls and boys regardless of background and affiliation.*
- *The City Council highlights social inclusion & a children's perspective in the planning process → creating greater independency for children.*

Checklist: Equity goals formulated.

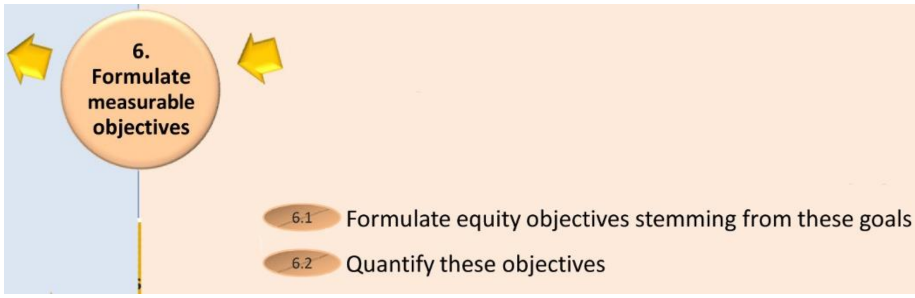
ACTIVITY 5.3: INCORPORATE THEM IN THE STRATEGIC GOALS OF THE PROJECT/POLICY

The equity goals will be part of the main strategic goals of the project/policy, but they will be combined with the other three sustainability perspectives (according to the project CIVITAS MIRACLES): environmental, economic and quality of life strategic goals.

Checklist: Equity goals incorporated in the overall strategic goals of the project/policy.

STEP 6: FORMULATE MEASURABLE OBJECTIVES

ACTIVITY 6.1: FORMULATE EQUITY OBJECTIVES STEMMING FROM THESE GOALS



"Analyze" the equity goals and break them down into clear and specific objectives. Depending on the nature of the project/policy, these can also be of short-, intermediate and long-term nature. The specific spatial/transportation/land use characteristics play a significant role in this process. Examples of equity objectives follow:

1) Goal: To reduce adverse effects of the transport system.
   a) Pollution: Reduce the exposure of X area to noise/air pollution.
   b) Accidents: Reduce the number of accidents in X area.
   c) Minimize the negative aesthetic externalities of transportation system in X area (landscape/urban environment/quality of life).
2) Goal: Increased transport system diversity.
   a) Improvements to modes used by disadvantaged people.
   b) Increase of the public transport modal share.
3) Goal: Improve the accessibility of X area.
   a) More affordable automobile options (carsharing, needbased discounts, etc.).
   b) Improve the connectivity of X area with the rest of the urban tissue.
   c) More accessible land use, and location-efficient development.
   d) Improve accessibility for people of X area to jobs.
   e) Improve the provided quality of service and especially the reliability of the public transport services in X area.

Example: Strategic plan for the National railway network of Israel (Objectives)

1) *Rail trips become the main mode on the major corridors between the metropolitan areas in Israel.*
2) *An inter-city network, based on high speed and high frequency rail service between the four metropolitan cities (Tel Aviv, Jerusalem, Haifa and Beer Sheva).*
3) *Improvement of the Rail Network hierarchy and operationality, in order to increase efficiency, reliability and level of service.*
4) *Improvement of the level of service in the external and middle rings of cities.*

Checklist: Every equity goal translated into specific equity objectives.

ACTIVITY 6.2: QUANTIFY THESE OBJECTIVES

Quantify each of the objectives set in the previous activity, in order to enable checking whether and when they are met.

Example: Strategic plan for the National railway network of Israel

1) *50% of population within 45 minutes ride from the nearest metropolitan city*
2) *50% of population in the periphery within 90 minutes ride to the Tel Aviv*
3) *40% of jobs within 90 minutes ride from low income population*
4) *50% of low income jobs within 60 minutes to Tel-Aviv*

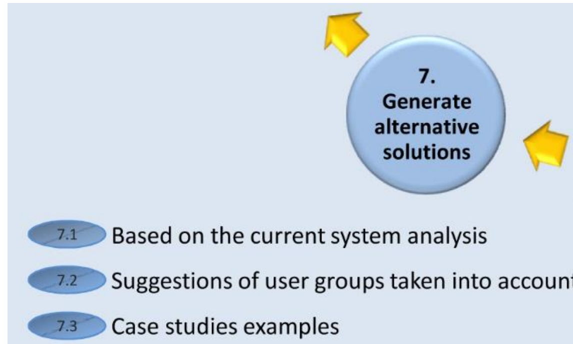
Checklist: Every equity goal translated into specific equity objectives.

STEP 7: GENERATE ALTERNATIVE SOLUTIONS

ACTIVITY 7.1: GENERATE ALTERNATIVE SOLUTIONS BASED ON THE CURRENT SYSTEM ANALYSIS

Come up with a number of alternative solutions addressing the equity problems identified in the previous phases and aiming at meeting the objectives of the project/policy.

Checklist: Alternative solutions identified.



ACTIVITY 7.2: SUGGESTIONS OF USER GROUPS TAKEN INTO ACCOUNT

Apart from the involvement of stakeholders, public engagement is crucial during the process of solutions formulation. This helps to legitimise the project/policy and enhance its quality. Involving citizens in planning is also a requirement stipulated by EU directives and international conventions. Therefore, it is crucial to create a transparent planning culture that is, based on regular communication and consultation. The ultimate goal of projects/policies is to improve the quality of life for every citizen, and create a broad public ownership of the planning process.

Checklist: Formulation or adaptation of the alternative solutions, based on the suggestions of the citizens.

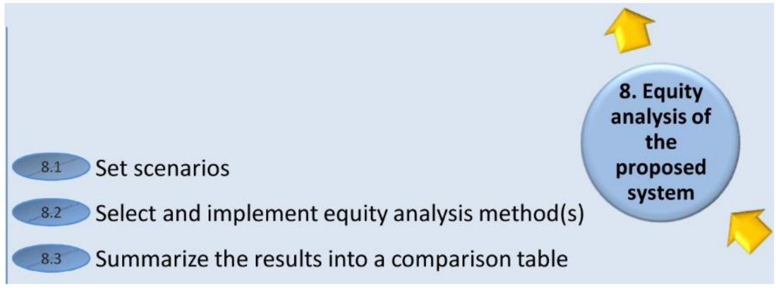
ACTIVITY 7.3: CHECK EXAMPLES OF RELEVANT CASE STUDIES

Similar equity problems might be encountered in other case studies. A review of the solutions that have been given can be of great help, as well as reports over the success of these solutions, in case they have been implemented. Nevertheless, special attention should be payed to the special characteristics of the current project/policy, which implies that case studies examples should be approached critically and not with a copying attitude.

Checklist: Solutions given to relevant case studies checked.

STEP 8: EQUITY ANALYSIS OF THE PROPOSED SYSTEM

ACTIVITY 8.1: SET SCENARIOS



The main target of this step is to compare the alternative solutions in terms of equity. Relevant scenarios can be set, based on which the equity analysis can be conducted. For instance, various finance/pricing scenarios can be considered (depending on the nature of the project), such as road pricing scenarios, transport fare change scenarios, etc. Another example would be to set scenarios based on the levels of provided service quality (e.g. average distance from closest bus stop and frequency of service), in order to test transit service improvements, bicycle services and infrastructure, etc..

Checklist: Scenarios identified.

ACTIVITY 8.2: SELECT AND IMPLEMENT EQUITY ANALYSIS METHOD(S)

A list of various methods that can be used in order to conduct the equity analysis and evaluate the various alternative solutions follows. The decision of which method to implement depends on the nature, the scope and the aims of the project. Moreover, various methods can be used in combination.

APPRAISAL METHODS	DESCRIPTION	EXAMPLES
COST-BENEFIT ANALYSIS	•Household level equity analysis •Community level equity analysis •Value of capability gains	• Equity considerations in Israeli cost-benefit analysis
MULTI-CRITERIA ANALYSIS	•SCBA results can be used as an input •Equity criteria •Criteria weights expressing political priorities	• Egnatia Odos Motorway (Greece)
COST-EFFECTIVENESS ANALYSIS	•Effects: accessibility improvements •Costs: investment and operation costs •Does not rely on monetary valuation of the effects (like SCBA)	
RISK ANALYSIS	•Major risks of the project identified •Sensitivity analysis	
ENVIRONMENTAL IMPACT ANALYSIS	•Noise mapping •Environmental capital based assessment techniques for landscape, etc. •Investigating whether some areas/neighborhoods, etc. are mostly exposed in the environmental effects of a project	• Baltimore Region Environmental Justice in Transportation Project
EQUITY MEASURES	•Lorenz curve •Gini coefficient •P2 measure •Magnitude of inequity measures (relative and absolute accessibility loss) •Mobility gap analysis	• P2 & inequity measures: Accessibility and social equity in Tel Aviv • Lorenz & Gini: Transit fare change in Haifa • Mobility gap analysis: Montana Rural Passenger Needs Study
ArcGIS	•Use of custom ArcGIS tools, facilitating geographic analysis of equity impacts	• Temporal variability in transit-based accessibility to supermarkets in Cincinnati • Fruin and Sriraj (2005) GIS tool for environmental justice
QUALITATIVE ANALYSIS	•Qualitative data on equity issues	• Equity effects of road-pricing in Madrid

1. **Social Cost Benefit Analysis** (**SCBA**) can be used first (for those effects where economic valuations are available) (van Wee et al., 2013). The overall assessment of the alternative solutions according to this method is the following: the changes in costs and benefits for all actors are specified for each alternative and then the net balance in the change in costs and benefits is computed.

CRITICISM

- No insight into the way in which net benefits and costs are distributed over different population groups. For instance, while the equity analysis can shed light on the distribution of net benefits over e.g. income groups, it would not provide insight whether low income groups reap net benefits because of a reduction in motorization costs—and hence may experience a real improvement in disposable income—or due to a reduction in air pollution (Martens, 2011).
- Money is not only the 'single currency' in which all costs and benefits are expressed, but that it is the only benefit whose distribution may warrant explicit analysis. Following this line of reasoning, the equity analysis has only to address the way in which the total monetary value of a project—the net benefits—is distributed over various population groups (Martens, 2011).

However, for the equity analysis, the focus should not be on the most efficient alternative (usually combined by expensive compensations), but on good alternatives which perform better in terms of distributional effects. This implies that for the purposes of equity analysis, the normal process of SCBA needs to be extended with social welfare and accessibility to key social activities measures (SACTRA, 1999).

Efforts to extend CBA and include equity

- Use of shadow values (method recommended by European Commission). Shadow values, which may be higher or lower than the corresponding market price are often used for promoting equal opportunities (e.g. single social value for travel time savings, in order to ignore increasing willingness to pay of high income groups, or use of labor costs below the real wages in order to induce labor-intensive solutions) (Penyalver & Turro, 2015).
    - Basing the value of travel time savings on equity values rather than market-based values, in an effort to level-out the impact of income differences (e.g., Gunn 2000; Jara-Diaz 2000; Mackie et al. 2001).
- Methodology of distributive weights, in which benefits accrued by different income groups are ascribed different weights (see e.g. Mishan 1976; Campbell and Brown 2003). In this way, stronger weight to some of the actors (e.g. low income groups) can be given and the distribution of costs and benefits problems is avoided (e.g. distribution effects over income classes or regions, etc.). The weights depend on the preferences of the consumers. Additionally, because estimates on no monetary valuations/attributes (environmental effects, effects on nature, landscape, safety, health, etc.) are not possible, add a PM (pro memory) indicator. It leaves the challenge to trade off the PM effect with the monetary effects to the decision maker.
    - Only relevant if decision-makers consider equalization as the guiding distributive principle → not relevant for equality or avoidance of disproportionate distributions
    - Reflects the preferences of the decision makers.
    - No guarantee that equalization projects will score better than other projects
    - No information on enabling
- Proxy of potential mobility (to divide population into relevant groups) → combination of car availability and income
- Apart from the consumer's preference described by means of a demand function and the estimation of consumer surplus, an equity value of time canbe used.

Example: Transport Project Appraisal in Israel

There is one value of time for all time components (in-vehicle and out-of-vehicle time), for all modes (private, public) and for all populations (age, income, geographic, and all other categories). This principle, common to many other countries, can be viewed as providing equal opportunities to poor and rich and to highway and public transport projects.

Suggestions

- First, it should be clarified whether the distributive principle on which the policy makers are based is: pure equality, avoidance of disproportionate distributions or equalization.

- Conduct a separate equity analysis and separate equity indicators, in addition to the standard CBA indicators
    - E.g. if the purpose is equalization → Cost-effectiveness analysis carried out in addition to CBA, to determine which alternative contributes most to the goal of equalization.
    - When data needs and types of indicators used in CBA and additional equity analysis are harmonized → higher chance that equity is taken into account in practice
- Base the CBA to the population groups and the objectives of the project.
- No need to include environmental externalities in CBA, due to the existence of norms.
- It is necessary to determine which distributive principle to use as a yardstick to judge the distribution of the selected benefits and/or costs.
- An adequate evaluation of the distributional impacts of transport projects requires an assessment alongside but separate from cost–benefit analysis
- Each cost or benefit generated by a transport project (measured in absolute and not monetary values) will require a different division of the population.
- Complementing CBA and MCA
    - the set of weights is established in MCA (reflecting the priorities of decision-makers)
    - Challenge of properly linking weights and objectives, which sometimes are contradictory and of producing a final result that can be interpreted (Turro, 2015).
- Furthermore, the following equity extensions can be considered for household and community level analysis respectively:

For the Household level analysis the following methodology is suggested (main steps are mentioned here, based on an example where the analysis is focused on travel times and costs):

a) Identify links/routes with changes in travel times, based on transport activity zones (demarcated as origins and/or destinations).
b) Calculate travel times by car and public transport for each alternative solution and for the do-nothing case (the scenarios set in the previous activity 8.1 should be also taken into account). Average access time, waiting time and egress-time can also be taken into account for the public transport case and average searching for parking time for the car travel times.
c) Assessment of travel times by public transport versus car for each proposed alternative (for every origin-destination pair for alternative A). Weighting of O-D zones, according to population size can also be applied.
d) Ratio between public transport and car time is calculated. This can be done at the level of origin-destination pairs and then added up to generate one travel time ratio for the do-nothing case and for each alternative solution.

e) Assessment of travel costs by public transport versus car for each proposed alternative (for every origin-destination pair for alternative A). Weighting of O-D zones, according to population size can also be applied.
f) Ratio between public transport and car travel cost is calculated.
g) For each alternative solution, the ratios are compared to the do-nothing case (whether the travel time or travel cost ratio will be used, depends on the data availability)
h) This comparison results in the Household Equity Indicator (**HEI**). A negative HEI value (below zero) implies that a proposed alternative has a negative equity impact, while a positive HEI value (above zero) means that a project alternative has a positive equity impact. In case HEI = 0, the proposed transport project has no equity impacts at the household level.
i) Equalization criterion: an alternative solution that narrows the existing gap between car-less and car-owning households is evaluated in a positive way, while an alternative solution that has the opposite impacts is evaluated in a negative way.

For the community level equity analysis, the following steps are suggested:

a) Categorize the types of communities on which the analysis will focus (if this not done already)

Example: Integrating equity considerations into the cost-benefit analysis: Guidelines for practice

Distinguish between two types of communities: weak and strong communities. The division is based on the Lamas (Israeli Central Bureau of Statistics) ranking of communities by socio-economic level (taking into account financial resources of the residents, housing-related variables, motorization level, schooling and education, (un)employment, and data on socio-economic distress). Based on these indicators, all localities are given a score ranging between 1 and 10: weak communities (ranked 1-5 by the Lamas) and strong communities (ranked 6-10).

b) Determine transport activity zones per community: link each transport activity zone to only one community. In case a transport activity zone is situated in two communities, the transport activity zone is ascribed to the community in which the largest surface area of the zone is located.
c) Calculate average aerial travel speed (AAS) by car and/or public transport between zones for each community: the quotient of the aerial distance between a zone and all other zones in the study-area and, on the other hand, the travel time on the transport network between a zone and all other zones in the study-area. Calculate the average aerial speed (AAS) for each zone, for each project alternative under consideration.
d) Weighting according to the size of the communities, the importance of the communities in terms of job attractiveness (number of jobs located in the community), etc. can be also applied. It depends on the aim/focus of the project/policy.

e) These calculations are repeated for every scenario taken into account in the project (e.g. peak and off-peak hours).
f) For each alternative, the AAS is compared to the do-nothing case.
g) The AAS of the group of weak communities is compared with the AAS of the group of strong communities.
h) This comparison results in the Community Equity Indicator (CEI). It is the ratio of the AAS improvements of the rich communities divided by the AAS improvements of the poor communities. A CEI value between 0 and +1 indicates that a proposed project has positive equity impacts, i.e. weak communities reap the largest share of the accessibility improvements generated by the project. In case the CEI = 1 accessibility improvements are distributed in an equal way over weak and strong communities. In case the indicator scores above +1, strong communities reap the most accessibility benefits. In this way, the analyst has a criterion of positive discrimination: this yardstick implies that transport projects that distribute more accessibility improvements to weak communities than to strong communities should always score positive in the equity analysis.
i) CEI calculations are repeated for every scenario taken into account in the project (e.g. peak and off-peak hours). In case the alternative solution has impact on travel times for both car and public transport, separate indicators should be calculated for each mode. This implies that the equity analysis generates either two indicators (single-mode case) or four equity indicators (dual-mode case).

- Furthermore, based on the Capability Approach (Sen Social Justice Theory) (Sen, 1985), the following measure is suggested to be added in the SCBA method (Nahmias-Biran & Shiftan, 2016): the Value of Capability Gains, which is calculated by aggregating consumer's capabilities together. It is based on Activity-based Capability measure, which is an alternative measure for consumer's benefits (including only alternatives that enhance traveler's capabilities). This is based on the Activity-based Accessibility measure, which focuses on the potentially achievable alternatives (not all opportunities within the network). It is calculated out of a person's capability set, following the principle of diminishing marginal utility.

Key phases in Social Impact Assessment

Since there is no single SIA procedure, the following key phases (based on IAIA, 2015) need to be considered in case a transport project is to have or likely cause immediate social impacts on people and communities. To gain in-depth insight into the social impacts of transport projects and how they affect the liveability of communities, mostly qualitative methods are suggested for collection of information, such as interviews, surveys and focus groups, based on stakeholder participation.

- *Identify the preliminary 'social area of influence' of the transport project, likely impacted and beneficiary communities (nearby and distant) and stakeholders and prepare a 'community profile' which includes: stakeholder analysis, the socio-economic context, an assessment of the differing needs, interests, values and aspirations of the various subgroups of the affected communities, an assessment of their experience of past projects impacts, a discussion of the assets, strengths and weaknesses of the communities.*

- *Indicators as minimum distance, travel time or generalized transport costs from residential locations to the activity locations (work, education, health services and supermarkets or groceries) could be relevant and can be calculated relatively easily. This may also include a minimum number of choice options, such as the distance at which at least three schools or health services can be reached.*
- *Analyse, by making use of inclusive participatory processes, the social changes and direct and indirect impacts to the affected communities that will likely result from the project and its various alternatives and determine the distribution of costs and benefits among groups and communities and how they will likely respond. Understand how they will be impacted, determine the acceptability of likely impacts and proposed benefits (identify the social and human rights issues that have potential to be of concern), make informed decisions about the project and facilitate community visioning about desired futures, and contribute to mitigation and monitoring plans.*
- *Identify ways of addressing potential negative impacts and enhance benefits and project-related opportunities and fully inform community members about the project, how they can be involved in the assessment, their procedural rights in the regulatory and social performance framework for the project, and their access to grievance and feedback mechanisms.*
- *Assist the proponent in facilitating stakeholder input and drafting a 'Social Impact Management Plan' (SIMP) which puts into operation the benefits, mitigation measures, monitoring arrangements and governance arrangements, as well as plans for dealing with any ongoing unanticipated issues as they may arise.*

Finally, since the results of CBA method depend on many uncertain inputs, sensitivity analysis is recommended.

2) **Multi-Criteria Analysis** (**MCA**) can be used for the non-monetary aspects (while the result of SCBA will be an important input of MCA). According to this method, various impacts of each alternative solution are presented in a summary table and the alternatives are evaluated according to the effects of a number of criteria (quantitative or qualitative or that can be quantified, but not monetized). The criteria are classified according to clusters. Examples of equity criteria are the following: contribution to accessibility, employment effects, effects on safety and environment. The importance of the criteria is also defined by the analyst, while sensitivity analysis is very important. Additionally, formulation of minimum or maximum requirements of criteria is also possible. In general, the weights assigned to the criteria express political priorities, but it is also possible that no weights are provided to the different criteria, so decision makers can make their own judgments about the importance of various elements.)

   Example: Egnatia Odos Motorway: MCA equity analysis conducted (Thomopoulos et al., 2008)

3) A **Cost Effectiveness Analysis** focuses on how much each alternative solution increases the transport efficiency/accessibility for each of the relevant population groups. According to this

method, the cost-effectiveness of an alternative solution is expressed as a ratio, where the denominator is a measure of the positive effects and the numerator is the cost associated with the intervention. Therefore, when this method is implemented for an equity analysis, the effects are the accessibility improvements and the costs are the investment and operation costs. Normative weighing of the benefits is also possible in this method, while it is important that this method does not rely on monetary valuation of the effects (like SCBA). However, Cost-effectiveness analysis is not common in equity analysis so far, mainly for the reason that in practice, this method mostly focuses on costs, while benefits are not identified in most cases.

4) **Risk** analysis: The alternative solutions major risks are identified and risk analysis is carried out in the form of scenario and sensitivity analysis.

5) **Environmental impact assessment** can be conducted in order to investigate whether some areas/neighborhoods, etc. are mostly exposed in the environmental effects of a project. For example, geographic analysis can help determine whether lower-income and minority communities contain an excessive portion of hazardous waste sites, or undesirable transportation facilities such as major highways and freight terminals (Bullard and Johnson 1997). Special programs may be justified to clean up brownfields, insure that regional transportation facilities meet local community needs, mitigate traffic impacts, and compensate for external costs imposed on disadvantaged populations. An environmental impact assessment can be based on a numerical measure taking into account the green area taken, its size, the way the transport project crosses the area, the type of infrastructure and the sensitivity of the area given its natural and other values. A numerical measure was also developed for the landscape effect, taking into account the population exposed, the view and visibility of the damage, the type of project, and the sensitivity of the area. Moreover, environmental capital based assessment techniques for landscape, heritage, water and biodiversity impacts, noise mapping, etc. fall in this category of appraisal method.

Example: Baltimore Region Environmental Justice in Transportation Project[1]

6) Various **equity measures** (most of them are explained in Activity 4.6):

   a) **P_2** measure (Foster et al, 1984): The measure takes both the intensity and the size of poverty into account in assessing the level of income poverty in a society. The value of P2 ranges from 0 to 1, with a score of 0 indicating the case of an entire population with an income level above the poverty line, and a score of 1 the case of an entire population below the poverty line. This measure is decomposable. This means that the measure makes it possible to identify the contribution of each subgroup *i* to overall poverty. In order to determine the contribution of a subgroup to the overall poverty level, the subgroup poverty level is weighed by its population share and then expressed as a percentage of overall poverty, which, when contributions of all subgroups are summed, add up to exactly

[1] http://brejtp.com/

100%. The delineation of a poverty line and the distinguishing of population groups are needed in order to calculate this measure.

Example: Accessibility and Social Equity in Tel-Aviv Metropolitan Area - examination of the current conditions and development scenarios (Martens, 2015)

P2 measure was used to assess and compare accessibility poverty

b) **Lorenz** curve
c) **Gini** coefficient
d) **Theil** Coefficient and the **Coefficient of Variation**
e) **Mobility gap analysis**
   Example: Montana Rural Passenger Needs Study
f) Measuring **magnitude of inequity**:
   i) Relative accessibility loss
   ii) Absolute accessibility loss
g) Use of a **generalized cost measure of accessibility** disaggregated according to the relevant socioeconomic groups.

7) Use of custom **ArcGIS** tools

Example: Fruin and Sriraj (2005) GIS tool to identify environmental justice

Example: Temporal variability in transit-based accessibility to supermarkets in Cincinnati

8) Analysis of **qualitative** data

Example: Equity effects of road-pricing in the Madrid Metropolitan Area (Di Ciommo & Lucas, 2014)

A mixed-methods quantitative and qualitative analytical approach was used there:

a) Quantitative study to estimate cost burden of road pricing on road users (especially lower income users):
   i) Micro simulation model to analyze the Madrid Mobility Regional Survey data.
   ii) Use of a generalized cost measure of accessibility (capturing both travel times and travel costs), disaggregated by low and high income areas.
   iii) Travel demand model (using LUTI model MARS-Madrid).

b) Qualitative study:
   i) Three, 1-h, focus groups of ten people.
   ii) Identification of people's access and use of public and private transport.
   iii) Assessment of the potential impact of the road-pricing scheme on their travel patterns, accessibility and social exclusion.

Checklist: Equity analysis of the alternation solutions conducted.

ACTIVITY 8.3: SUMMARIZE THE ANALYSIS RESULTS INTO A COMPARISON TABLE

Focus on the comparison between the indicators values in the analysis of the current and the future system (within the various scenarios). Highlight which objectives are met under each scenario case.

Example: Strategic plan for the National railway network of Israel

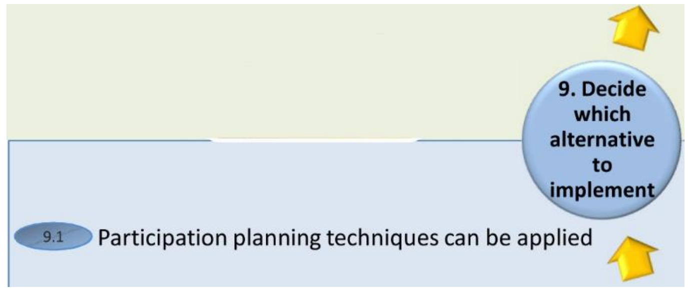
1) *People in peripheral areas will have a better accessibility to the four big cities (the percentage of population within 45 minutes ride from the nearest metropolitan area increased from 26 to 44%).*
2) *The fact that the percentage of the population in the periphery within 90 minutes ride to Tel Aviv increases from 23% to 45%, is expected to contribute to the constrain of the urban sprawl of the biggest city of Israel. This is because it will be possible for those people to remain in their current residential areas without feeling "isolated" from this attractive city (in terms of services, job market and overall financial development).*
3) *Low income people are favored by the project in terms of jobs accessibility (the percentage of jobs within 90 minutes ride from low income population increased from 22% to 36%).*
4) *The number of passengers on train network increased from 120 to 555 million per year. This leads to less congestion and subsequently a reduction of pollution (a beneficial effect for all the citizens).*

Checklist: Comparison table constructed.

STEP 9: DECIDE WHICH ALTERNATIVE TO IMPLEMENT

ACTIVITY 9.1: PARTICIPATION PLANNING TECHNIQUES CAN BE APPLIED

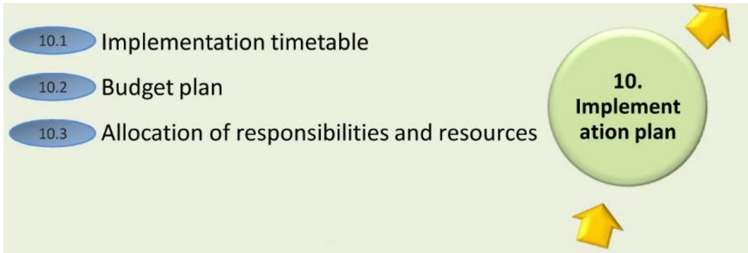
Based on the comparison table, the best alternative solution in terms of equity is selected to be implemented. Participatory planning techniques can also be applied, in order to enhance public acceptance and support.



Checklist: Alternative solution is selected (public involvement into this decision process).

STEP 10: IMPLEMENTATION PLAN

ACTIVITY 10.1: IMPLEMENTATION TIMETABLE



Create a timetable for the short-, mid- and long-term implementation of the solution that was selected. The monitoring actions and measures after the implementation of the project/policy should be also specified.

Checklist: Timetable developed.

ACTIVITY 10.2: BUDGET PLAN

Specify the budget plan of the project, taking into account the available resources.

Checklist: Budget plan developed.

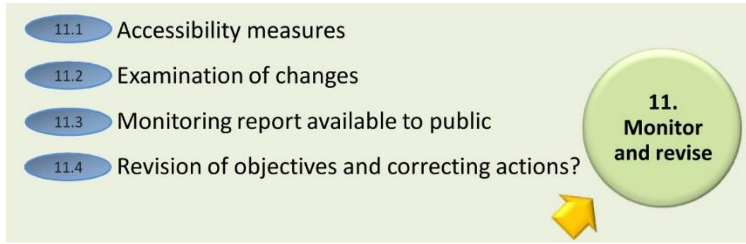
ACTIVITY 10.3: CLEAR ALLOCATION OF RESPONSIBILITIES AND RESOURCES

Specify in detail and distribute the responsibilities and the resources.

Checklist: Responsibilities and resources clarified.

STEP 11: MONITOR AND REVISE

ACTIVITY 11.1: ACCESSIBILITY MEASURES



After the implementation of the selected solution(s), multiple accessibility measures can be applied in order to regularly monitor the impacts of the project/policy. The selection of the suitable measures is based on the indicator framework. Ensure timely access to the relevant data and statistics

Checklist: Accessibility measures conducted after the implementation of the project/policy.

ACTIVITY 11.2: EXAMINATION OF CHANGES

The changes in the composition of the population, their residential locations, their abilities to make use of particular transport modes, etc. are examined. The changes on which this activity will focus, depend on the scope and the objectives of the project/policy.

Checklist: Changes examines.

ACTIVITY 11.3: MONITORING REPORT AVAILABLE TO THE PUBLIC

The examined changes, as well as the extent to which the objectives of the project/policy are met, should be mentioned in a monitoring report. This report should be shared and communicated to the public.

Checklist: Monitoring report prepared and open access.

ACTIVITY 11.4: REVISION OF OBJECTIVES AND CORRECTING ACTIONS?

Check whether there is a need of revising the objectives of the project/policy and respectively adjust various aspects of the implementation plan.

Checklist: It is checked whether there is a need to revise the project/policy.

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