A Place-Based Multi-sectoral Project for the Definition of Indicators and Thresholds to Support Sustainable Mobility Policies in Italian Cities

Francesco Alberti[1], Giacomo Rossi[1], Giovanna Acampa[1], and Alessio Pino[2(✉)]

[1] University of Florence, Via P.A. Micheli 2, 50129 Florence, Italy
[2] University of Enna "Kore", Cittadella Universitaria, 94100 Enna, Italy
alessio.pino@unikorestudent.it

Abstract. This paper describes the background, methodology, and expected outcomes of the URGET VADEMECUM 2030–2050 Research Project of National Interest (PRIN, Progetto di Ricerca di Interesse Nazionale), funded by the Italian Ministry of University and Research in the framework of the Italian National Recovery and Resilience Plan (NRRP) and the Next Generation Europe fund. The project addresses the issue of urban transition towards carbon neutrality, the pivot of the European Green Deal program, by proposing an innovative assessment procedure to support sustainable urban mobility policies in Italy, which is characterized by the highest car-dependency rate among major European countries, following a place-based approach. The proposed step-by-step procedure combines different analysis and evaluation methodologies, i.e., Threshold Theory, Cluster Analysis, and Multi-Criteria Analysis, re-interpreted in an up-to-date way to provide structured guidance for public authorities to select the most efficient and cost-effective measure packages in terms of suitable technologies, transport policies, urban planning, and regulatory issues, fitting to places' peculiar characteristics.

As the first step of the procedure, a set of indicators and related thresholds, processed using GIS tools, are meant to define the spatial variables that can affect urban mobility in that specific context, narrowing down the number of viable transport modes, innovative technologies and services, to be subjected to the subsequent evaluation steps.

Keywords: sustainable mobility · indicators · threshold theory

1 Introduction

Mobility is one of the fields of technological innovation that have most affected the evolution of settlement systems in close relation to the availability of low-cost energy sources. From the mid-19th century to the end of the 20th, the two great revolutions in the field of transportation - the rail-transit revolution and the automobile revolution – have allowed a seemingly limitless process of urban growth in most industrialized regions.

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2026
O. Gervasi et al. (Eds.): ICCSA 2025 Workshops, LNCS 15891, pp. 78–89, 2026.
https://doi.org/10.1007/978-3-031-97617-9_6

In recent decades, the process has expanded at an increasingly frantic pace in emerging countries. The figures of global urbanization are well-known: the rate of urban population will reach approx. 70% of 9,2 billion people in 2050; it was 36% of 3,7 billion in 1970 and 46,5% of 6,1 billion in 2000 [1].

In the meantime, a new "wave of innovation" [2] has taken off, pushed by the need for sustainability and the double sword of Damocles of climate change and oil depletion. In detail, they derive from opposite trends related to the use of fossil fuels, which still cover more than 90% of the total energy needs in the transport sector: on the one hand, the risk of natural disasters due to the concentration of greenhouse gases (GHGs) in the atmosphere; on the other hand, that of a global recession, due to the rising cost of fuels as the joint effect of a steady increase in demand and the depletion of primary source [3]. In the fight against global threats, which require energy diversification and the search for a balance between consumption and resources, the questions raised by the issue of transport in cities differ from the past. Now, we are trying to understand whether and how leveraging mobility governance through the combination of technological innovation, planning, and management can allow for meeting the objective set by the Paris Agreement (2015): that is, to limit the global temperature increase at the end of this century "well below" 2 °C above pre-industrial levels (and preferably restrict the rise to 1.5 °C), shorting the 23% of global CO2 emissions from fuel combustion accounted for by the transportation sector (74% of which generated by road transport).

From this perspective, mobility planning appears to be one of the main tools available to the public sector to set up urban sustainability policies, opposite to how traffic congestion caused by unrestrained development of private motorization at the detriment of other transport modes has been a source of functional imbalance and environmental degradation in urban areas in all industrialized regions of the planet.

This issue significantly affects all three "pillars" of sustainable development – Environment, Economy, and Social cohesion [4]. Moreover, it shows most evidently their mutual conflict potential within urban and metropolitan contexts, as shown in Table 1.

Table 1. Transportation Impacts on Sustainability [4]

Economic	Social	Environmental
Traffic congestion	Inequity of impacts	Air pollution
Mobility barriers	Disadvantages in mobility	Climate change
Vehicular accidents	Impacts on human health	Loss of habitats
Transportation facility costs	Community cohesion	Water pollution
Consumer transportation costs	Community livability	Hydrologic impacts
Depletion of non-renewable resources	Aesthetics	Noise pollution

Moreover, the role of transport is implied in the achievement of most of the 17 Sustainable Development Goals of the UN Agenda 2030 and directly or indirectly mainstreamed into 12 targets of 8 SDGs (Fig. 1), as expressly specified by the High-level

Political Forum on Sustainable Development (HLPF), the UN central platform for the follow-up of the Agenda [5].

The European Union addresses the aim to turn mobility into a lever of urban sustainability in many documents, directives, and funding programs (e.g., Horizon 2020 Work program "Mobility for Growth" and Horizon Europe's Cluster 5 "Climate, Energy, and Mobility) and initiatives (e.g., URBACT, CIVITAS, ELTIS, EPOMM, etc.).

In 2011, with the publication of the White Paper *Roadmap to a Single European Transport Area. Towards a competitive and resource-efficient transport system*, the European Commission set the goal for the Member Countries to halve the use of conventionally fuelled cars in cities by 2030 and phase them out by 2050.

Two years later, the *Urban Mobility Package* was adopted by the EU to stimulate a shift towards sustainable transport modes, such as walking, cycling, and public transport, and new patterns for car use and ownership, using Sustainable Urban Mobility Plans (SUMP) as a tool for addressing significant issues such as congestion, air/noise pollution, climate change, road accidents, waste of public space and the integration of new mobility services [6].

The transition of urban mobility from the car-dominant model to a multimodal and innovative model is also one of the priorities set by the European Urban Agenda (2016).

The aim of achieving net-zero GHG emissions from human activities in the EU by 2050 was first envisaged in the EC Communication *A clean planet for all: strategic long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050* (2018) and finally established as a pivot of the European Green Deal, launched in December 2019 by the Von der Layen Commission. For the transport field, it implies a reduction of 90% of emissions by 2050.

In this framework, in December 2020, the EC adopted the *Sustainable and Smart Mobility Strategy – putting European transport on track for the future* (SSMS), calling for an acceleration of the processes already underway, so far in a piecemeal fashion, for "the decarbonization and modernization of the entire transport and mobility system."

Consistently, sustainable mobility is one of the assets of the *Next Generation Europe* program for the allocation of 'recovery and resilience' funding in response to the crisis caused by the COVID-19 pandemic.

2 The Research Project: URGET VADEMECUM 2030–50

2.1 A Support to Italy's "Mobility Shift"

Among the major European countries, Italy has the highest motorization rate (62 vehicles per 100 inhabitants, 20% more than the EU average). 44 Mio of the 50 Mio vehicles in circulation are cars and motorbikes, and only 100,000 (i.e., less than 1% of the total amount) are buses [7].

In 2019, 22 million people traveled to work and 11 million to school daily. Data on Italy's 14 metropolitan cities show that during the pandemic, the rate of trips made by public transport halved compared to the previous period (from 10.8% to 5.4%); the car fell just a few points short (from 62.5% to 59%), while soft mobility (including micro-electric mobility) rose from 24.1% to 32.7% [8]. The pandemic also highlighted

the limits and alternatives of urban mobility, showing the well-being potential of less urbanized areas [9], characterized by fewer flows and narrow-scope mobility [10].

Since 2011, when national guidelines for the development of SUMPs (Sustainable Urban Mobility Plans) were introduced following the European guidelines, 196 SUMPs have been initiated by individual Municipalities above 100,000 inhabitants, Unions of Municipalities, Provinces, and Metropolitan Cities, financed mainly by a specific state fund. However, only 79 are already operational.

The UE policies to support the transition to cleaner, greener and smarter mobility, which have a cornerstone in the "SUMP concept," as stressed in The New EU Urban Mobility Framework adopted in 2021 following the SSMS, are the references of a research project led by an interdisciplinary pool from the Universities of Florence, Naples "Federico II," and Enna "Kore" (Sicily) and the Polytechnic University of Turin, namely URGET VADEMECUM 2030–50 ("URban de-pollution and de-carbonisation from emissions GEnerated by Transport systems: eVAluation of DEdicated Methodologies, technologies and EConomic thresholds for an Unprecedented Mobility at 2030–50", here shortened to UV30–50). The project was acknowledged as a Research Project of National Interest (PRIN, Progetto di Ricerca di Interesse Nazionale) by the Italian Ministry of University and Research and funded with NRRP (National Recovery and Resilience Plan from the Next Generation EU program.

The outcomes of the project, currently in the middle of its overall development, are intended to influence and support decision-making as far as urban transport and related urban planning choices are concerned, allowing for the selection of the most efficient and cost-effective urban mobility scenarios tailored to the specific urban context, among the different available combinations of policies and measures aimed at reducing transport-related environmental and climate impacts.

2.2 Research Background

A further reference point of the UV30-50 project is the *Global Macro-Roadmap to Decarbonise the Transport Sector*, launched at the 22nd Conference of Parties in Marrakech (2016) by the platform Paris Process on Mobility and Climate. The roadmap identifies a balanced package of actions according to the so-called A-S-I approach, which combines Avoid (reduce unnecessary travel, e.g., through land use planning, logistics redesign, and remote services), Shift (shift goods and people to the most efficient and sustainable modes), and Improve (improve the environmental performance of energy fuels and vehicles, co-modality, and transport management) [11].

A significant precedent of the approach underlying the research project is represented by the study conducted by VIBAT (Visioning and Backcasting for Transport Policy) in London in 2007–2009. The study reviewed about 150 policy interventions for reducing transport-related CO_2 emissions. It grouped them into 12 policy packages (including Low-emission vehicles, Alternative fuels, Pricing regimes, Public transport, Walking and cycling, Urban planning, ICT, etc.). The study assumes that applying a range of policy packages, clustered as scenarios, can meet the gap between business-as-usual projections and strategic targets [12].

A preliminary task of the UV30-50 project is to define a package of A-S-I policy interventions compliant with the Italian context. The ordered checklist of the key items to be considered is reported below.

1) To reduce the dependence on transport to meet people's everyday needs (work, education, healthcare, shopping, recreation, etc.).
   Fields of action:
   - Development of motionless communication and smart working to a reasonable extent; provision of public remote and home services.
   - Balanced land-use planning aimed at reducing people's mobility due to the lack of basic services and facilities, incl. leisure opportunities, close to the residence.

2) To reduce the strong dependence on private motorized transport for traveling within the urban/metropolitan area by promoting the shift to soft mobility (walking and cycling, guaranteeing safety).
   Fields of action:
   - Creating safe pedestrian networks within and among the urban neighborhoods and districts, including sidewalk improvements, increased road crossings, walkable public spaces, parks, greenways, etc.
   - Creation of hierarchical, well-equipped cycling networks to effectively connect the main urban zones and magnets, incl. fast inter-municipal links.

3) To reduce car dependence on motorized displacements.
   Fields of action:
   - Provision of efficient and cost-effective modal alternatives to meet different mobility-related needs, including commuting and random mobility, such as:
     i. Alternative options to private vehicles: rail, metro, and road public transport; shared mobility; park & plug (in/out) & ride solutions; MaaS.
     ii. Alternative options for private vehicles: micro-and light-mobility vehicles.
   - Provision of widespread and user-friendly points of interchange between different transport modes.
   - Measures to limit car use (e.g., traffic-restricted zones, parking, road pricing, etc.)

4) To reduce the dependence on crude oil for the propulsion of transport systems.
   Fields of action:
   - Migration toward the electrification of presently un-electrified transport modes and vehicles (using as much electricity from renewable sources as possible), including:
     i. Public road transport
     ii. Private road transport
     iii. Urban logistics
   - Fostering the take-up of further alternative fuels and energy carriers (e.g., fuel cells).

5) Mitigate/compensate for the local pollution and GHG emissions generated by transport systems at the different stages of the transition, including residual non-compressible emissions.

Fields of action:

- Monitoring and management of the local aspects of transport-related emissions - i.e.
  i. Combustion emissions by motor vehicles.
  ii. Further emissions derived from the wear of brakes and tires, as well as from the dust raised by rolling and given the wear of paving.
- Monitoring and management of the local aspects of transport-related pollution - i.e.,
  i. Temperature inversion and stack effects in urban environments concerning the pollution of the surrounding areas.
  ii. Pollutants' accumulation from motorways, urban rings, roads, etc.
- Creation or improvement of green infrastructures aimed at CO_2 sequestration and air purification.

The analysis must also consider the forthcoming EU initiatives announced in the SSMS, including a strategic roll-out plan for deploying alternative fuel infrastructure and subsidies for users to make more sustainable transport choices.

In the dynamic context of global change, it is also essential to record in real-time post-pandemic implications for mobility in European urban areas. The infection acted as an accelerator for many processes, like the diffusion of smart working, e-commerce, and other digital services, which can result in, or be addressed to, a permanent reduction of daily transport demand. Moreover, while public transport demonstrated its lack of resilience in the face of the crisis, other modes, like cycling and light electric vehicles, have made progress, along with the concept of the "15-min city" [13], which is expected to have a significant influence on urban and mobility planning in the next future. The sudden outbreak of the Russian-Ukrainian crisis, with its immediate repercussions on energy costs, has been a further factor of uncertainty; similar geopolitical situations can shape the context of mobility.

2.3 Essential Methodological Structure of UV30–50

The research project will develop an innovative assessment methodology aimed at defining tailor-made, place-based, as well as technologically oriented solutions to foster the transition to sustainable mobility in Italian cities and towns.

A novel approach to the Threshold Theory [14] and a modern application of Multi-Criteria Analysis (MCA) [15, 16] will be put in sequence for analyzing and assessing alternative scenarios, integrating modal and technological options.

A further step is to join the concept of threshold with the clustering methodology [17]. Cluster analysis is adopted for processing data when no assumption is made about their mutual relationships. In this case, clusters refer to possible combinations of strategic actions in the field of urban mobility to achieve the goal of de-carbonization and de-pollution while optimizing costs.

2.4 Indicators and Thresholds

The research's core is identifying significant indicators and thresholds to be applied in the construction of transitional and/or alternative climate-neutral and clean mobility scenarios. The wide range of options theoretically available to promote transition according to the A-S-I framework has to pass the scrutiny of actual operating conditions, which depend on a) spatial settings, b) the limits, both operational and economic, of the various transport options, along with the market take-up and implementation of new technologies and innovative solutions in the transport sector, and c) the costs and availability of resources.

a) The first selection of all potential policy packages depends on the structural features of the site, among which morphological features (i.e., size, form, and structure of the urban area) and land-use-related parameters (e.g., population, density, and distribution of land use) are those that most affect mobility. By further developing GIS-based applications, already tested by the research unit of the University of Florence, spatial thresholds will be derived from the analysis of both physical (e.g., road widths) and accessibility parameters (e.g., network distances from urban attractors) that condition the use of transport infrastructure.

   Furthermore, threshold values for ecosystem services will be explored to assess the potential of green areas within and around the urban area to compensate for residual CO2 emissions from different urban transport scenarios.

b) The second level of selection will depend on transport issues, to which thresholds can be related, on the one hand, to the viable transport modes and, on the other hand, to the performances of new transport technologies and solutions, with particular regard to the transition to electric vehicles.

   After that, different scenarios addressed to achieve carbon neutrality in urban mobility will be obtained by clustering data from real travels, the implementation of new ITS (e.g., electrical geofencing, MaaS), and reinterpreted random utility models.

c) The range of urban mobility scenarios compliant with the place, resulting from the previous assessing stages, will pass through the further sieve of cost analysis. Thresholds will refer to the additional costs (per user) needed for implementing each alternative scenario, which must either be spent before the interventions or be spread over a period.

   After a test phase of the procedure in selected cities representative of different sizes and complexity levels of Italian urban settlements, the final stage of the proposed methodology focuses on Multicriteria Analysis. This is structured in the following steps: i) selection of the alternative sustainable mobility scenarios (resulting from thresholds and cluster analysis); ii) definition of judgment criteria; iii) analysis of the impacts on the alternative mobility scenarios; iv) assessment of the actions' impacts on each selected criteria; v) aggregation of judgments; 6) choice of the preferred/optimal sustainable mobility scenario(s) to orient administrations' choices in achieving the best results with the minimal resource allocation [18].

A Focus on Spatial Indicators. One of the most innovative aspects of the methodology delivered by UV30–50 is the importance acknowledged of spatial variables, usually overlooked by transport planning, in selecting alternative options to be considered in building local strategies for decarbonized and unpolluted urban mobility.

The specific objective of the research for the first stage of the proposed selective procedure is to articulate, within a nested structure, a set of indicators and related thresholds, both by systemizing indicators already used in urban studies and spatial planning and by defining new ones, to assess the propensity and potential of a given urban system to meet the targets of overall decrease, modal differentiation, and improved environmental performance of internal motorized mobility, consistent with the aforementioned A-S-I framework.

There is empirical and scientific evidence that low-density dispersed urban patterns and rigid land-use zoning generate car dependency, higher energy consumption, and emissions from transport. In contrast, compact mixed-use urban patterns are more likely to reduce people's dependence on transport for their daily needs and encourage sustainable mobility [19, 20]. Monocentric or polycentric settlement patterns may also influence the choice of different public transport systems according to the geometric features of the road network. Instead, the presence of blue-green corridors may favor or discourage, depending on the acclivity of the terrain or the availability of crossing points, the creation of bicycle routes, whether isolated or integrated into a network. In turn, the connectivity and attractiveness of pedestrian systems are strongly conditioned by the characteristics of urban fabrics and streets, the location of public spaces and facilities, the urban landscape, the microclimate of streets, etc.

A non-exhaustive list of spatial variables to be included in the assessment is given below in Table 2. The definition of relevant indicators, significant combinations, and threshold values is one of the expected outcomes of UV30-50.

a) The first selection of all potential policy packages depends on the structural features of the site, among which morphological features (i.e., size, form, and structure of the urban area) and land-use-related parameters (e.g., population, density, and distribution of land use) are those that most affect mobility. By further developing GIS-based applications, already tested by the research unit of the University of Florence, spatial thresholds will be derived from the analysis of both physical (e.g., road widths) and accessibility parameters (e.g., network distances from urban attractors) that condition the use of transport infrastructure.

   Furthermore, threshold values for ecosystem services will be explored to assess the potential of green areas within and around the urban area to compensate for residual CO2 emissions from different urban transport scenarios.

b) The second level of selection will depend on transport issues, to which thresholds can be related, on the one hand, to the viable transport modes and, on the other hand, to the performances of new transport technologies and solutions, with particular regard to the transition to electric vehicles.

   After that, different scenarios addressed to achieve carbon neutrality in urban mobility will be obtained by clustering data from real travels, the implementation of new ITS (e.g., electrical geofencing, MaaS), and reinterpreted random utility models.

c) The range of urban mobility scenarios compliant with the place, resulting from the previous assessing stages, will pass through the further sieve of cost analysis. Thresholds will refer to the additional costs (per user) needed for implementing each alternative scenario, which must either be spent before the interventions or be spread over a period.

The procedure will be tested in selected cities with different sizes and complexity levels to represent the whole range of Italian urban settlements. Then, the final stage of the proposed methodology focuses on Multicriteria Analysis. This is structured into the following steps: i) selection of the alternative sustainable mobility scenarios (resulting from thresholds and cluster analysis); ii) definition of judgment criteria; iii) analysis of the impacts on the alternative mobility scenarios; iv) assessment of the actions' impacts on each selected criteria; v) aggregation of judgments; 6) choice of the preferred/optimal sustainable mobility scenario(s).

Table 2. Spatial variables in cities affecting urban mobility and possible indicators.

City form, demography and density	Land features	Urban fabric features
Population density and level of urbanization	Land morphology (acclivity)	Building and population density
Settlement's monocentric or polycentric pattern	Presence of natural barriers and characteristics of crossing points	Classification of specialized (non-residential) fabrics and monofunctional compounds
Compactness/fragmentation/urban sprawl	Agricultural and natural areas	Size and morphology of urban blocks
Demography dynamics		Building coverage
		Mixed uses
		Historic urban fabric

Land use	Transport network geometry	Urban microclimate
Land use and urban land use	Existing road and transport infrastructure density and classification	Building dimensional ratio (between buildings' height and street width)
Classification and distribution of public open space	Street density	Location of urban heat islands
Classification of urban attractors and centralities	Variability of road cross-sections	Urban green areas (for climate mitigation and CO2 sequestration)
Multimodal accessibility to urban attractors	Space-syntax analysis [21] (integration and connectivity of street and road networks)	

Further indicators refer to topical concepts in urban studies focusing on public transport and soft mobility as the keys to a paradigm shift in spatial planning to achieve sustainable and resilient cities: Transit-oriented development [22], Urban walkability [23, 24] and bikeability [25] and the City of Proximity [26], as synthesized in Table 3.

Table 3. New urban concept pivoted on sustainable mobility and related indicators

Transit-oriented development	Walkability/bikeability	City of proximity
Multimodal accessibility of railway nodes	Pedestrian and bicycle accessibility to places and facilities	Urban and neighborhood centralities
Place/Node Analysis [27]	Continuity/legibility of networks	Classification and mapping of local facilities
TOD Index [28]	Integration of paths / public spaces	Accessibility to public spaces and facilities within a 15-min walk or 5-min bike ride
	Presence of traffic-restricted / pedestrian areas	
	Greenways	

GIS platforms and plug-ins are the tools for mapping, analyzing, and visualizing all indicators, the complexity of which is closely related to the availability and quality of geospatial data.

3 Conclusions

The methodology addressed by the UV30-50 research project, based on the combination of consolidated evaluation tools that are re-interpreted in an up-to-date way, is intended to support decision-making and fund-raising by selecting and calibrating different measures and policy packages to reduce/eliminate transport-related pollution and GHG emissions.

The research will be carried out with the involvement of four Municipalities, representative of different sizes and complexity levels of Italian urban areas, as testing benches of the proposed methodology: namely, Turin, Siena, Catania, and Giugliano in the Metropolitan City of Naples. For each of them, example evaluations will be carried out concerning spatial, transport, and economic aspects by applying the thresholds previously defined. The application of the procedure will provide different alternative/transitional scenarios to be subjected to a Multi-Criteria Analysis to select the optimal one. The outcomes from the test phase will be analyzed and integrated to readjust and optimize the methodology, also considering external factors that could positively or negatively affect its application (regulations, socio-economic aspects, possible future crises, etc.). The completion of the research is expected by the end of 2025.

References

1. United Nations, World Urbanization Prospects: the 2009 Revision. http://esa.un.org/unpd/wup/index.htm. Accessed 7 Feb 2024
2. Hargroves, K., Smith, M.: The Natural Advantages of Nations: Business Opportunities, Innovation and Governance in the 21st Century. Earthscan (2005)

3. Newman, P., Beatley, T., Boyer, H.: Resilient cities: responding to peak oil and climate change. Island Press, Washington (2009)
4. VTPI, Victoria Transport Policy Institute: Online Transport Demand Management (TDM) Encyclopedia (2017). http://www.vtpi.org/tdm/tdm67.htm. Accessed 7 Feb 2024
5. You, A., Peet, K., Medimorec, N., Dalkmann, H.: Showcasing the critical role of the transport sector to achieve the Sustainable Development Goals. UN, High-level Political Forum on Sustainable Development (2018)
6. Rupprecht Consult (ed.): Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan, Second Edition. https://urban-mobility-observatory.transport.ec.europa.eu/document/download/87adaa0c-cd13-4ce0-9a15-d138ea31bb2c_en?filename=sump_guidelines_2019_second%20edition.pdf. Accessed 2 Feb 2024
7. ISTAT Database on Italian Vehicle Fleet. http://dati.istat.it/Index.aspx?DataSetCode=DCIS_VEICOLIPRA. Accessed 7 Feb 2024
8. ISFORT: 19° rapporto sulla mobilità degli italiani, CNEL (2022)
9. Acampa, G., Pino, A.: Village repopulation: analysis of extra-economic indicators to evaluate and valorise social generativity in ecovillages. In: Gervasi, O., Murgante, B., Misra, S., et al. (eds.) Networks, Markets, and People: Proceedings of the 2024 International Conference on Computational Science and Its Applications – ICCSA 2024, LNCS, vol. 14300, pp. 376–385. Springer, Cham (2024). https://doi.org/10.1007/978-3-031-74679-6_25
10. Acampa, G., Pino, A.: Filling the old with new life. Application of original indicators for evaluating ecovillages as village repopulation initiatives. Aestimum **85**, 73–86 (2024)
11. Dalkmann, H., Brannigan, C.: Transport and climate change, module 5e, sustainable transport, a sourcebook for policy-makers in developing cities. GTZ global. Ministry for Economic Cooperation and Development, Federal Eschborn, Germany (2007)
12. Hickman, R., Banister, D.: Transport, climate change and the city. Routledge (2015).
13. Moreno, C., Allam, Z., Chabaud, D., Gall, C., Pratlong, F.: Introducing the "15-Minute City": sustainability, resilience and place identity in future post-pandemic cities. Smart Cities **4**(1), 93–111 (2021)
14. Malisz, B.: Teoria Progow (Threshold Theory). Biuletyn IUA, 16 (1963)
15. Beria, P., Maltese, I., Mariotti, I.: Multicriteria versus Cost Benefit Analysis: a comparative perspective in the assessment of sustainable mobility. Eur. Transp. Res. Rev. **4**, 137–152 (2012)
16. Battisti, F.: ELECTRE III for strategic environmental assessment: a "phantom" approach. Sustainability **14**(10), 6221 (2022)
17. Zhang, G., Wang, Z.: Correlation degree and clustering analysis-based alarm threshold optimization. Processes **10**(2), 224 (2022)
18. Acampa, G., Pino, A.: Optimal computing budget allocation for urban regeneration: an unprecedented match between economic/extra-economic evaluations and urban planning. In: Gervasi, O., Murgante, B., Misra, S., et al. (eds.) Computational Science and Its Applications – ICCSA 2023 Workshops, LNCS, vol. 14300, pp. 69–79. Springer, Cham (2023)
19. Newman, P.W., Kenworthy, J.R.: The land use—transport connection: an overview. Land Use Policy **13**(1), 1–22 (1996)
20. Newman, P., Kenworthy, J.: Urban design to reduce automobile dependence. Opolis **2**(1) (2006)
21. Desyllas, J., Duxbury, E., Ward, J., Smith A.: Pedestrian demand modellling of large cities: an applied example from London. UCL Working Paper Series - Paper 62 (2003)
22. Calthorpe, P.: The next american metropolis. Community and the American Dream. Princeton Architectural Press, New York, Ecology (1993)
23. Ewing, R., Handy, S.: Measuring the unmeasurable: urban design qualities related to walkability. J. Urban Des. **14**(1), 65–84 (2009)

24. Maghelal, P.K., Capp, C.J.: Walkability: a review of existing pedestrian indices. J. Urban Region. Inform. Syst. Assoc. **23**(2) (2011)
25. Kellstedt, D.K., Spengler, J.O., Foster, M., Lee, C., Maddock, J.E.: A scoping review of bikeability assessment methods. J. Commun. Health **46**, 211–224 (2021)
26. Alberti, F., Radicchi, A.: From the neighbourhood unit to the 15-minute city. past and recent urban models for post-COVID cities. In: Alberti, F., Matamanda, A.R., He, BJ., Galderisi, A., Smol, M., Gallo, P. (eds.) Urban and Transit Planning. ASTI. Springer, Cham (2023). https://doi.org/10.1007/978-3-031-20995-6_15
27. Bertolini, L.: Spatial development patterns and public transport: the application of an analytical model in the Netherlands". Plan. Pract. Res. **14**(2), 199–210 (1999)
28. Evans, J.E., Pratt, R.H.: Transit Oriented Development, TCRP's Traveler Response to Transportation System Changes Handbook series. Transport Research Board, USA (2007)