Sustainable Urban Mobility (SUM), a bibliometric analysis with examples from Budapest and Vienna

Ola Qasseer[1,2,*], and *Gábor* Szalkai[1]

[1] ELTE Eötvös Loránd University, Institute of Geography and Earth Sciences, Department of Regional Science, 1117, Budapest, Hungary
[2]KTI Hungarian Institute for Transport Sciences and Logistics Non-Profit Limited Liability Company, 1119, Budapest, Hungary

Abstract. Sustainable Urban Mobility (SUM) is a relatively modern term that started to be used in literature after the beginning of the 21st century and has recently gained significant popularity. In this paper we analyze the main aspects of SUM term, its development, and its main concepts and keywords. We also analyze the main aspects of SUM in Budapest and Vienna and compare them. A bibliometric analysis is achieved on the extracted literature using VOSviewer and Excel software. Analyzing the two case studies is achieved through revising the published plans of SUM in both cities then comparing them. SUM term reached its peak around 2020. The main aspects which accompanied this term are related to sustainable modes, planning, and policies. Budapest and Vienna cities are heading to be more sustainable cities. However, additional steps need to be taken in this regard. Analyzing the situation in the two case studies, depending on the results of the bibliometric analysis and comparing them will help in understanding to which level they represent successful examples of sustainability in Europe. In addition to proposing some useful points to develop the process of producing SUM plans to provide a more balanced and livable urban environment.

1 Introduction

The concept of sustainability has become more and more valuable during recent years. With the enormous effect of urbanization on the environment, there is a growing importance to take sustainability into consideration when planning any part of the city. When it comes to the built environment and its all-related topics, it is essential to deeply consider the aspect of sustainability. One of the main elements of the built environment is transportation and its patterns of mobility. Sustainability has been questioned in transportation with considering its essential role in movements and interactions [1]. In 1997, the United Nations general assembly noted that transportation would be the major force behind the world demand for energy during the following 20 years and has recognized the role of sustainable development in transportation earlier in 1992 [2]. Several strategies and innovations have been suggested for making transportation greener and improving its form of mobility [3].

Urban mobility represents an essential form of mobility, where all movements and trips take place in urban areas or urban settings [4]. Delivering sustainable strategies and methods of transportation held equal significance in urban mobility as well as in other varieties of mobility. Here is when the role of Sustainable Urban Mobility (SUM) appeared with many suggested strategies and with increasing academic interest in this term since the beginning of the 21st century.

In this paper we analyze the main aspects of SUM term, its development through the years, and the main concepts and keywords which accompany this term. To explore the practical function of SUMPs and how they could be developed according to the strategy of each city, we also analyze the main aspects of SUM in two European case studies; Budapest and Vienna and compare them to define the main advantages and disadvantages in each case. Analyzing the strategies in these two European case studies can provide valuable insights for improving policies, fostering collaboration, guiding urban development, and promoting public awareness.

1.1 Sustainable Urban Mobility (SUM)

It is hard to define Sustainable Urban Mobility due to the complexity of sustainability concept and its different aspects: the environmental, social, economic, and cultural considerations [5]. However, it basically represents the planning of transport systems in environmentally friendly methods with considering the social sustainability. It includes - but does not limit to- friendly walkable infrastructure, cycling networks, and well-structured public transportation systems [6]. SUM considers safety and security as key components, in addition to providing equity to the residents with more suitable and equal possibilities among different places [7]. Raising awareness and enhancing the role of social media in promoting sustainable urban mobility have been very essential [8], without neglecting the role of Non-

* Corresponding author: ola.qasseer@kti.hu

Governmental Organizations (NGOs) in this regard [7]. It is fundamental to move towards sustainable urban mobility to limit global warming especially when considering the continuous growth of the cities and its accompanied problems [9]. The process should not neglect the distribution and management of urban logistics by providing more environmental solutions for freight transport and last-mile delivery [7]. This movement is not possible without supporting plans and strategies for developing SUM.

1.2 Sustainable Urban Mobility Plans (SUMPs)

The suggested plans and strategies of SUM are different depending on the varied visions of the involved stakeholders [5]. However, the main idea of sustainable urban mobility plans (SUMPs) is to shift towards sustainable mobility by effectively dealing with the complexity of urban transport and improving quality of life and accessibility. They also elevate the standard of living and inclusiveness for urban residents by enhancing their ease of movement and access to essential services and opportunities. [10–14]. All that makes them different from traditional transport plans. It is known that these traditional plans used to focus only on addressing transportation needs based on standards and historical practices. They also focused on constructing and improving roads and motorized transport without a significant concern of environmental and health issues [10,13]. One of the main differences is the importance of involvement and integration among different actors and stakeholders. SUMPs consider the participation of citizens, governmental agencies, and private sectors [10,12,14,15]. They encourage involving transport, land use, environment, economic development, health, social elements, and energy [10,12]. However, these plans did not give urban safety and security enough attention. These two aspects were considered by the most innovative plans with regards to road accidents [16].

SUMPs emphasize the importance of integration and accessibility of public transport and the role of non-motorized transport like walking and cycling. They support the seamless inter-modality between different transportation modes. SUMPs support improving road safety and encourage reallocating road space to other modes of non-motorized transport or public transportation. These plans do not neglect the importance of developing freight transport and mobility management, in addition to including the applications of intelligent systems [17]. The focus of SUMPs is to ensure equal access to transport options for all citizens with concerning their different physical abilities, income levels, and geographical locations [12,18]. They also focus on reducing pollution and energy consumption, and enhancing the attractiveness of urban environments in a way that benefits the citizens, the economy, and the society as a whole [18]. In other words, the goal of these plans is to meet the mobility needs of the people within the urban context and create a transportation framework that is not only efficient and reliable but also seamlessly adaptable to the changing dynamics of urban life [19].

A sustainable urban mobility plan was considered as a product related to what would be adopted by political decision-makers and as a process consisting of several steps [20]. Moving towards sustainable urban mobility planning methodology requires considering the specific planning context of the urban area and its spatial characteristics [14]. However, many guidelines and strategies have been developed for helping municipalities in their aim to adopt similar plans. One of the most famous guidelines is Sustainable Urban Mobility Planning Cycle which summarizes the steps for the local planning authorities from setting up the working structure and determining planning framework ending with analyzing mobility situation and building scenarios. It provides the steps for developing the vision with stakeholders, setting the targets, and selecting measuring packages and responsibilities. It also defines the steps for financing and implementation, and finally developing communication and analyzing the results of the process with achieving a review process and defining the learnt lessons out of the whole plan [21].

1.3 Why is it important to move towards Sustainable Urban Mobility?

The increasing demand for mobility has been very challenging for our cities. Traditional modes of urban transportation have heavily relied on fossil fuels. Increasing the road space has not solved the problem but rather increased congestion, air pollution, and greenhouse gas emission. It makes cities unhuman and unlivable. All these reasons have confirmed the need for a new way of thinking [22], that responds to the need for solving the issues of inequality and fossil fuel dependence which requires behavior change, community engagement, and modification of regulations [23].

The growing urbanization in European cities has led to the appearance of commuter belts that share the infrastructure and workplaces and create a new functional area that exceeds the administrational boundaries of the cities [21]. That is why SUMPs were supported by the European Commission with many initiatives and innovative programs [15]. However, recent surveys have shown that the intention of municipalities for moving towards SUM is related to the population of the urban area. Cities with a population of less than 100,000 are much less likely to develop SUMPs than larger cities [12]. The transition towards sustainable urban mobility systems requires financing and long-term funding [19]. Promoting this kind of mobility requires well-trained political leadership and effective engagement and management [17]. It is important to assess the readiness level of the city and observe its infrastructure before starting to prepare a SUMP [20]. It was shown in a study by May et al. that several European countries have plans for SUM, but the political support is limited or absent. Austria is one of the few countries which have political support and technical capability for SUMPs, while Hungary misses this support and capability [24]. This also has encouraged us to proceed in our research by presenting these two examples

and benefiting from their experiments in the field of SUMPs.

2 Methodology

The first step is achieving a bibliometric analysis on the extracted literature from Scopus and Web of Science databases using VOSviewer and Excel software. The used keyword for the search is "sustainable urban mobility". Our bibliometric analysis includes presenting the changes in number of publications through the years, exploring the geographical distribution of publications, observing the related keywords, and exploring the main research areas. The extracted results from the databases –taking the titles, keywords, and abstracts into consideration– were exported as plain text to be used in visualization via VOSviewer and Excel software.

The second step is analyzing the two case studies of Budapest and Vienna by revising the published plans of SUM in both cities. This step is achieved as a representation of the applications of SUMPs that were discussed in the published literature and analyzed in the bibliometric analysis. The revision is built depending on the main elements that are extracted from the bibliometric analysis of the keywords and the main themes. The aim of the revision is to explore how much these two cities are heading to provide more sustainable mobility, in what stage they are currently in, and whether they provide a balanced and livable environment for the residents. The comparison is made according to the main results from the bibliometric analysis and the main aspects which are discussed in the formal published plans for the two case studies.

3 Results and discussion

3.1 Sustainable Urban Mobility in literature

The number of results, until the date of conducting this research, is 740 publications in Scopus and 727 publications in Web of Science. With around 700 publications written in English in each database, the other results are written in Spanish, Portuguese, Italian, French, Czech, or Chinese. Some papers are indexed in both databases which results in the overlapping between the two databases.

As shown in Fig.1, "Sustainable Urban Mobility" term started to appear in literature around the beginning of the twenty first century. The highest number of publications of this topic were conducted between 2019 and 2021. This could be related to the increased attention of the sustainable aspects during this period and the increased concerns of the role of public transportation and private mobility during the COVID-19 pandemic.

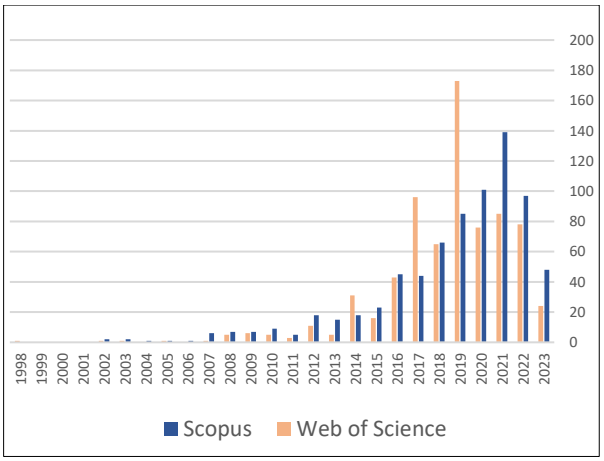


Fig. 1. Number of publications per year in Scopus and WoS – Source: authors' edition.

Regarding the research area to which the collected literature is related, according to the classification of WoS, the highest numbers of published articles were in the research areas of transportation, technology, environmental sciences, computer science, and urban studies, as shown in Fig.2. It is important to mention that some articles are classified into multiple research areas.

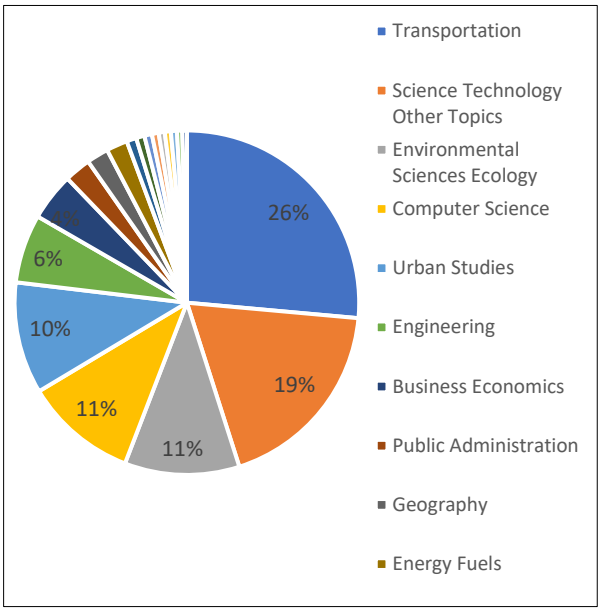


Fig. 2. Distribution of records according to research area in WoS – Source: authors' edition.

The geographical distribution of the publications showed a significant interest in the topic of SUM especially in Greece, Italy, Spain, and Germany. This could be related to the ancient structure and urban fabric of the cities in these countries which require extra attention for conservation. Fig. 3 presents the quantities according to both Scopus and Web of Science databases. Only countries with more than 10 publications were considered in this graph.

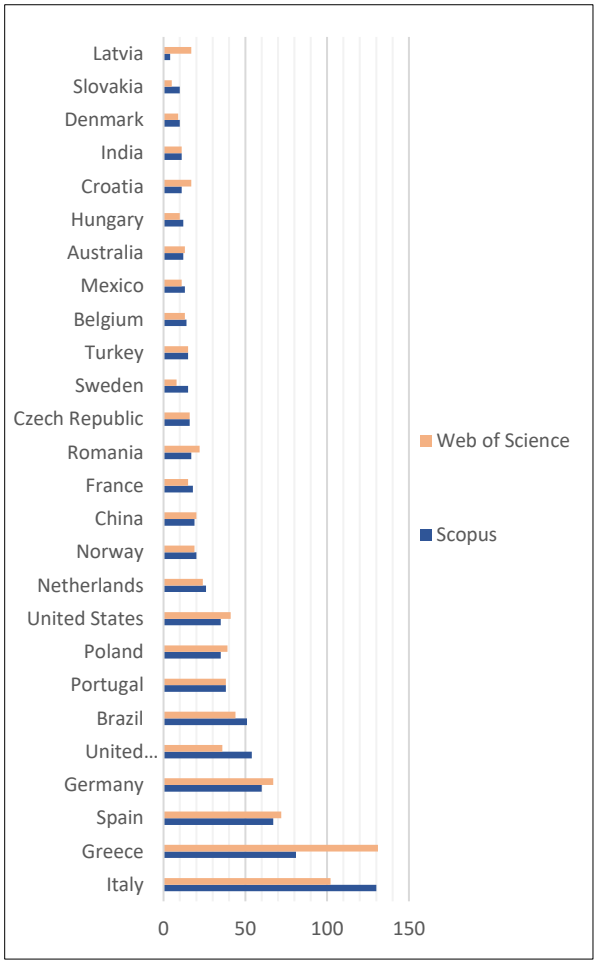
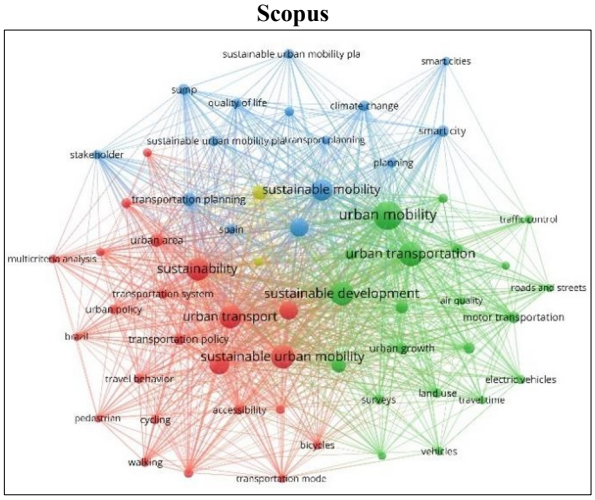


Fig. 3. Distribution of publications per country in Scopus and WoS databases – Source: authors' edition.

Visualizing the keywords of literature in both Scopus and WoS databases showed the main discussed themes. These themes and keywords represent the key elements for analyzing the strategies of SUM in the case studies. In this visualization, only keywords that appear 15 times at least were considered. Keywords show that concepts of sustainability, air quality, quality of life, and greenhouse gas emissions were significantly present in the literature. The ideas of accessibility and travel behavior were also discussed in the literature. Decision-making and policy were part of the discussed topics in addition to stakeholders and city logistics. Walking, cycling, electric vehicles, and public transportation were mainly mentioned as the preferable modes of transportation in sustainable urban mobility. Land-use and urban planning were not neglected in literature in addition to the idea of smartness and the concept of smart cities. Covid-19 was also part of the discussed topic after 2020. Fig. 4 shows the related keywords to SUM in both Scopus and WoS databases and table 1. presents the main clusters of these keywords.

Scopus



Web of Science

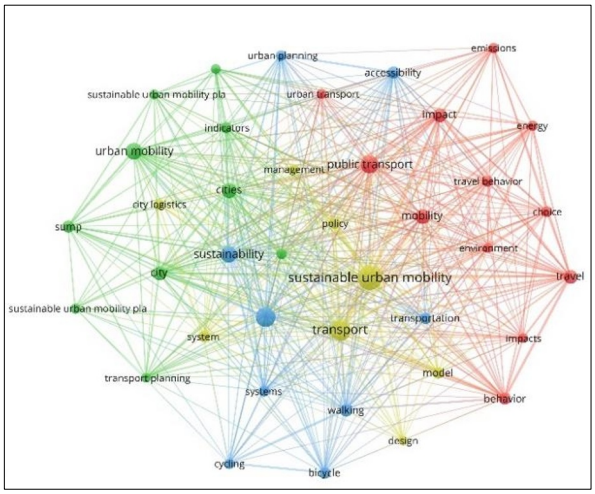


Fig. 4. Related keywords to sustainable urban mobility in Scopus and WoS databases – Source: authors' edition.

Table 1. The main clusters of keywords that are related to sustainable urban mobility in Scopus and Web of Science databases.

Scopus database	Web of Science database
Cluster 1 (23 keywords): Accessibility, bicycles, Brazil, COVID-19, Cycle transport, cycling, Italy, mobility, multicriteria analysis, pedestrian, public transport, sustainability, sustainable urban mobility, transport policy, transportation modes, transportation policy, transportation system, travel behavior, urban area, urban	Cluster 1 (12 keywords): Behavior, choice, emissions, energy, environment, impact, impacts, mobility, public transport, travel, travel behavior, urban transport

development, urban policy, urban transport, walking	
Cluster 2 (21 keywords): Air quality, economics, electric vehicles, environmental impact, greenhouse gases, land use, mass transportation, motor transportation, roads and streets, surveys, sustainable development, sustainable transport, sustainable transportation, traffic congestion, traffic control, transportation, travel time, urban growth, urban mobility, urban transportation, vehicles	Cluster 2 (10 keywords): Cities, city, indicators, SUMP, sustainable transport, sustainable urban mobility plan, sustainable urban mobility plans, transport planning, transport policy, urban mobility
Cluster 3 (15 keywords): Climate change, European Union, planning, quality of life, smart cities, smart city, Spain, stakeholder, SUMP, sustainable mobility, sustainable urban mobility plan, sustainable urban mobility plans, transport planning, transport planning, transportation planning, urban planning	Cluster 3 (9 keywords): Accessibility, bicycle, cycling, sustainability, sustainable mobility, systems, transportation, urban planning, walking
Cluster 4 (2 keywords): Decision making, metropolitan area	Cluster 4 (8 keywords): City logistics, design, management, model, policy, sustainable urban mobility, system, transport

What was previously mentioned in relation to the support of the European Union for the projects of SUMPs was also confirmed by the bibliometric analysis. The analysis showed that the most active funding sponsors with the highest numbers of supported research are European Commission, Horizon 2020, and European Regional Development Fund with more than 90 supported research in the field of SUM.

3.2 Sustainable Urban Mobility Plan in Budapest

The main framework for sustainable urban mobility planning in Budapest was suggested in the *Balázs Mór Plan* strategy in 2013 [25]. This plan contributes to achieving the goals of SUM as follows:
- *Sustainability and quality of life:* By providing environmental-friendly vehicles to limit the pollution of transport modes [26,27].
- *Public transport and accessibility:* The plan focuses on developing the radial connecting routes to decrease commuting through the center when it is not needed, in addition to providing the city's transport structure with more Danube crossing [26].
- *Non-motorized transport:* By increasing the cycling routes to develop their connectivity with the transportation network and regional areas [26,28].
- *Inter-modality:* The plan provides integrated network development with more connectivity and availability [26].
- *Policies and decision-making:* Ensuring harmonization with regional policies and exceeding administrative boundaries [26].
- *Land-use and urban planning:* It ensures enhancing urban life and implementing livable public spaces. The plan considers the management of parking spaces in accordance with different land uses [26].
- *Commuting belt:* The plan emphasizes the importance of developing commuting from suburban areas by improving regional cooperation and developing the network in suburban areas on an equivalent level to the inner city [26]. The plan also highlights developing the suburban railways to increase the total number of passengers [29]. It also provides more connections via different modes in the outer parts of the city and integrates the bike routes with the public transportation network [26,30].
- *City logistics:* The plan focuses on developing the urban logistics system by moving towards alternative vehicles for last-mile delivery, supporting deliveries outside congestion periods, and managing the procedure between different stakeholders [26].
- *Smartness and intelligent systems:* By spreading and applying intelligent systems for providing real time information and organizing public transport, developing ticketing systems with more intelligent solutions [26], and improving mobility as a service [31].

3.3 Sustainable Urban Mobility Plan in Vienna

The sustainable urban mobility plan in Vienna was suggested under the framework of *STEP 2025* which was adopted by the City Council in 2014 [32,33]. It presents the goal of SUM as follows:
- *Sustainability and quality of life:* By providing eco-mobility and promoting the idea of sharing instead of owning. The plan focuses on providing solutions for a diverse community and improving safety [33].
- *Public transport and accessibility:* The plan is committed to prioritizing public transport and providing human-scale forms of transport for all citizens [33,34]. It also supports the development of more connections and integration of different modes of transportation [33]. It aims to making public transportation affordable and restricting car use [23].
- *Non-motorized transport:* By encouraging cycling and walking and providing more spaces for micro mobility [23,33]. Reducing the waiting time for cyclists and pedestrians is also a part of the plan [33].
- *Inter-modality:* By developing the nodes of changing different means of public transport, shared transport, and micro transport [33].
- *Policies and decision-making:* The plan suggests a new level of cooperation or "governance" that integrates different stakeholders in public and private sectors and space management during different periods of the day [33,34].

- *Land-use and urban planning:* The plan aims to improve the public space and provide more shared places on the streets. It promotes transport planning as the backbone of the city for more accessibility and easy management of different functions [33].
- *Commuting belt:* The plan aims to improve the connections with the surrounding belt by developing suburban railways and improving the railway's connections on the region level [33].
- *City logistics:* Improving freight transport by using more environmentally friendly vehicles and implementing bikes for last-mile delivery with time and space management [33].
- *Smartness and intelligent systems:* By organizing transport in a smarter way of managing mobility and providing all needed information at the right time for all people [33].

4 Conclusion

The bibliometric analysis proved that sustainable urban mobility is a recent term that appeared in the literature after the increased interest in providing cities with more sustainable and environmentally friendly solutions. Developing the plans of SUM benefits from the development of smart technology and increases the availability of data. The research in this field spread throughout different countries. However, the interest of the European Union in improving such plans was remarkable by the number of supported publications. Moving towards SUM was considered as an essential solution for the cities' problems and their environmental impact.

Both Budapest and Vienna have developed strategies for SUM while considering their main aspects. Solving the issue of suburban commuters was more present in the plan of Budapest than the plan of Vienna. On the other hand, the idea of equality among different groups of people and the engagement of several stakeholders had more focus in the plan of Vienna. Integration between different modes and providing affordable transport were the interest of both plans. Both plans discussed the role of city logistics, but the actual steps were more serious in the Austrian case.

Finally, we can say that implementing SUMPs is still in progress in both case studies but within a different context and environment. Availability of data and transparency play an important role in developing SUMPs but it is still facing numerous obstacles due to the high number of players and the complexity of urban transport and its structure.

References

1. J.-P. Rodrigue, C. Comtois, B. Slack, *The Geography of Transport Systems*, 3rd ed. (Routledge, London, 2013)
2. United Nations, Sustainable Transport
3. K. J. Shah, S.-Y. Pan, I. Lee, H. Kim, Z. You, J.-M. Zheng, P.-C. Chiang, J Clean Prod **326**, 129392 (2021)
4. I. C. Semanjski, *Smart Urban Mobility: Transport Planning in the Age of Big Data and Digital Twins* (pp. 9–23, Elsevier, 2023)
5. H. Brůhová Foltýnová, E. Vejchodská, K. Rybová, V. Květoň, Transp Res D Transp Environ **87**, 102465 (2020)
6. New Zealand Government, *Benchmarking Sustainable Urban Mobility*
7. Un-Habitat, *Planning and Design for Sustainable Urban Mobility* (Routledge, 2013)
8. G. Punzo, D. Panarello, R. Castellano, Qual Quant **56**, 3135 (2022)
9. Global New Mobility Coalition, *The Urban Mobility Scorecard Tool: Benchmarking the Transition to Sustainable Urban Mobility* (Geneva, Switzerland, 2023)
10. A. Oyofo, Eltis: European Platform on Sustainable Urban Mobility Plans (2019)
11. P. Auwerx, R. Pressl, I. Cré, N. Kocak, T. Rye, *Parking and Sustainable Urban Mobility Planning: How to Make Parking Policies More Strategic, Effective and Sustainable* (Eltis: European Platform on Sustainable Urban Mobility Plans, Brussels, 2019)
12. L. Brand, S. Böhler, S. Rupprecht, *Topic Guide: Sustainable Urban Mobility Planning in Smaller Cities and Towns* (Eltis: European Platform on Sustainable Urban Mobility Plans, Cologne, Germany, 2021)
13. M. Chinellato, M. Morfoulaki, *Sustainable Urban Mobility Planning in Metropolitan Regions. Sustainable Urban Mobility Planning and Governance Models in EU Metropolitan Regions* (Eltis: European Platform on Sustainable Urban Mobility Plans, Brussels, 2019)
14. The ASEAN Secretariat Jakarta, *Guidelines for the Development of Sustainable Urban Mobility Plans (SUMP) in ASEAN Metropolitan Regions* (Jakarta, Indonesia, 2022)
15. Interreg Europe, *Sustainable Urban Mobility Plans: A Policy Brief from the Policy Learning Platform on Low-Carbon Economy* (2018)
16. S. Casdia, F. Pirlone, and I. Spadaro, in *WIT Transactions on The Built Environment* (pp. 187–198, WIT Press, 2018)
17. United Nations Economic Commission for Europe, *A Handbook on Sustainable Urban Mobility and Spatial Planning Promoting Active Mobility* (Geneva, 2020)
18. European Cyclists' Federation
19. S. Werland, F. Rudolph, *Funding and Financing of Sustainable Urban Mobility Measures* (Eltis: European Platform on Sustainable Urban Mobility Plans, Wuppertal, Germany, 2019)
20. M. Cleuet, A. Jehanno, *Developing Sustainable Urban Mobility Plans Guidelines for MobiliseYourCity Geographies*, 2nd ed. (MobiliseYourCity, Bruxelles, Belgium, 2023)
21. M. Chinellato, M. Morfoulaki, *Sustainable Urban Mobility Planning in Metropolitan Regions. Sustainable Urban Mobility Planning and Governance Models in EU Metropolitan Regions*

(Eltis: European Platform on Sustainable Urban Mobility Plans, Brussels, 2019)
22. D. Bongardt, L. Stiller, A. Swart, A. Wagner, *Sustainable Urban Transport: Avoid-Shift-Improve (A-S-I)* (Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn and Eschborn, Germany, 2019)
23. Taylor & Francis, (n.d.)
24. A. May, S. Boehler-Baedeker, L. Delgado, T. Durlin, M. Enache, J.-W. van der Pas, European Transport Research Review **9**, 7 (2017)
25. Eltis: European Platform on Sustainable Urban Mobility Plans (2016)
26. Budapest Főváros Önkormányzata and BKK Budapesti Közlekedési Központ, *Balázs Mór Plan: Budapest Mobility Plan - Volume 1: Objectives and Measures* (2019)
27. USER-CHI (n.d.)
28. MOL Bubi (n.d.)
29. Budapestvasut2040 (n.d.)
30. Mobilissimus (n.d.)
31. BKK Centre for Budapest Transport (n.d.)
32. R. Jellinek, Eltis: European Platform on Sustainable Urban Mobility Plans (2019)
33. *STEP 2025: Urban Development Plan Vienna* (Vienna City Administration, Municipal Department 18 (MA 18) - Urban Development and Planning, Vienna, 2014)
34. R. Buehler, J. Pucher, A. Altshuler, Int J Sustain Transp **11**, 257 (2017)