



Article Sustainable Urban Mobility Plans: How Do They Work?

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Abstract: The growing demand for passenger and freight transport in cities, resulting from the population growth in urbanized areas, has led to increasing problems with congestion, environmental pollution and, as a consequence, to a decrease in quality of life. This problem was noticed by the European Commission, which began to promote the concept of sustainable urban mobility plans (SUMPs). The efficient implementation of SUMPs requires tools for its evaluation. However, in the literature, most proposed assessment tools relate mainly to passenger transport, omitting the freight transport. The purpose of this paper is to utilize a multiple criteria analysis with the use of the Promethee method in order to assess the level of advancement of selected European Union (EU) capital cities in the field of sustainable urban mobility plan formulation and implementation. This method has been applied on the basis of a survey conducted among representatives of 15 EU capital cities and analyses of transportation plans. This research shows that cities that have a comprehensive transport plan consistently collaborate with different stakeholder groups, have implemented the greatest number of measures in the field of sustainable urban transport, and have achieved the best results in terms of safety and NO₂ (nitrogen oxides) and PM (particulate matter) emissions.

Keywords: sustainable urban mobility plans; SUMP; Promethee; MCDM; Multiple Criteria Decision Making; strategic planning

1. Introduction

The growing rate of passenger and freight transport in cities causes many problems in terms of sustainability, such as noise, CO₂ (carbon dioxide), PM (particulate matter) and NO₂ (nitrogen oxides) emissions (environmental problem), an increase in transport costs caused by congestion (economic problem) and the risk of accidents (social problem), etc. [1–4]. The increased traffic causes fatal road accidents, which exceed 100 persons per million inhabitants in some cities [5]. In the case of air pollution, urban passenger transport and freight transport are responsible for 40% of all CO₂ emissions in road transport [6] and up to 70% of other pollutants from transport [7]. Forecasts show that the volume of these emissions will be doubled by 2050 in the case of a lack of strategic decisions in this area [6]. Additionally, according to the European Commission's calculations, congestion costs in European cities amount to almost EUR 100 billion [5]. The local government, which is responsible for traffic and quality of life, plays an important role in solving problems that require long-term decisions on the basis of strategic plans. However, many local authorities still mainly focus on passenger transport in strategic planning, treating freight transport as an area for which the private sector is responsible [8–11]. Freight transport, according to the research results, represents approximately 20–30% vehicle kilometers and generates 16 to 50% of the emission of air pollution in the city [11]. Therefore, it is essential that local authorities include not only passenger transport but also freight

transport into city strategic planning and then carry out actions facilitating this field in accordance with the plans.

In recent years, the European Union is increasingly focused on the development of sustainable urban transport and has introduced legislation and formal directives. As a result of these activities, there are many strategic documents containing long-term goals for passenger and freight transport and environment protection [12,13]. In the White Paper, specific targets for ecological transport in the city were developed [14]. As a result of growing interest in this issue at the European Union (EU) level, several projects and initiatives were created (CH4LLENGE, CIVITAS (SUMPs-Up), within which assumptions and guidelines were developed to create sustainable mobility plans. One of these documents is the sustainable urban mobility plan (SUMP), which should integrate passenger and freight transport demands, taking into account citizens' quality of life [15,16].

In the guide "Developing and implementing a sustainable urban mobility plan", introduced on the Urban Mobility Observatory ELTIS website, the essence of the evaluation of SUMP implementation was underlined [17]. In the literature, there are publications in which attempts were made to develop tools to assess the results of SUMP implementation [18–20]. They concern both the assessment of the implemented measures and the results arising from them. In the CIVITAS II project, 29 framework indicators were developed in order to evaluate measure implementation in the economic, energy, environmental, social, and transport areas [19]. Awasthi et al. [21] proposed a slightly different classification of categories according to which the criteria were identified in order to assess the SUMP, dividing the categories into: economic, environmental, social and technical. Both these classifications concentrate mostly on results arising from implemented measures. Lopez-Carreiro and Monzon [22] focused more on the assessment of implemented solutions within the SUMP, identifying a group of so-called smartness indicators. Among them, they proposed areas such as sustainability (social transport indicators, and environmental transport indicators) and innovation (technological transportation indicators). In turn, Curiel-Esparca et al. [23] developed a proposal for the evaluation of sustainable mobility by areas such as economy, travel quality and sustainability. However, these indicators mainly concerned public transport, omitting freight transport. In addition, in the sustainability area, only indicators related to health and air pollution were included. In turn, Cavalcanti et al. [18] identified, on the basis of the literature of the subject, a list of 17 most frequently utilized indicators for the evaluation of the sustainability of urban mobility projects. These include actions to reduce air pollutant emissions, extend bike path networks, improve user safety, increase the diversity of transportation modes, increase the cost efficiency of the project, etc. Among the identified indicators, there is also one that assesses compatibility with the master plan and local urban mobility polices. The need to include indicators, which assess the planning sphere, was also noticed by Perra et al. [24]. She and her colleagues proposed assessing the results of sustainable urban mobility plan implementation in five areas, namely, integrated regional/urban and transport planning, effective traffic and parking management, the promotion of cycling and walking, the promotion of public transport, and the promotion of "green" technologies and measures. In the area of integrated regional/urban and transport planning, they included indicators such as GDP (Gross Domestic Product) per capita, population density, land use mix, PT (Public Transport) network coverage, access to basic services, and private car ownership. In the group of these indicators, however, there are no indicators related to the integration of stakeholders during the formulation and implementation of the SUMP. This issue has been underlined by Cavalcanti et al. [18], who integrated planning in the developed criteria used for the assessment of sustainable urban mobility involved (including regional integration, land use and transportation planning integration, and integrated strategic planning). However, most indicators introduced in the literature for the assessment of the sustainable urban mobility plan do not take into account the stage of formulating a strategic plan in the field of sustainable transport (especially the scope of the cooperation with stakeholders and other local authorities), which, if properly developed, may affect the effective implementation of the strategy [25]. In addition, the presented indicators focus primarily on passenger transport, omitting most freight transport.

On the basis of the above presented literature review, the authors propose the following set of indicators to assess the implementation of sustainable mobility plans by dividing them into three clusters [26]:

- I. Cluster: Strategy formulation (indicators that assess whether the local authority developed a plan for passenger and freight transport, the scope of cooperation with stakeholders, and participation in freight quality partnerships (FQPs));
- II. Cluster: The implementation of measures towards sustainable urban mobility (this area includes indicators related to five groups of the implementation of measures in the field of passenger and freight transport in terms of sustainable urban mobility development, namely, infrastructure, land use management, access condition, innovation and ideas, and promotion and dissemination);
- III. Results regarding the implementation of measures in terms of sustainable urban mobility (economic, such as costs caused by congestion, social, such as safety and security, and environmental, such as the number of inhabitants travelling with the use of ecological means, NO₂, PM emission, etc.).

The purpose of this paper is to utilize a Multiple Criteria Decision-Making (MCDM) analysis with the use of the Promethee method in order to assess the level of advancement of selected EU capital cities in the field of sustainable urban mobility plan formulation and implementation. The Promethee method has been utilized on the basis a survey conducted among representatives of 15 EU capital cities and analyses of transportation (mobility) plans.

Research will help elicit answers to the following questions:

- What purposes have been indicated by the analyzed cities regarding transportation (mobility) plans in terms of sustainable urban mobility?
- What kind of measures have been implemented in the cities regarding sustainable urban mobility?
- What are the results of the undertaken activities in the field of sustainable urban mobility in the analyzed cities (regarding pollutant emissions, safety, etc.)?
- Which analyzed city is an outstanding city in terms of formulating and implementing the sustainable urban mobility plan?

The structure of this paper is as follows: the next section presents the materials and methods, including the research procedure and indicator descriptions, followed by a section on the study results and discussion.

2. Materials and Methods

2.1. Research Procedure

In this paper, five stages were developed to implement the study:

Stage 1. The development of the research methodology

This stage was developed on the basis of the literature review in the area of the assessment of the sustainable urban mobility plan. The authors have thoroughly investigated papers published in international databases, including Web of Science and Scopus. EU strategic documents were also analyzed, including A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development [27]; Review of the EU Sustainable Development Strategy–Renewed Strategy [28]; Green Paper: Towards a new culture for urban mobility [29]; Freight Transport Action Plan [30]; Action Plan on Urban Mobility [31]; A Sustainable Future for Transport: Towards an Integrated Technology-Led and User-Friendly System [32]; White Paper: Roadmap to a Single European Transport Area–Towards a competitive and resource efficient transport system [33]; and A European Strategy for Low-Emission Mobility [34].

Stage 2. The development of the research tool

The research tool was developed on the basis of the relevant literature [8,35], knowledge and personal experience. The purpose of the survey was, among others, to obtain information on passenger and freight transport planning in terms of sustainable development within the project financed by the National Science Centre in Poland granted on the basis of the decision number DEC-2013/09/B/HS4/01284. The survey consisted of three main parts. The first part was directed at representatives of local authorities from the transport planning department and included questions related to planning and cooperation. The next two parts of the survey were directed at experts involved in freight and passenger transport in the city. They were asked about implemented measures in the city in the field of passenger and freight transport. Respondents were also asked about existing standards (regulations) concerning the collection of data on urban freight and passenger transport. The questionnaire was consulted via e-mail with five experts.

Stage 3. Gathering the study results

This research was conducted between 2015 and 2016. The questionnaire, in terms of its wide range of research, was sent via e-mail to mayors of 28 EU capital cities. It required the involvement of various departments responsible for passenger and freight transport. There were also direct interviews conducted with two representatives of the City Halls in Warsaw and Berlin. However, this method of interview was proposed to all the representatives of studied cities. As a result of the survey, fifteen completed questionnaires have been obtained from the following cities: Warsaw, Stockholm, Vienna, Paris, Berlin, Athens, Helsinki, Riga, Prague, Budapest, Bucharest, Dublin, Lisbon, Tallinn, and London (Figure 1). The authors have also investigated transportation plans (including the SUMP) of the analyzed cities.



Figure 1. European Union (EU) capital cities that were selected for the analyses (Google Maps).

Stage 4. Final selection of the criteria for the analysis

The family of criteria was obtained from the survey, interviews and Eurostat database. For the final selection of criteria, a statistical method of selection was used. The purpose of the method was to select the criteria which are characteristic for their relatively high spatial volatility, the lack of excessive correlation of the criteria representing the selected area and the asymmetry of distribution. This analysis enabled the elimination of criteria which were characterized by insufficient spatial variability [26]. For this purpose, the authors utilized the coefficient of variation, which was calculated for all the criteria under consideration using the following formula [36]:

$$v_j = \frac{s_j}{|\bar{x}_j|}, \ j = 1, \dots, k,$$
 (1)

where:

$$s_j = \left[m^{-1} \sum_{i=1}^m (x_{ij} - \bar{x}_j)^2\right]^{0,5}, \ (j = 1, \dots, k),$$
(2)

$$\overline{x}_j = m^{-1} \sum_{i=1}^m x_{ij}, \ (j = 1, \dots, k)$$
 (3)

where:

m—number of examined objects,

 v_i —coefficient of variation set for the *j*-th criterion,

 s_j —standard deviation for the *j*-th criterion,

 \overline{x}_{j} —arithmetic mean of the *j*-th criterion,

 x_{ij} —value of the *j*-th criterion for the *i*-th city.

According to the above calculation, criteria that satisfy the inequality below

$$v_j \le \varepsilon$$
, (4)

should be eliminated in further analysis. A small positive number is where $\varepsilon > 0$ and its value usually equals 0.1 (a threshold value of the coefficient of variation, presented also as the percentage value 10%) [36]. In this study, none of the criteria were eliminated from the further analysis because all of them obtained a high coefficient of variation $v_j \leq \varepsilon$.

The authors also analyzed the criteria using correlation coefficients in order to examine the degree of dependence between some of the criteria and eliminate those with a similar informative potential. The author applied the parametric method of Hellwig [37], which classifies criteria into central and isolated criteria. As a result of that procedure, none of the criteria were eliminated.

Stage 5. Data analysis with the use of the Promethee method

In order to evaluate cities in terms of formulating and implementing sustainable urban mobility plans, the multiple criteria method Promethee was applied. This method was used to compare cities in terms of the level of advancement in formulating and implementing urban mobility plans in terms of sustainability (or sustainable urban mobility plans, if available) and selecting cities with a high, medium and low degree of advancement in this area. In order to make calculations, the criteria presented in the next section were used.

The procedure for the Promethee analysis included the following steps [38,39]:

Step 1. Defining clusters, groups of criteria and criteria (C) for EU capitals (A).

Step 2. Defining functions and preference thresholds. In this analysis, linear functions were adopted for all criteria. For each criterion, the thresholds of incomparability (indistinguishability) *Q* and preferences *P* were also defined.

Step 3. The comparison of individual variants in pairs. The first step is to calculate the multi-criteria preference index π according to the following equation:

$$\pi(a,b) = \sum_{j=1}^{k} w_j \times P_j(a,b)$$

where $w_j > 0$ is the normalized weight assigned to the criterion K_j (the more important f_j , the larger w_j); P_j (a, b) is the value of the preference function for the criterion K_j , when the variant a is compared with the variant b.

The index, the value of which ranges from 0 to 1, describes the degree to which the variant *a* is preferred in relation to the variant *b*, considering the criteria and normalized weights. Thus:

 $\pi(a, b) \approx 0$ means that there is a slight prevalence of variant *a* over *b*. $\pi(a, b) \approx 1$ means that there is a significant prevalence of variant *a* over *b*.

Step 4. Obtaining a ranking using negative and positive preference flows using Visual PROMETHE computer software. Preference flows are calculated in order to consolidate the comparison results of variants in pairs and order all variants in the ranking from the best to the worst. Three different preference flows are calculated: Phi + (ϕ^+): positive flow (or leaving flow), which measures how much variant *a* is preferred over another n - 1; Phi-(ϕ^-): negative flow (or entering flow), which measures how many variants n - 1 are more preferred in relation to the variant *a*; Phi (ϕ): net flow, which is the balance between positive and negative flows. It is obtained by aggregating positive and negative flows of a given variant into one final result. ϕ (*a*) can be positive or negative. The higher the score, the better the position of the given variant in the ranking. As a result of computer simulation, one can obtain two types of rankings: a partial ranking (Promethee 1) and a complete ranking (Promethee 2). The partial ranking shows the negative and positive flows and the complete ranking of the net flows.

2.2. Indicator Descriptions

In the analysis conducted with the Promethee method, 45 indicators [26] were classified into three clusters (Table 1):

- I. Cluster: Strategy formulation, includes two groups of criteria:
 - 1.1. Group of criteria: Planning (which includes two criteria: C1 and C2. This group of criteria includes those which are related to the planning phase while developing the SUMP).
 - 1.2. Group of criteria: Cooperation (which includes one criterion C3, which is related to the freight partnership in a city).
- II. Cluster: The implementation of measures towards sustainable urban mobility covers the types of solutions in the areas of passenger transport (15 criteria) and freight transport (17 criteria) that affect sustainable urban mobility development. This cluster includes 32 indicators (C4–C35) divided into five groups of indicators:
 - 2.1. Group of criteria: *Infrastructure*. This group includes 7 solutions (C4–C10) related to the construction or the development of logistics infrastructure. Among them are: C4. Building a city distribution center; C6. Utilization of public infrastructure (e.g., metro or cargo-trams) for the delivery of goods; C9. Introduction of a bicycle rental system.
 - 2.2. Group of criteria: *Land use management*. This group includes three indicators (C11–C13), including C11. Allocating land (roads) in the city for logistic operations (zones for loading up and unloading delivery vehicles); C13. Kiss and Ride parking area.

- 2.3. Group of criteria: *Access condition*. This group consists of 8 indicators (C14–C21) related to the introduction of traffic-restrictive or completely prohibiting regulations in the selected zones. Among the adopted indicators one can mention: C14. Spatial restrictions for freight vehicles depending on weight and size (e.g., entry ban to the center for the vehicles above 3.5 t); C17. *Low Emission Zones* (LEZ) for delivery vehicles over 3.5 t; C18. The introduction of time limits (so-called time windows) for urban freight transport.
- 2.4. Group of criteria: Innovation and ideas. This group includes innovative solutions that improve the organization of passenger and freight transport in a sustainable manner. A total of 7 solutions have qualified for this group, among which can be mentioned: C23. Introduction of night-time deliveries in urban transport of goods; C24. Introduction of the bicycle transport of goods in the city; C25. Introduction of collective deliveries to the city centre; C26. The access to the integrated passenger information system
- 2.5. Group of criteria: *Promotion and dissemination*. This group includes measures (C29–C32) promoting sustainable mobility in a place such as a forum, organizing events, actions motivating companies/residents to use alternative, ecological fuels, means of transport, etc.
- 2.6. Group of criteria: *Information standards*. This group includes measures (C33–C35) in the field of data collection standards on the flow of people and cargo.

For all indicators from the area of the implementation of measures towards sustainable urban mobility, the values strive for the maximum (max), which means that their high value is desirable.

- III. Cluster: Results regarding implementation of measures in terms of sustainable urban mobility. In this area, three groups of criteria were distinguished:
 - 3.1. Group of criteria: *Economic*. This group includes only one indicator due to the lack of access to data. It is an indicator showing the level of congestion in the city (C36). The indicator shows the increase in the total travel time resulting from congestion compared to the situation where the trip would take place beyond the traffic peaks. Assuming that the higher the level of congestion, the higher the costs associated with moving people and loads in the city.
 - 3.2. Group of criteria: *Social*. This group includes 5 indicators (C37–C41), which present information on, inter alia, the following: the healthy and pro-ecological communication behavior of residents (for example, the percentage of people travelling by bicycle/walking to work) and safety—the number of people killed in accidents per million inhabitants.
 - 3.3. Group of criteria: *Ecological*. This group includes 4 criteria (C42–C45) related to environmental protection. Among them, two criteria relate to the communication behavior of residents affecting the environment in the city (C43. The percentage of the population travelling by public transport; C42. The percentage of residents travelling by private cars daily). The next two indicators present the annual average concentration of NO₂ (C44) and PM (C45) in the city.

In the last cluster, indicators with results that can be influenced by SUMP implementation were selected. According to Pisoni et al. [40], the implementation of the SUMP contributes to a better quality of life, reduced noise, PM, NOx and CO₂ emissions, a decrease in congestion, and an increase in safety.

The selection of criteria for the analysis was mainly based on the availability of data. For indicators selected for Cluster I and Cluster II, the data was obtained as a result of the conducted surveys. Cluster III includes statistical data obtained from the Eurostat database. The hierarchy of the family of criteria is presented in Figure 2 and the detailed description of each indicator is introduced in Table 1.

Table 1. Criteria description.

I. Cluster: Strategy Formulation

1.1. Group of Criteria: Planning

C1. The local government has a prepared comprehensive plan in the area of city logistics which includes both passenger and freight transport (the city has a comprehensive plan—3 p., it does not have a plan and has no intention to do so—1 p., 2015–2016, [max ¹])

C2. The scope of a city's partnership with experts/institutions/entities specializing in city logistics in order to improve the transport of passengers and/or goods (number of types of the experts/institutions, etc., max = 6, 2015/2016, [max])

1.2. Group of criteria: Cooperation

C3. Local government has a freight quality partnership (FQP) in the city (1-yes, 0-no, 2015-2016, [max])

II. Cluster: Implementation of Measures towards Sustainable Urban Mobility

2.1. Group of Criteria: Infrastructure

C4. Building a city distribution center (the place where deliveries are consolidated and delivered jointly to the city center) (1—yes, 0—no, 2015–2016, [max])

C5. Access to infrastructure for transport and/or production companies located outside the city center (the land offered by the local authorities for investment on the city's outskirts on attractive conditions, which can eliminate traffic from the center) (1—yes, 0—no, 2015–2016, [max])

C6. Utilization of public infrastructure (e.g., metro or cargo trams) to deliver goods (1—yes, 0—no, 2015–2016, [max])

C7. "Park and Ride" system (access to free car parks located near public transport hubs) (1—yes, 0.5—being built or on the outskirts, 0—no, 2015–2016, [max])

C8. Building a network of cycle paths (the length of the paths built per the area of the city in km², 2015–2016, [max])

C9. Introduction of a bicycle rental system (total number of bicycles available in the urban bike rental system in relation to number of residents per 1000 persons, 2015–2016, [max]) C10. Introduction of electric buses into the city's system of public transport (1—one complete bus line operates in the city's public transport or a few dozen electric buses, 0.5—a small number (a few) buses, 0—no electric buses, 2015–2016, [max])

2.2. Group of Criteria: Land Use Management

C11. Allocating land (roads) in the city for logistic operations (zones for loading up and unloading delivery vehicles) (1—yes, 0—no, 2015–2016, [max])

C12. Removal of freight transport generators due to the revitalization or revival of the city (moving companies generating transport of goods out of the city center to other areas less frequented by residents) (1—yes, 0—no, 2015–2016, [max])

C13. Kiss and Ride car parks enable a quick stop—from a few minutes up to a quarter of an hour to drop off a passenger to school or station (coach, railway, etc.) (1—yes, 0—no, [max]).

2.3. Group of criteria: Access condition

C14. Spatial restrictions for freight transport vehicles depending on their weight and size (e.g., entry ban to the center for the vehicles over 3.5 t) (1—yes, 0—no, 2015–2016, [max])

C15. Introduction of loading and unloading zones for delivery vehicles (assignment of special loading bays for loading/unloading vehicles) (1—yes, 0—no, 2015–2016, [max])

C16. Introduction of toll zones for entry to the city center of HGVs (1-yes, 0-no, 2015-2016, [max])

C17. Low Emission Zones (LEZs) for delivery vehicles over 3.5 t (e.g., entry to the city center only for delivery vehicles marked Euro 6) (1—yes, 0—no, 2015–2016, [max])

C18. Introduction of time limits (the so-called time windows for making deliveries) for urban freight transport (1-yes, 0-no, 2015-2016, [max])

C19. Low Emissions Zones (LEZ) for passenger cars (1-yes, 0-no, 2015-2016, [max])

C20. Introduction of toll zones for entry to the city center for passenger cars (1—yes, 0—no, 2015–2016, [max])

C21. Introduction of a ban on access by passenger cars to the city center (1—yes, 0—no, 2015–2016, [max])

2.4. Group of Criteria: Innovation and Ideas

C22. Introduction of electric delivery vehicles for urban transport of goods (1—yes, 0—no, 2015–2016, [max])

C23. Introduction of night-time deliveries in urban transport of goods (1-yes, 0-no, 2015-2016, [max])

C24. Introduction of the bicycle transport of goods in the city (1—yes, 0—no, 2015–2016, [max])

Table 1. Cont.

C25. Introduction of collective deliveries to the city center (consolidation of deliveries through, e.g., micro-hubs located near the city center) (1—yes, 0—no, 2015–2016, [max])

C26. Access to an integrated passenger information system (the system provides the passengers with information about the real arrival times of buses/trams/metro) (1—yes, 0—no, 2015–2016, [max])

C27. Coordination of tariffs and timetables for public transport (1—yes, 0—no, 2015–2016, [max])

C28. Smartphone apps which enable buying public transport tickets, and optimize the routes (dedicated—offered by local government (its transport department) —1, universal—offered by international companies, e.g., Google—0.5, 2015–2016, [max])

2.5. Group of Criteria: Promotion and Dissemination

C29. Creating a forum (or other ideas) dedicated to ecological urban freight transport (via the Internet, meetings with various stakeholders, etc.) (1—yes, 0—no, 2015–2016, [max]) C30. Encouraging transport operators to use alternative fuels (information meetings, advertising) (1—yes, 0—no, 2015–2016, [max])

C31. Realization of events and actions encouraging residents to use ecological transport (1-yes, 0-no, 2015-2016, [max])

C32. Access to the free public passenger transport (1—yes, 0.5—in part (e.g., for people with disabilities, children, etc. 0—no, 2015–2016, [max])

2.6. Group of Criteria: Information Standards

C33. The city implemented formal regulations regarding the collection of data on the subject of freight transport (4—yes, collects data in real time/daily, 3—yes, cyclically, 2—yes, sometimes, 1-no, 2015–2016, [max])

C34. The city implemented formal regulations regarding the collection of data on public passenger transport (4—yes, collects data in real time/daily, 3—yes, cyclically, 2—yes, sometimes, 1—no, 2015–2016, [max])

C35. The city implemented formal regulations regarding the collection of data on individual transport (4—yes, collects data in real time/daily, 3—yes, cyclically, 2—yes, sometimes, 1—no, 2015–2016, [max])

III. Cluster: Results Regarding the Implementation of Measures in Terms of Sustainable Urban Mobility

3.1. Group of Criteria: Economic

C36. Level of traffic congestion according to the TomTom index 2 in respect of the main hubs of the TEN-T (Trans-European Transport Network) -the index shows an increase in the total time of travel resulting from congestion compared to the same journey during the off-peak times (%, 2015, [min ³]);

3.2. Group of Criteria: Social

C37. Percentage of residents satisfied with the functioning of a city's public transport (% answers: very satisfied and fairly satisfied, 2015, [max]

C38. Percentage of residents using bicycles when going to work/gym (% of respondents using this type of transport, 2015, [max]);

C39. Percentage of residents going to work/gym on foot (% of respondents who walk to work/gym, 2015, [max])

C40. Number of people killed in accidents per million inhabitants (2015, [min])

C41. Safety satisfaction of citizens (sum of the answers: very satisfy and somehow satisfy, 2015, [max])

3.3. Group of Criteria: Environmental

C42. Percentage of residents using a private car when going to work/gym (% of respondents using this type of transport, 2015, [min])

C43. Percentage of residents using public transport when going to work/gym (% of respondents using this type of transport, 2015, [max])

C44. Average annual concentration of NO₂ (nitrogen oxides) (µg/m³, 2013, [min]);

C45. Average annual concentration of PM (particulate matter) (µg/m³, 2013, [min]);

¹ Max means that values tend to be the maximum, which means that, for those criteria, higher values are expected. ² Detailed information on how the traffic index has been calculated can be found on the website: https://www.tomtom.com/en_gb/traffic-index/about, 10 July 2019. ³ Min means that values tend to be the minimum, which means that, for those criteria, lower values are expected.



Figure 2. Hierarchy of the family of criteria.

3. Results and Discussion

The research shows that in all the analyzed plans, the objectives focused on sustainable urban transport. In the economic area, among the most frequently mentioned goals were creating framework conditions to increase the effectiveness and economic sustainability of the overall transport system (11 indications), the improvement of accessibility to transport infrastructure and public transport (seven indications), traffic reduction (six indications). In the social area, the most frequently indicated goals were increasing safety (14 indications), increasing active mobility by walking or cycling (nine indications) and improving the accessibility of urban sub-areas and neighborhoods (nine indications). In the case of ecological area, the most frequently indicated target (15 indications) was the reduction of environmental pollution (energy, noise, CO_2 emissions, PM and NOx). The need to increase ecological mobility was also pointed out.

The results of a computer simulation performed with the Promethee method, using 45 indicators (C1–C45), are presented in Table 2 and Figure 3. The computer simulation was performed with the use of the Visual Promethee computer software (VP Solutions, 2013). As a result of the simulation, three groups of cities were identified: those cities with a high level of advancement in the formulation and implementation of sustainable mobility plans (Stockholm, Vienna, Paris, Berlin, Helsinki and London), and medium-level (Budapest, Prague, Warsaw and Dublin) and low-level (Tallinn, Lisbon, Riga, Bucharest and Athens) cities. Most of the analyzed cities (apart from Bucharest, Lisbon and Paris) participated in initiatives and projects dedicated to the SUMP (such as CIVITAS (2002–2016), CH4LLENGE (2013–2016), ENDURANCE (2013–2016) or CIVITAS forum. On the day of the conducted research, a comprehensive plan, covering both the flow of people and goods, existed in 10 of the analyzed cities, and another five declared implementation within the next year. The research shows that Stockholm is the most advanced city in terms of the formulation and implementation of the sustainable urban mobility plan. At the same time, the urban transport strategy of Stockholm has the features of a sustainable mobility strategy as it has a long-term vision and goals up to 2030, a measurable target, and priority ecological transport (public transport, walking, and cycling). In addition, the city consistently cooperates with various stakeholder groups (including other local governments) and has implemented many measures affecting urban sustainable mobility, such as building a city distribution center, the introduction of unloading and loading zones for delivery vehicles, spatial and time restrictions, the introduction of electric vehicles, night delivery for urban freight transport, a city logistics forum or freight quality partnership, etc. In this city, the number of people killed in road accidents (9.88 fatalities per million of residents) is the lowest, compared to other cities, and there is a relatively low concentration of NO₂ (13.7 μ g/m³) and PM (14.9 μ g/m³). This study confirmed the results of the research conducted by Pisoni et al. [40], that implementation of SUMP in the city can improve quality of life by reducing noise and environmental degradation and improving safety. In turn, according to Louro et al. [15], the SUMP brings benefits for a healthy city framework. Therefore, in Athens, which did not have a sustainable comprehensive transport plan covering passenger and freight transport on the day of the research, very high emission rates of NO₂ (48.3 μ g/m³) and PM $(40 \ \mu\text{g/m}^3)$ as well as a high level of congestion according to the TomTom index (37%) can be observed. In Athens, there is also a very high rate of people killed in road accidents (66 fatalities per million of residents). Athens did not implement many solutions so far, primarily concerned with access restrictions (time windows), which were also implemented in most analyzed cities. This study confirms the study results by Mozos-Blanco et al. [41]—according to which, regulations on access limitations for unloading, loading and parking cars are the most common measures introduced in cities. It can be assumed that this measure is an easy to implement measure and, at the same time, is a cost-effective solution for many cites. However, in practice, it does not resolve all the problems regarding city logistics. In turn, it is worth underlining that the analyzed cities that qualified at a high and medium level of advancement in the formulation and implementation of sustainable mobility plans have a comprehensive transport plan (which include both passenger and freight transport) and consistently collaborate with different stakeholder groups. However, at the same time, in some of these cities, there is still a high level of congestion (e.g., in London, Paris, and Dublin). Therefore, it is necessary to thoroughly investigate each city separately.

Rank	Action	Phi	Phi+	Phi-	Involvement in SUMP Projects and Initiatives 1
1	Stockholm	0.3511	0.4221	0.0710	CIVITAS (2002–2016); CIVITAS forum
					Do the Right Mix, SUMP award (2012–2015)
2	Vienna	0.2634	0.3360	0.0727	CH4LLENGE (2013–2016); CIVINET;
					ENDURANCE (2013–2016); PUMAS EU
					(2013–2015)
3	Paris	0.2283	0.3480	0.1197	-
4	Berlin	0.1857	0.3107	0.1250	CIVITAS (2002–2016); CIVITAS forum
					Do the Right Mix; SUMP award (2012–2015)
5	Helsinki	0.1737	0.2964	0.1227	Do the Right Mix, SUMP award (2012–2015)
6	London	0.1640	0.2990	0.1351	CIVITAS forum
					BUMP (2013-2016); CH4LLENGE (2013-2016);
7	Budapest	0.0992	0.2521	0.1529	CIVITAS forum; ENDURANCE (2013-2016);
	1				Solutions (2013–2016); TIDE (2012–2015)
8	Prague	0.0309	0.2264	0.1955	CIVITAS (2002–2016); CIVITAS forum;
					ENDURANCE (2013–2016)
9	Warsaw	-0.0815	0.1520	0.2335	CH4LLENGE (2013-2016); CIVITAS forum;
					TIDE (2012–2015)
10	Dublin	-0.1121	0.1346	0.2467	CIVITAS forum; ENDURANCE (2013–2016)
11	Tallinn	-0.1510	0.1229	0.2739	CIVITAS (2002–2016); CIVITAS forum; PILOT
					(2005–2007); TIDE (2012–2015)
12	Lisbon	-0.1723	0.1213	0.2936	-
13	Riga	-0.2484	0.0969	0.3453	CH4LLENGE (2013–2016); CIVITAS forum
14	Bucharest	-0.3631	0.0393	0.4023	-
15	Athens	-0.3678	0.0477	0.4155	Involved in EU project on SUMP; CIVITAS
					forum; Do the Right Mix, SUMP award
					(2012–2015); ENDURANCE (2013–2016)

Table 2. Computer simulation results with the use of the Promethee method.

¹ Information on the participation of cities in sustainable urban mobility plan (SUMP) projects and initiatives was obtained from the database on the cities available at http://www.eltis.org/mobility-plans/city-database (access on 19 January 2015). Other initiatives and projects in which the examined cities could participate were not included here.

The method presented in the article for assessing the formulation and implementation of the SUMP using the Promethee Multiple Criteria Decision-Making method allows for not only obtaining the ranking of cities participating in the analysis, it also allows for a more in-depth analysis that can identify areas and groups of criteria—both those that require significant improvement and those that were assessed well in the study (Figure 4). Individual groups of criteria can be analyzed separately in the context of a single city, as well as compared to other cities.

The method proposed by the authors differs from others presented in the literature [19,21] in that it covers the sphere of planning and implementation as well as the results stemming from these two areas. In particular, an important factor that is included in the analysis is the scope of the cooperation

with stakeholders, other local authorities, which has a strong influence on the effective implementation of the strategy [25]. In addition, the proposed method focuses on both passenger and freight transport. It can be useful tool for the strategic analysis of local authorities while developing or improving sustainable urban mobility plans of the city.



Figure 3. Cities on the Promethee network (Visual Promethee software).



Figure 4. (a). Promethee results broken down into clusters for Athens; (b) Promethee results broken down into clusters for Stockholm; (c) Promethee results broken down into groups of criteria for Athens (Visual Promethee software).

4. Conclusions

In the paper, a multiple criteria analysis with the use of the Promethee method has been utilized in order to assess the level of advancement of selected EU capital cities in the field of sustainable urban mobility plan formulation and implementation. In order to conduct the study, a family of criteria used to assess cities in the field of sustainable urban mobility plan formulation and implementation (or if not applicable—transport plans in terms of their compliance with the SUMP) was proposed. Research shows that there is still a significant difference between EU capital cities in the formulation and implementation of sustainable urban mobility plans. These differences may result from different factors, such as social, economic and environmental factors. Despite the fact that all the analyzed cities included sustainable urban mobility objectives in their transport plans, the implementation of various types of measures is diversified. Among the analyzed plans, the most frequently indicated goals were increasing the efficiency of passenger and freight transport, improving safety, increasing active and ecological mobility and reducing environmental pollution. The most commonly introduced measures by cities are spatial (14 cities) and time (11 cities) access restrictions for passenger and freight transport. The least commonly introduced measures by cities were the use of public infrastructure (trams, underground) for the purpose of cargo delivery (one city) and night and collective delivery (two cities). This research shows that cities that have a comprehensive transport plan consistently collaborate with different stakeholder groups, have implemented the greatest number of measures in the field of sustainable urban transport, and have achieved the best results in terms of safety and NO₂ (nitrogen oxides) and PM (particulate matter) emissions. However, it should be emphasized that some of these cities (such as London and Paris) still have a problem with a high level of congestion. In addition, in most the analyzed cities, measures for freight transport are much less commonly undertaken than in the case of passenger transport.

The evaluation tool proposed in this article can help local governments formulate, implement and control sustainable urban mobility plans. However, it requires a more in-depth analysis of a single city in terms of its results in individual areas and groups. In the future, the authors would like to develop a tool that will allow more thoroughly evaluating the effectiveness of the implementation sustainable transport plans in a city, as well as extending the research to the cities from other continents, such as Australia, America and Asia.

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