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Evaluation approach for scaling up urban mobility measures on TEN-T urban nodes: the case of Madrid

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Abstract

The European Green Deal intends to speed up the transition towards sustainable mobility to achieve climate neutrality by 2050. Among the different transformative policies it proposes, accelerating the shift to sustainable, smart, and inclusive mobility is one of the main strategies. This work presents a phase on how to apply the evaluation framework from CIVITAS SCALE-UP project, in Madrid's context. This paper describes the project's multilevel evaluation framework being developed and presents relevant findings on Madrid´s mobility baseline. Results support the need for the different strategies and plans that are currently being implemented in the city and the region, which include the 8 mobility measures studied in SCALE-UP.

Keywords: CIVITAS SCALE-UP; upscaling; replication; sustainable cities and communities; multimodal transport;

1. Introduction

The transport sector generates negative externalities to society, among which, traffic congestion, air pollution and accidents have been identified as some of the most important ones (Maibach et al., 2008; Newbery,1990; Parry, Walls, &Harrington, 2007). As Banister (2008) points out, in order to improve transport sustainability, it is necessary to take actions in both the physical layer of the city (urban form and traffic flows) and the social dimension (people and proximity). To achieve that, the integration of transportation policies in different plans and policy packages plays a key role in finding ways of addressing transportation problems (Hull, 2008).

In this regard, one of the European Commission's primary initiatives is to accelerate the shift to sustainable, smart, and inclusive mobility (Poppeliers & Ricci,2013) as well as to reduce transport emissions, which currently account for a quarter of the European Union (EU´s) greenhouse gases, with a sustained upward trend (Eurostat,2016).

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The European Green Deal (EC, 2019) outlines a comprehensive framework of regulations and legislation to achieve EU´s targets of net-zero carbon emissions by 2050. Among the different transport related actions, the deal fosters multimodal transport and the digitalization of the mobility system. It prioritizes users, under the idea that "the green transition will be socially fair, leaving no one behind" (EC, n.d.).

In order to contribute and accelerate these efforts, the EU funds projects that demonstrate, evaluate, and disseminate innovative mobility measures and encourage upscaling and replication of good practices. Commonly, these policy packages are part of a bigger strategy, since experience has shown that single isolated policies have often proven to provide only limited results (Hull, 2008; Geerlings and Stead, 2003; van Wee, 2002; May et al., 2001).

This is the framework for SCALE-UP project and Madrid´s case study. This work focuses on the 8 mobility measures that are being implemented in Madrid and particularly on the impact evaluation approach being developed as part of the project. The paper describes the evaluation framework, the scope of the mobility measures and presents Madrid´s mobility baseline which will be used at the end of the project to evaluate mobility related changes.

2. SCALE-UP evaluation framework

SCALE-UP ("Scale up User-Centric and data driven solutions for connected Urban Poles") is an EU-funded Innovation Action. The project demonstrates and evaluates the combination of 28 technical and non-technical innovative, clean, smart, and inclusive mobility measures under real-life conditions with a special focus on the strategies to achieve their upscaling beyond the urban level and in an interconnected mobility ecosystem. Three urban nodes situated on the Trans-European Transport Network (TEN-T) team up in SCALE-UP: Antwerp (situated alongside North Sea-Baltic, Rhine-Alphine and North Sea-Mediterranean corridors), Madrid (situated along Mediterranean and Atlantic corridors), and Turku (situated alongside the Scandinavian-Mediterranean corridor). The project proposes a two-dimensional integration process (Fig.1). The vertical upscaling (Y-axis) is related to the integration of mobility and transport strategies on multiple governance levels and beyond geographical boundaries (city, functional urban area (FUA), TEN-T). On the other hand, the horizontal axis (X-axis) attempts to integrate different layers of the mobility system (physical, digital, and human) in a balanced way. The measures studied in SCALE-UP, all fall among 5 different intervention fields: Governance, Multimodal, Clean-safe-inclusive, Data, and Behavior, which are directly related to the 5 main objectives of the project.

Fig. 1. SCALE-UP concept (https://www.scale-up-project.eu)

SCALE-UP evaluation framework develops some 'add-ons' to the one CIVITAS 2020 (Engels, 2021) in order to respond to the specific needs of the 3 urban nodes for evaluating the effectiveness of their strategies and measures to become climate-resilient, well-connected, multimodal, and multi-usage nodes for smart and clean mobility. It proposes a layered and integrated evaluation approach encompassing 3 main layers for evaluation: (1) SCALE-UP mobility measures, (2) city and FUA and (3) strategies for integration, analyzing the SCALE-UP concept of vertical (local–

FUA–TEN-T) and horizontal (multi-layered mobility system) upscaling. This paper will summarize the first level and will present the main findings on the second one. The third level falls out of the scope of this work.

(1) The first level is a measure-oriented evaluation, applied to the measures studied in SCALE-UP urban nodes through the selection of the most appropriate indicators. This evaluation includes the identification of possible barriers and

drivers in the implementation process to gain knowledge on the impact and effectiveness of the selected SCALE-UP actions.

(2) The second level focuses on understanding the overall changes, evolution, and trends in the 3 urban nodes. Several qualitative and quantitative indicators (previously tested in European Projects CIVITAS SATELLITE, SUMI, CREATE (Vectos, 2018)) were defined, to evaluate changes and to understand the main reasons behind them. This level also includes a baseline, to describe the context for change in each city and to be able to compare it at the end of the project in 2025.

3. SCALE-UP evaluation objectives in the case of Madrid

Madrid, aligned with Europe´s objectives for reaching a more sustainable mobility, is deploying a set of actions in the city and the region. Among them, 8 mobility measures are being studied, monitored, and evaluated in SCALE-UP. The scope of these 8 measures, organized within the 5 intervention fields mentioned earlier, are:

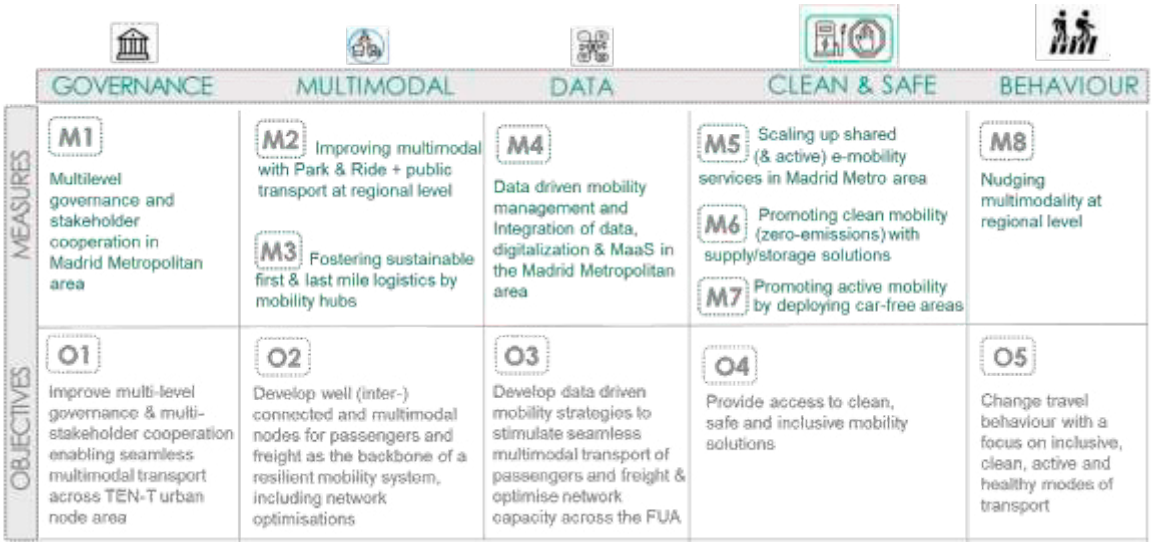

Fig. 2. Madrid´s measures and SCALE-UP´s objectives

M1 main objective is to have a better governance and cooperation model for the whole Madrid Region. New plans and measures that improve cooperation between all the agents involved in Public Transport (PT) services at different levels will be implemented. Cooperation mechanisms and partnerships with other public and private stakeholders will be fostered. It will also serve to establish the best ecosystem for the development of a mature MaaS system for the whole Madrid Region.

M2 seeks to decrease car-dependence in Madrid´s periphery, of people commuting from the region into the city center, by providing Park & Ride (P&R) facilities connected to the public transport network and new shared mobility services. The proper connection will allow people to commute to the city center leaving their private vehicles next to a rapid transit system that will take them quickly, comfortably and cost effectively to their destination.

M3 includes the deployment of one logistic hub for last mile distribution. It seeks to serve as a tool to help improve the logistic sector and has a high replicability potential in other locations and districts, by setting public-private partnerships and agreements. It will include parking and added value services such as charging points for e-vehicles. The pilot´s operation data will be useful in studying how to optimize last mile logistic processes.

M4 aims to find a data-driven strategy that leverages data from public and private mobility providers to create a digital mobility layer. The measure intends to integrate data from a new MaaS ecosystem that brings together all mobility stakeholders to test different MaaS solutions. This data integration will also serve for the development of an advanced mobility big data visualization tool.

M5, in order to foster clean and safe mobility, considers the expansion of Madrid´s public bike sharing system (BiciMAD) and the development of a mobile bike station to be used in large events.

M6 focuses on promoting zero emissions mobility through supply and storage solutions by providing charging facilities and better access to information. It will test V2G solutions that might support the deployment of a fast-charging points network.

M7 will create multiple car free zones, as a way to reduce air pollution and to promote active modes. The main pedestrian area, Puerta del Sol, is expected to be replicated in different districts of the city.

M8 focuses on the improvement of communication campaigns to promote sustainable and multimodal travels to large events within Madrid Region.

Since most of the measures in Madrid are in the research and procurement stages of the implementation and demonstration phases, the evaluation of their impacts has not been done yet.

4. Second level: establishing Madrid´s baseline

To monitor the overall changes of the urban node and to understand these changes SCALE-UP proposes an evaluation at city + FUA level. This evaluation serves to set Madrid´s baseline which will be a reference to monitor the evolution at city and FUA level in the perspective of SCALE-UP objectives. Over twenty indicators were selected, which have already been tested in other European projects, such as CIVITAS SATELLITE (2020) and CREATE (2018). This work presents a synthesis of the results obtained in the evaluation of Madrid's baseline at city and FUA level. For this paper, the thirteen indicators mostly related to the project´s intervention fields presented in Figure 3 were selected. It is important to highlight that in most of the cases data from 2019 or 2018 was used for the baseline, in order to avoid the possible bias caused by COVID-19's impact in mobility.

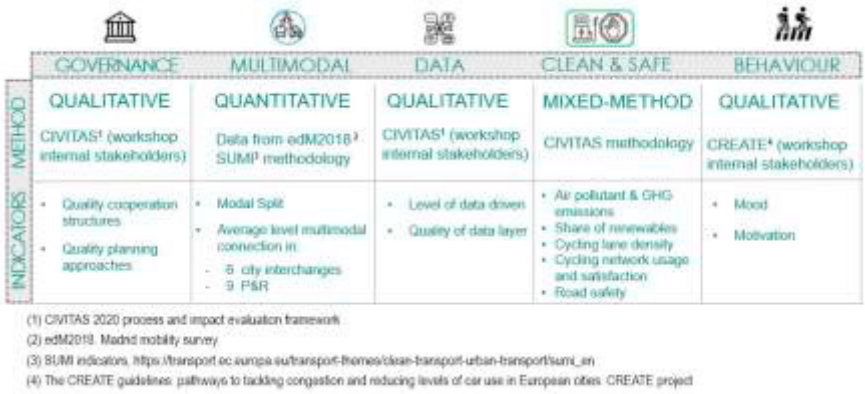

Fig. 3. Madrid´s indicators and methods used for evaluating impacts at city and FUA level

5. Current situation diagnosis and priorities for action

The methodology employed to evaluate each indicator together with the main findings grouped in the five intervention fields are presented below. Fig. 4 synthesizes the most relevant results and data gathered from the indicators measured in each of SCALE-UP intervention fields.

5.1. Governance

To provide an understanding of Madrid's current governance situation, two indicators were addressed: quality of the cooperation structures and quality of the planning approaches. The evaluation of these indicators was done in an online stakeholders' workshop. The participants -representatives from the city of Madrid and main transport authorities and operators-, were asked to give their opinion and expertise on certain topics, in order to evaluate the two indicators. Most of the participants agreed that Madrid's hierarchical governance structure facilitates the

implementation of mobility and transport strategies and European Directives, although at regional level there is still a lot to be done. There is stability in working relationships and business agreements among different mobility stakeholders but there is a need to improve the participative process to shape new mobility solutions. Moreover, cooperation mechanisms to foster public-private partnerships need to be addressed. Regarding the quality of the planning approaches, Madrid´s City Council, the Municipal Transport Company (EMT) and the Regional Public Transport Authority (CRTM) are working in different mobility plans and strategies aligned with the European mobility guidelines and regulations, with similar objectives and putting all the efforts together with the common goal of fostering a shift to a more sustainable mobility in Madrid.

5.2. Multimodal

Two indicators were used to assess multimodality: the modal split in the city and region (pre-pandemic) and the multimodal integration of transport offer for persons (using SUMI methodology). The latter gives an index between 0 and 1 that shows the average level of multimodal connection of the interchanges within the transport network.

As presented in Fig.4, the modal split was analyzed in 4 different areas: the central business district (CBD-Madrid's almendra), Madrid's periphery, Madrid's metropolitan ring and Madrid's regional ring. The modal split in CBD and Madrid's periphery is similar, with the highest shares in public transport and walking. Moreover, for Madrid's metropolitan ring and regional ring the use of private vehicle has a considerable higher share than in the other two areas (48% and 56% respectively). It is important to highlight that in the four areas cycling has a share lower than 1%. For the estimation of SUMI's multimodal integration index two different analyses were made. The first one included the evaluation of the 6 main interchanges in the city of Madrid: Avenida de América, Moncloa, Atocha, Méndez Álvaro, Chamartín and Principe Pío. The second one included the evaluation of 9 P&R facilities (part of SCALE-UP). As can be seen in figure 4, the index for interchanges was 0.68, whereas the index for P&R was 0.52.

This difference is mainly due to the fact that most P&Rs are currently in the implementation phase or at the beginning of the operational phase.

5.3. Clean & Safe

To set Madrid's baseline in terms of clean and safe mobility, 5 indicators were evaluated: air pollutant and GHG emissions, share of renewables, cycling lane density, cycling network usage and satisfaction, and road safety. Air pollutant (PM2.5, PM10, NOx) and GHG emissions from road transport in Madrid city were extracted from the Inventory of Emissions of pollutants available in the Air Quality Portal from Madrid City Council. Fig. 4 presents the emissions of 2019.

The share of renewables was considered by evaluating the share of electric and hybrid vehicles in Madrid City and at FUA level, using data from Madrid´s mobility survey (edM2018). Results show that only 1% of the vehicle fleet in the city of Madrid is low emission and at FUA level this percentage is even lower (0.83%).

The quality of the cycling network was evaluated using three indicators: lane density, cycling infrastructure usage and citizens satisfaction with infrastructure. As can be seen in Figure 4, with a total of 361 km of cycling lanes, Madrid has only 0.04 km of cycling lane per road network km. Cycling infrastructure usage, and users´ satisfaction with the infrastructure were evaluated using data from the City Council Quality of Life survey. Results show that more than 25% of people surveyed have never used cycling lanes available in the city. Furthermore, this percentage was constant from 2014 to 2019. In terms of user satisfaction, data shows that people are mostly satisfied (score of 6/10), although this response was also constant during those same years.

Finally, to evaluate road safety the number of collisions, deaths in collisions, and deaths in collisions per 100 000 inhabitants in 2019 were considered (Fig.4). Results show that Madrid has only 1.01 deaths per 100000 inhabitants per year.

Fig. 4. Main findings from the current situation evaluation

5.4. Data

Two indicators were assessed to understand Madrid's baseline in the Data intervention field: quality of data layer and level of data driven. Concerning the quality of the data layer, Madrid has many data sources such as the Open Data Initiative platform, where all the data produced or compiled by public administrations are made available to citizens; or the Regional Transport Consortium catalogue, where different data related to urban buses, metro, light and suburban rail, and interurban buses is included. In the last years the city has gained a great deal of experience with data collection, however, there are some problems such as data reliability of different number of platforms, variety of formats, and data collection methodologies. These are some of the challenges that need to be overcome to ensure the quality and usefulness of the mobility layer. Regarding the level of data driven, although there is lot of data available from different sources, most of it is off-line or from different owners, which makes management and processing more complicated.

5.5. Behaviour

The indicators, mood and motivation, from the CREATE project were assessed to evaluate the level of acceptance of new types of transport policies. Both indicators were evaluated in the previously mentioned stakeholder workshop. Fig.4 presents the aspects considered to evaluate them. There is a common consensus that despite the fact that local authorities are open to new transport policies, it takes some time for citizens to accept them. This might be due to the lack of effective communication strategies and information channels for citizens. Moreover, there is a clear need to foster participative processes in shaping new mobility, since citizens' initiatives can turn out to be real game changers.

6. Strategic action plan

Madrid's mobility baseline was evaluated considering the five areas of intervention proposed in SCALE-UP. Madrid´s City Council, EMT and CRTM are working in different mobility plans and strategies aligned with the European mobility guidelines and regulations to speed up the shift to sustainable mobility. M1 aims to improve cooperation between stakeholders at different levels and to foster public-private partnerships.

To contextualize M2. Madrid has one of the highest walking shares in big European cities and in public transport usage, collectively sustainable transport modes reach up to 60% of the trips. The annual public transport demand has registered an upward trend since 2015 with more than 1.5 bn trips. Its affordability and the fact that the monthly pass includes all the transport means available makes it attractive to users. Moreover, to enhance multimodality, especially among commuters, both the region and the city are working on the promotion of PT by combining it with P&R facilities, the center piece of M2.

In the last years the concentration of pollutants like PM2.5, PM10 and NOx in Madrid was barely below the World Health Organization's (WHO) levels, with some episodes beyond the limits. The fact that emissions coming from transport account for more than 50% of the total pollutant emissions supports the promotion of clean mobility through low emission vehicles for transport and logistic purposes as considered in measures M3 and M6. Complementary, M7 contemplates the deployment of car free areas to foster active and safe mobility, even though according to the European cities rank in sustainable transport (Kodukula et al. 2018), Madrid scores 4th for road safety right after Amsterdam, Copenhagen, and Oslo.

Despite the successful implementation of the public bike-sharing system -BiciMAD, the absence of an extensive cycling infrastructure hinders the goal to increase the share of cycling (Julio & Monzon, 2022). In line with this, M5 aims to scale up BiciMAD service. Therefore, construction of new segregated cycling lanes is one of the city´s priorities.

Finally, in the last years, considerable efforts are being taken for data collection and data usage in shaping new mobility solutions. The M4, aims to use these data driven initiatives for an adequate mobility management by testing different Mobility as a Service solutions. Previous studies (Lopez-Carreiro et al. 2021) have shown a very high level of affinity with these technological innovations among Madrid´s citizens. The use these technologies and the improvement in communication campaigns considered in M8 are expected to serve as change catalysers for citizens' behaviour towards sustainable mobility decisions.

7. Conclusions

SCALE-UP evaluation approach was applied to Madrid to assess the baseline at city and FUA level. The results will serve as baseline to evaluate the impact on mobility of the 8 SCALE-UP measures' implementation. Results show that in Madrid's case, there is still a lot of work to be done in order to reach a safe, smart, and sustainable mobility system that covers all users' needs and achieves the Green Deal objectives.

In this sense, Madrid's city and region have been proposing new strategies and plans, such as the recently approved city´s Sustainable Mobility Plan (SUMP), Madrid360. This plan sets 2030 as the horizon to reach a "4Ss" mobility: *Sostenible, Segura, Saludable y Smart* (sustainable, safe, healthy, and smart). Among its different objectives, Madrid360 aims to reduce travel time on public transport by an average of 32.5%; to reduce traffic congestion by up to 10%; to reduce CO_2 emissions by 65% compared to 1990 and to reduce road fatalities and serious casualties by 50%. Most of the SCALE-UP measures are included in the SUMP and contain innovative processes, techniques, and

methods. Since they are part of wider strategies and supported by different ordinances such as the new Ordenanza de Movilidad Sotanible (Sustainable Mobility Ordinance), they try to respond to social, economic, environmental, cultural, technical and technological changes related to mobility. Their joint deployment is expected to contribute to their adequate implementation and to optimize their impact, making valuable contributions towards a more sustainable mobility and transportation system, among the three different functional levels (city, FUA, TEN-T).

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