A Holistic Approach to SUMP Strategies and Actions in the Post-pandemic and Energy Crisis Era

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Abstract. Since its first appearance, the COVID-19 pandemic has disrupted urban mobility in cities. Governments around the world have tried to implement various actions to limit the spread of this virus. As a result, a significant amount of research on sustainable urban mobility has been published since 2020. The spread of the virus has led to changes in transport supply and demand, which is represented by policy makers and users. In fact, the literature reviewed is classified into two broad categories:

(i) User studies: analysis of modal choice before and after the pandemic.
(ii) Policy makers' studies: analysis of government actions to promote public transport (bus, train), soft mobility (cycling, walking) and micro-mobility (especially electric scooters) and rationalization of private car use.

Therefore, this manuscript analyses the relationship between urban mobility and COVID-19 through a holistic review of the literature published from 2020 until 2022. The main objective of the research aims at identifying new trends in research and recommendations in the field of sustainable urban mobility. While the COVID-19 pandemic represents an opportunity for governments to rethink the mobility system, this synthesis helps to clarify the vision of policy makers in developing post-pandemic urban mobility recovery plans and developing or updating Sustainable Urban Mobility Plans (SUMPs) in line with sustainable development goals and also taking into account the recent energy crisis.

Keywords: Sustainable mobility · SUMPs · COVID-19 pandemic · Energy crisis

1 Introduction

In general, an event such as a crisis causes disruptions that affect the functionality of infrastructure, services and travel patterns of citizens.

In the context of the COVID-19 pandemic, there is no direct impact on infrastructure, but rather on demand and mobility patterns.

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These events threaten the sustainability of urban mobility not only in the short term but also in the long term. Therefore, cities have accelerated their efforts to take emergency measures to rebuild and maintain urban mobility through the implementation of resilient and sustainable alternatives.

These alternatives are related both to transport infrastructure (roads, railways, ports and airports) but also to mobility services and energy and digital infrastructure.

Technological development can foster a country's resilience and contribute to the process of reducing greenhouse gas emissions and should always be correlated with political strategies aimed at aligning economic opportunities with minimising environmental impact. Digital technology, for example, can directly and indirectly contribute to reducing a significant share of overall emissions.

The current demographic trends and the agglomeration development have underlined the need for real adaptation, resilience and mitigation actions.

According to the UN 2030 Agenda and the G7 and G20 goals, a sustainable infrastructure system must respect individual characteristics, improve the lives of communities in economic and social terms, and enhance the landscapes concerned.

The Sustainable Development Goal (SDG) directly related to infrastructure is known as SDG 9; however, it is clear that the impacts go far beyond this and relate to gender issues (SDG 5), inequality reduction (SDG 10), sustainable cities (SDG 11), access to clean water and energy (SDGs 6 and 7) and responsible production and consumption (SDG 12).

Therefore, acting on infrastructure generates very strong impacts on the 2030 Agenda.

The energy crisis, exacerbated even more by the recent events of the war in Ukraine, has undoubtedly created a very strong shock on all fronts, especially energy. However, despite the drama of the moment, it is clear that there is a greater need to accelerate the European Green Deal. If completed as planned, it should reach net zero in 2050.

Achieving this goal, starting today with a strong commitment to increase renewable energy production, also goes in the direction of making Europe energy independent, thus also supporting the goal of overcoming the energy crisis.

Consequently, these short-term measures are triggering a sustainable transition that continues even after the end of the pandemic. Indeed, crisis management requires emergency actions by urban mobility planning represented by the Sustainable Urban Mobility Plan (SUMP) and long-term perspectives that align with the Sustainable Development Goals (SDGs).

1.1 The Evolution of Strategies Introduced by SUMPs in the Era of the COVID Pandemic and the Energy Crisis

The Sustainable Urban Mobility Plan (SUMP) is about improving the accessibility of urban areas and ensuring sustainable mobility and transport within the urban area and its periphery. Indeed, much research has been published since 2020 that describes, analyses and recommends various actions taken by public authorities in different regions of the world. These actions cover urban infrastructure design, new trends in urban mobility, and strategic planning for the SUMP. In order to plan resilient cities that are able to

maintain their functioning with the minimum amount of contamination, it is essential to prioritize post-COVID urban plans that are inclusive and low-carbon.

The main urban characteristics of the European cities most affected by the pandemic, namely Italy, Germany and the United Kingdom, were analysed by a study conducted by [1]. This study found the impacts resulting from urban connectivity by public transport. these impacts correlated with the speed of virus spread but also with population size, density and urban morphology.

Another research investigated the urban planning trends during the pandemic, considering the strategies for a better and sustainable transportation and the new development of urban parks. In fact, a new approach to resilient urban planning based on seven aspects is recommended, namely; density, inclusiveness, public spaces, public health system, movement of goods and people, migration of populations, tourism and travel. [2].

In addition, the situation related to the pandemic, highlights the importance of public space, green networks and soft mobility also supported by the Sustainable Development Goals. [3] analyses the results of integrating urban planning and projects through the design of public space along blue and green networks in the United Kingdom. The resulting model of cooperation is based on a responsible, inclusive and sustainable strategy for building and networking new resilient urban spaces, green infrastructure and new forms of sustainable mobility.

In the same context, the organization of space plays a decisive role in the orientation of people's behaviours. [4] Recommends that the planning of spaces where Parklets can be implemented should be included in the guidelines of urban planning strategies in Italy. A new initiative accelerated by the COVID-19 pandemic in the city of Rotterdam, Holland and initially concluded in the context of the local climate agreement and the study conducted by [5] describes the governance process for this city's transition. This transition is based on inclusive, zero-emission and shared mobility in 2030. Thus, local policies prioritize bicycling, walking, car sharing and public transport in line with urban mobility systems in developed countries based on integrated policies that include individual, private and public transport.

Obviously, the updating of the current SUMPs is strongly recommended in order to achieve sustainable and intelligent mobility. This objective is achieved through the active participation of citizens in the implementation of sustainable mobility actions.

A study by [6] showed the actions needed for a new post-pandemic vision of SUMP in Latin America and the Caribbean region. This study emphasised that the promotion of cycling requires the development of the necessary infrastructure in terms of bicycle lanes and parking.

Likewise, it is recommended that the necessary public spaces be developed to encourage walking. In addition, modes of transport are re-evaluated in terms of necessity and usability.

Similarly, a study conducted by [7] proposed developing walking and cycling paths and improving the connectivity of transit stations and car parks to contribute to the resilience of urban mobility in Turkey.

Finally, a study by [8] highlighted how the COVID-19 pandemic represents a window of opportunity for sustainable mobility in Germany and other jurisdictions. This study states that individuals can actively participate in the transformation towards sustainability

by changing their travel habits and lifestyle. Table 1 summarises the main SUMP-related contributions:

Table 1. Classification of contributions by aspect of SUMP

Infrastructure development	New trends in urban mobility	Strategic planning for SUMP
[1–6, 10]	[3, 5, 8]	[9–11]

Source: Authors elaboration

Since 2022, some literature studies have analysed the measures adopted in the various cities of the world due to the COVID-19 emergency in terms of urban mobility and assess which have been the most effective, verifying their effects both in the short and long term. In particular, it was conducted on some cities located in Europe and in North and South America, analysing and comparing the most effective measures adopted [12]. Due to the difficulties brought about by the COVID-19 pandemic, there is a need to provide road users with a range of appropriate services and infrastructure to discourage the use of private vehicles with combustion engines.

For some years now, several scientific works have focused on the problems and stresses of the contemporary city, mainly due to natural and health factors as well as climate change and the COVID19 pandemic [13–15]. Some work has integrated the aspect of health security into the SUMP in order to promote safer mobility by assessing accidents, risk perception, the location of possible vaccination hubs and generally taking into account health emergencies [9–16]. Therefore, the evolution of the strategies to be intruded in the next SUMP will have to identify factors and possible mitigation actions considering both the behavioural aspect of the transport demand subjected to the above-mentioned scenarios and to consider previous policy and planning actions in order to make further modifications and decisive choices. In this context, literature suggests that in many countries there is still a need to create or implement an adequate network of public charging infrastructure and to facilitate the establishment of private charging stations.

In particular, an analysis of some of the European Sustainable Urban Mobility Plans (SUMP) and the transport offerings related to several cities was recently carried out. The comparison revealed factors and criteria that allow for exemplification in the development and adaptation of the planning and design concept [17]. In addition to increased infrastructure and services, the deployment of intelligent transport systems (ITS) and info mobility systems is crucial. Research conducted by [18] laid the foundations for the definition of Key Performance Indicators (KPIs) to measure and monitor the impact of technologies on the development of smart cities and promote sustainable mobility approaches, addressing the urban planning and transport mobility issues of modern society. The Fig. 1 summarise the challenges and the results on short and long terms of the sustainable urban mobility planning.

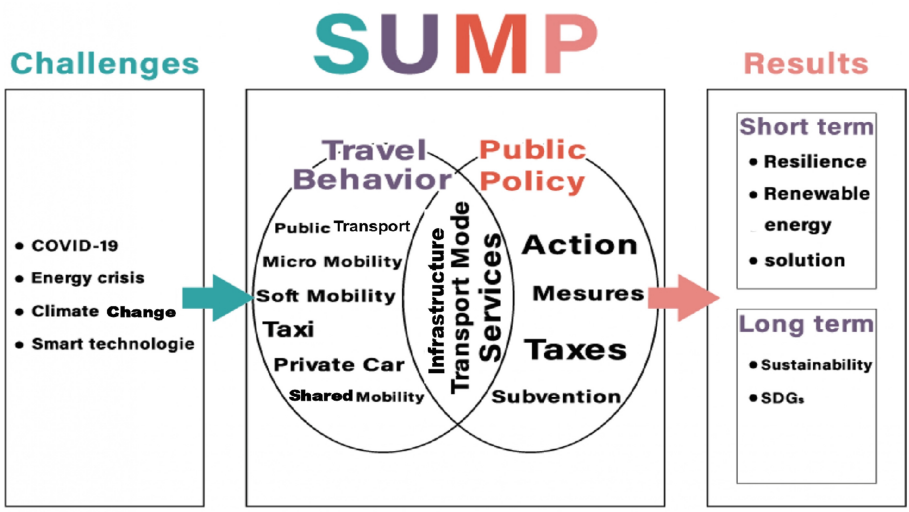

Fig. 1. Summary of challenges and results of SUMP. (Source: Authors elaboration)

With these events in mind, this paper aims to analyse the literature of the last two years with regard to transport demand and modal choices and compare the results with the actions implemented by planners and politicians.

The following paragraphs show summary tables comparing the literature and the discussion and conclusion paragraph suggests the criticalities and possible improvement actions and also the limitations of the research are underlined and the next research steps are announced.

2 Literature Review

This paragraph shows a comparison of literature acquired on google scholar considering the recent literature from 2020 until today and related to the two categories related respectively to the behaviour of the transport demand (users) and to the political choices implemented and actions promoted through the creation and evolution of planning tools such as SUMPs.

2.1 Mobility User Trends

With the intention of limiting the spread of the virus, cities around the world have instituted restrictive measures that vary from social distancing, telecommuting, distance education, travel barriers, and lockdown. This situation has caused a sense of fear and anxiety among citizens, which has resulted in a change in daily travel patterns [19]. Indeed, through the variation in travel demand and modal choice, users seek safe and healthy means of transportation [9].

For example, a high number of citizens have stopped commuting to work due to shifts to remote work and online education [20]. Also, leisure-related travel has been reduced

as meeting places such as restaurants and movie theatres are closed [21]. In contrast, travel for basic necessities has not seen a major change as these are vital trips for anyone exposed to shocks especially the COVID-19 pandemic [22]. Thus, the analysis of new travel patterns facilitates the updating of urban mobility policies [23]. At the end of the above, there is an interaction relationship between changes in travel patterns and public policies stimulated by the coronavirus pandemic. As evidenced by [24], before imposing restrictions on public transport, it is necessary to understand users' modal choice. In this respect, a large number of papers have been published from 2020 onwards analysing modal choice and intention to use transport means [25] in different regions of the world with the aim of helping public authorities to formulate new urban mobility policies.

Some work has been based on travel surveys, others on smart card systems and mobile travel data such as Google and Apple like described on Table 2:

Table 2. Summary of main finding from previous modal choice research

References	Main outcome	Data source	Country
[19]	Reduction of travel distance Low-income people are more likely to use public transport	L	South Korea
[21]	Reduction of bus and train use Increase of walking activities	S	Greece
[25]	Increase of the use of personal motorized vehicles Reduction in the use of public transport Reduction of national air transport	S	New Zealand-Australia
[26]	PT is the choice for long journeys Reduced use of carpooling services people without cars prefer to buy electric vehicles rather than cars	S	China
[22]	Reduction in leisure travel Modal choice depends on socio-economic status Increasing car use for long trips Decreasing carpooling rates Increasing feeling of fear of PT	S	China
[27]	Increased teleworking Increase in the use of shared mobility and active transport Lack of equity in public transport increase of car use	S	USA

(*continued*)

Table 2. (*continued*)

References	Main outcome	Data source	Country
[27]	The rate of car use was tripled Reduction of the emission rate linked to transport following the decline in the number of trips at the beginning of the pandemic	S	Canada
[23]	High perception of risk of contamination in PT Interactivity between behaviour change and public policy	S	Japan
[24]	Low-income users are more likely to use public transport Women are more likely to use public transport because authorities do not allow women to drive cars Car owners have not changed their travel habits	S	Pakistan
[29]	Reduction of non-essential travel Older people tend not to travel	S	India
[30]	Overall decrease in mobility for all commercial activities Increase in residence-to-park trips Decrease in traffic and accidents	L, G	Germany
[30]	Overall decrease in mobility except for residential mobility Reduction of traffic and accidents	L,G	Qatar
[31]	Walking and driving have not been affected by the pandemic The spread of the virus is linked to travel to the market and to work Restrictive measures are not effective enough	G, A	Turkey

Source: Authors elaboration
Notes: A = Apple mobility report; G = google mobility report; L = local agencies; S = survey

It is clear that there is a consensus on the new trend of using individual modes of transport at the expense of collective modes.

Indeed, there is a significant reduction in the use of buses and trains, which is related to the decrease in the need to travel and the fear of contamination in closed areas [32]. A study conducted by [33] finds that there is a decline in public transport use in Zagreb-Croatia, but it is less proportional than that recorded in other EU member countries.

In African cities, the crisis has significantly affected the mobility of people. While changes in mobility differ among governments, the number of public transport trips made in African cities declined by an average of 40% in April 2020 compared to the

pre-COVID-19 period. In contrast, low-income users, who are more likely to use public transport [19], have not changed their travel patterns [34], because their mode choices are limited [23].

Hence the need to develop a transport system that is equitable, inclusive, and reduces disparities in accessibility among residents of a region regardless of socioeconomic background, that encourages citizens to regain confidence in public transport [21], and that helps promote sustainable development [27].

In this sense, society is becoming increasingly dependent on the car in the post-pandemic phase given the personal sense of safety and non-contact that the car provides [27]. However, [26] states that the purchase intention of two-wheeled electric vehicles is higher than that of automobiles.

However, it is still dependent on the development of smart infrastructure and charging stations in China.

In addition, there is a trend of walking and biking as non-contact modes of travel. [35, 36] study the trend of shared bike usage during the coronavirus period.

Thus, this alternative mode of transportation reduces the fear of contamination that is likely to occur in crowded public transportation. It also preserves health, social distancing, reduces polluting emissions and traffic congestion.

Therefore, the shift towards active transport promotes modal transition in the long term [37]. It is clear that bicycle sharing requires less investment in infrastructure development and capital than public transport [38]. In this respect, this situation represents opportunity for public authorities to reformulate their strategies for sustainable and resilient urban mobility planning.

In addition, the evolution of micromobility, including the supply of electric scooters, has been a kind of alternative to public transport for short trips in urban areas.

These new intelligent modes of travel have also been supported by government measures. In order to analyse the effectiveness of e-scooters even in the post-pandemic phase [39] studies the diffusion of electric scooters in Italian cities and proposes to elaborate a GIS containing the origins and destinations as well as the areas of implementation of shared e-scooter systems in order to promote its use at the community level.

2.2 Public Policy Aspects

Policies put in place in response to the COVID-19 crisis help promote the use of public transport, encourage the deployment of low-carbon transport modes, promote walking and cycling where possible, and limit the use of private motorized cars.

Table 3. Summary of main research on shifts in travel patterns in responding to new public policy measures

Public transport (bus, train, metro)	Soft mobility (cycling, walking)	Micro mobility (e-scooter)	Private car
[7, 32, 33, 40–42] [43–53]	[20, 35–38, 54–59, 69]	[39, 60–68, 70]	[25, 26, 28, 70]

Source: Authors elaboration

The Table 3 summarizes key research on changing travel patterns in response to new government measures during the pandemic.

These policies must be consistent with the Sustainable Development Goals as they relate to long-term climate change reduction.

Similarly, these actions must interact with changes in user behaviour during the pandemic. It is obvious that these measures differ according to the objectives and urban characteristics of the region of implementation. As evidenced by the COVID Mobility Works platform, which is dedicated to collecting, synthesizing and sharing mobility initiatives that facilitated citizens' travel during the pandemic. The Table 4 shows examples of various actions carried out by different regions.

Table 4. Example of public policies for urban mobility implemented during the COVID pandemic 19 [71]

Purpose	Action	Cities
Public health	17 km walkway implemented	Mexico city-Mexico
	Active and family street	Quebec-Montreal Canada
Equity	CARTA allows rides to use expired passes	South Caroline-USA
	TriMet opens virtual application for low-income fare program	Oregon Portland-USA
Safety	Adds 150 km of bicycle lanes	Rome-Italy
	Temporary transformation of car lane into space for bicycles	Utrecht-Netherlands
Public engagement	Collaborative services to smooth demand at peak hours	Ile de France
Moving people	Launches app to show passengers bus occupancy levels	Catalonia-Spain
	Free use of bicycles through the bike citizens app	Stuttgant-Germany

In addition, the World Bank Transport Group recommends improving governance, financing and capacity building, supporting non-motorised and active modes, improving the existing public transport system, and supporting modal shift from private vehicles to high-capacity transport systems in Africa. [72]. The increase in the price of fuel affects everyone and not just those who use a private vehicle with a combustion engine. It is enough to consider the "last mile" to understand why: the goods arrive in the places where we buy them by trucks and vans, to get them moving, fuel is needed, they often have to travel long distances and all this partly affects those who carry them, partly about who sells them and, above all, about who buys them. Those who suffer the greatest burden of this mechanism are the less well-off classes. When the fuel increases, it always ends up like this: the worst damage is always suffered by those who have no room to make ends meet. hence the need to rethink the entire supply chain by integrating the Block Chain

in order to reduce the total cost and improve the quality of services. Some states have reduced excise duties on fuels (such as Italy).

Others are considering different energy sources and implementing measures that may discourage the use of cars by using bikes, skates and scooters instead As in Tunisia, which has reduced subsidies for petroleum products and increased car taxes in order to limit the use of private vehicles.

3 Discussion and Conclusions

In this context, when defining the incentive measures to be adopted, a fair balance should be sought between subsidy or tax relief policies and fiscal policies (taxes or permits) in order to keep the public budget constraint as balanced as possible. Some examples of measures to decarbonise transport and mobility can be related to:

- the differentiation of tariffs of managed services (airports, motorways, railways) on the basis of vehicle emissions and tax recovery on the same basis;
- the strengthening of Green Public Procurement to use rewarding or disincentive criteria in public (procurement code) and private tenders;
- incentives for urban public transport vs. private transport as mobility in cities and penalties for car use (eco pass style or road pricing).

In conclusion, this study established that a holistic approach is needed in research and publications related to understanding the factors and strategies driving the evolution of sustainable mobility considering the recent criticalities produced by the COVID19 pandemic and the growing energy crisis.

Our systematic review and analysis of the literature of the last two years highlighted that the covid-19 pandemic has led to changes in travel choices and perceptions of transport use. Trends in walking, cycling and private car use are expressed by feelings of fear of contamination on congested public transport. In order to limit car dependency, promote active mobility and significantly reduce GHG emissions, cities are being asked to rethink urban planning through the design of "15-min cities". This type of planning represents an effective solution to reduce congestion, ensure equity of access to services and strengthen the attractiveness and sense of belonging to cities. In this regard, public policymakers must take advantage of changing modal choices to promote intermodality and shared mobility by integrating new service modes such as MAAS to make it easier for citizens to move around and to make mobility more sustainable and economical. Similarly, urban mobility planning strategies should prioritize the provision of bicycle lanes and pedestrian sidewalks.

Thus, public authorities are called to invest more in transport strategies centred on intelligent transport systems (IT), new Internet of Things (IOT) technologies and technologies based on artificial intelligence (AI) in order to promote the concept of smart cities. In this same context, to face the dependence on fossil fuels accelerated by the energy crisis that emerged from the war in Ukraine, the strategies must include renewable alternatives accompanied by the implementation of new charging stations.

These new strategies promote planning for urban mobility that is sustainable in the face of climate change and resilient to disruption.

In the end, the success of sustainable and smart cities depends on the interaction between transport demand and supply in close connection with energy and smart technology developments. Therefore, future research must not only define actions to mitigate impacts but also maximise these correlations in order to generate sustainable and more resilient actions and strategies.

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