# The future urban road: A systematic literature review-enhanced Q-method study with experts.

Stefanos Tsigdinos, Panagiotis G. Tzouras, Efthimios Bakogiannis, Konstantinos Kepaptsoglou and Alexandros Nikitas

## Abstract

In an era of complexity and rapid technological advances, urban roads may need to transform. The aim of this research is to identify, contextualize and prioritize the concepts underpinning the fundamental dimensions of the urban road of the future. We used a combinatorial approach incorporating a Systematic Literature Review (SLR) to a Q method. SLR helped us identify and organise the transforming concepts into five categories, namely: efficiency, safety, liveability, accessibility, and smartness. Through a Q-method, 50 transport experts "described" the urban road of the future. The results revealed 28 transforming concepts that may be its key ingredients. Four main factors emerged allowing the classification of our experts into four group of thinkers, namely: People-first techno-centrists, AV-scepticists, Unconventionalists and Infrastructurists. The main dilemmas arising for future research are: a) prioritisation of modes: human first or not? b) share or segregate and c) design systems or roads?

**Keywords:** urban road; systematic literature review; Q-method; future mobility; transport futures

## 1 Introduction

Urban roads are considered as the backbone of urban public space and cities in general (von Schönfeld & Bertolini, 2017). There are various driving forces that tend to reshape them and modify the structure of urban road networks (Loorbach & Shiroyama, 2016). Over the years, mobility cultures and citizens' needs, in particular, influenced the form and the characteristics of urban streets (Nikitas et al., 2017).

Since there is no consensus on what the ideal scenario is for urban road design, transport and urban planners dealt with urban streets in a discontinuous manner, leading to a fragmented planning approach. More specifically, by considering mobility demand as something constant, transport planners attempted to provide enough space to motorized traffic intending to increase the road capacity and the efficiency of the road network (Tumlin, 2012). Whereas urban planners tried to add some different perspectives in the planning process by taking into account the density, the distribution of land uses, the space availability and the qualitative characteristics of each city (Sheller & Urry, 2016). More recently, the sustainable mobility paradigm tried to combine these different planning philosophies (Holden et al., 2020) advocating that the efficiency of the urban road network and the quality of the urban street environment can be simultaneously improved (Brůhová Foltýnová et al., 2020).

Another critical issue in the debates for the urban road of the future is traffic safety. Conventional approaches such as 30 km/h speed limits or traffic calming zones around school facilities have been proposed by planners for accident prevention purposes (Domenichini et al., 2018). Other innovative road design concepts deriving by the study of the drivers' behavior and workload propose the segregation of traffic flows as an efficient measure to address traffic safety problems by creating multimodal corridors (Tsigdinos et al., 2020) or the use of 'shared space', where all road users are encouraged to legally occupy and share the same street space (Tzouras et al., 2021).

In the era of technological advance, new transport modes such as autonomous vehicles (AVs) and Mobility-as-a-Service (MaaS) are coming to our cities. Some cities have already deployed very early shared autonomous vehicle (SAV) schemes in piloting phases (Iclodean et al., 2020), aiming to identify their potential while others are testing MaaS-like systems still in embryonic forms (Alyavina et al., 2020; Nikitas et al., 2020). In this context, there is an ongoing debate about the possible impacts on the road network caused by a high penetration rate of AI-based mobility (Milakis et al., 2018a). This new condition will raise questions about the configuration and the allocation of the urban road, whether these modes shall be given a central or supplementary role.

Unexpected disruptive events such as pandemics or extreme climate conditions will also affect the “identity” of the urban road of the future. For instance, the Covid-19 pandemic created unprecedented uncertainty and disruption for transport systems challenging the established planning wisdom (Nikitas et al., 2021; Nurse & Dunning, 2020). Yet, it brought out a new notion called “social distancing” that may reshape the form and the role of urban roads considerably (Katrakazas et al., 2020).

For these reasons, it is now important to rethink the urban road network of the future with the aim of creating urban environments that are sustainable and liveable, even in pandemic conditions (Sharifi & Khavarian-Garmsir, 2020). Bearing upon the ever-growing complexity of our cities and an emerging focus on sustainability, urban road infrastructure may possibly undergo serious transformations (Lyons & Davidson, 2016). For this reason, this paper will examine the form of the future urban road through a broad and interdisciplinary perspective, in order to provide the theoretical rationale for implementing measures, cultivating proper circumstances and tackling possible negative impacts. Cross-disciplinary approaches could enhance cooperation and resolve the contradictions among different perspectives, demonstrating directions for the urban road of the future. Over the past decades, admirable progress has been made towards the examination of the interactions between land uses and transport systems (Miller et al., 2011). However, there is still no existent study which attempts to consider and critically examine all the potential approaches aspiring to ‘configure’ the urban road of the future.

The aim of our study is twin. Firstly, it intends to identify through a systematic literature review the main transforming concepts by focusing on five different approaches (i.e. groups of concepts), namely: concepts aiming to improve efficiency, road safety, accessibility, liveability as well as concepts aiming to make roads smarter. The next step of this study is to bring the identified concepts into discussion to explore the views existing among experts from different

European countries. Therefore, we attempt to identify the dimensions and underpinning dilemmas of the future urban road through a multidisciplinary synthesis of ideas that is achieved through the use of a Q-method framework.

The paper is structured as follows: in Section 2, the research methodology is described, while in Section 3, the systematic literature review findings are presented. In Section 4, the leading perspectives are identified through an expert-based Q-method experiment. The qualitative and quantitative outputs from both perspectives are discussed in Section 5 to define dilemmas for further research. The last section draws a conclusion to the paper.

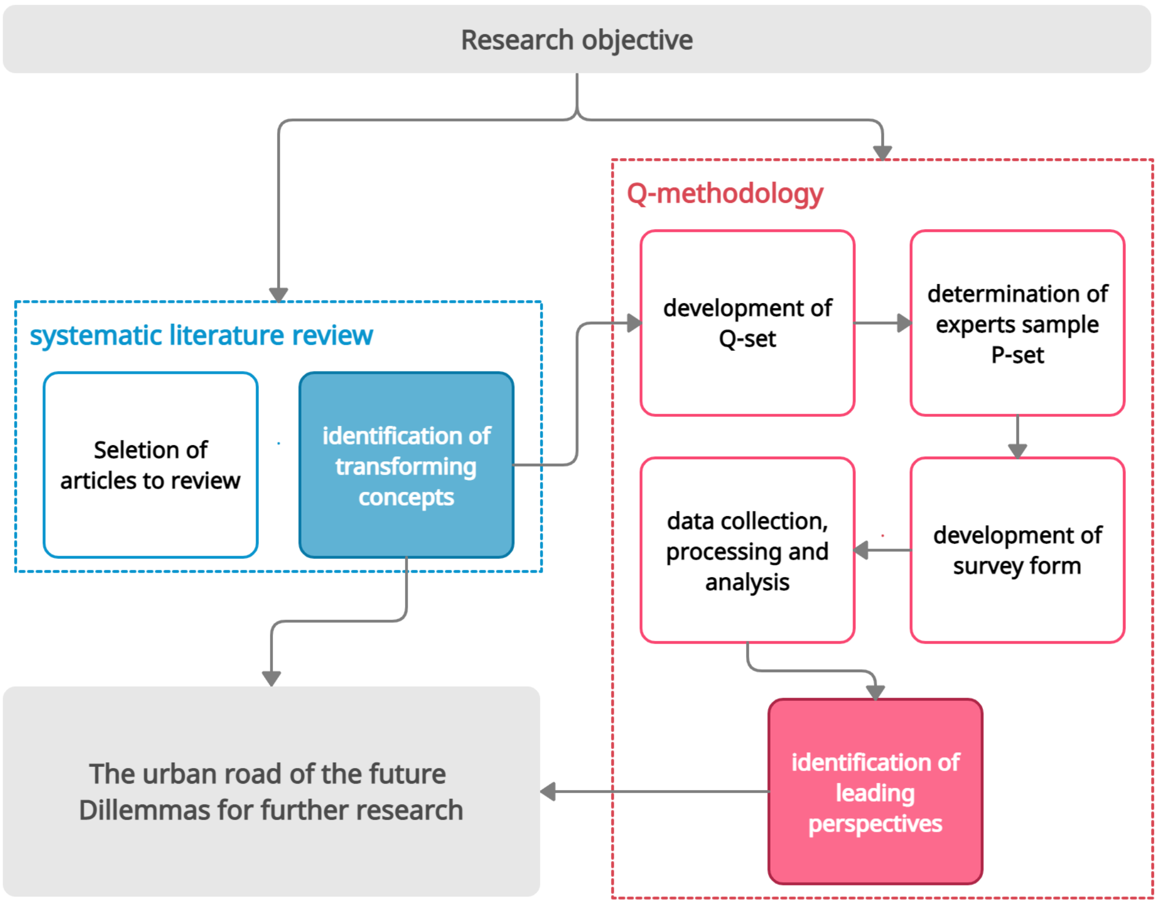

Figure 1: Methodological flow chart

## 2 Research Methodology

First, a systematic literature review identifies the underpinning dimensions of the phenomenon investigated and the elements that need to be tested via primary data analysis. An elite-survey (i.e., a survey answered by subject experts) employing the powerful Q-method was the primary approach taken. **Figure 1** illustrates the methodological framework of the work. This mixed method sequential methodological procedure ensures the delivery of more holistic, reliable and valid results.

### 2.1 Systematic literature review

Systematic literature review (SLR) is a powerful technique in social science research, which is about systematically locating, evaluating and synthesizing all available information to an effect or a topic area (Davis et al., 2014; Rowley & Slack, 2004). In contrast to a traditional or narrative literature review, a SLR complies to a set of principles intending to limit possible biases in the sample of studies (Booth et al., 2016; Dekker & Bekkers, 2015). SLR synthesizes research findings to show evidence on a meta-level (Snyder, 2019) and thus is considered sufficient for building a discrete theoretical background contextualising the key concepts that may determine the configuration of the urban road of the future.

Our SLR adopts a three-step procedure conforming to the methodological approach used by Bask and Rajahonka (2017), Yigitcanlar et al. (2020) and Oliveira et al. (2017). Initially, step 1 is the Planning stage which contains the objectives and a review protocol for the systematic review and also defines the sources and procedures for literature searches. Next, step 2 deals with the conduction of the review process through implementing the defined (inclusion/exclusion) criteria. Last, step 3 involves the identification of concepts via an objective centric results synthesis.

First, a research plan involving the research aim and questions, keywords and a set of inclusion and exclusion criteria was delineated (Yigitcanlar et al., 2019). The research aim was to identify the transforming concepts and leading perspectives related to the urban road of the future. Hence, a great variety of keywords was assembled. Namely, group 1 displaying technology and traffic management includes the following keywords: "traffic management", "urban road network", "autonomous vehicles", "electric vehicles", "smart cities" and "smart mobility". Next, group 2 “Sustainability and urban planning”, contains the following ones: "urban planning", "public health", "quality of life", "sustainability" and "urban environment". The third group portraying Traffic safety, road design and behaviour issues, includes the subsequent keywords: "traffic safety", "mixed traffic", "drivers' behaviour", "road design", "traffic calming", "vulnerable road users", "shared space". The fourth and final group on “transport geography and accessibility” uses the following keywords: "public transport", "transport geography", "parking", "accessibility", "sustainable mobility", "public space", "social welfare", "social interactions", "social equity", "shared mobility" and "network hierarchy". The list of keywords is broad because of the holistic character of the research. They are accompanied by the phrase “urban road” which connects the main research objective with the SLR process, narrowing down the potential numbers of papers examined.

The inclusion criteria were defined as academic journal papers written in English that are in line to our research objectives. Furthermore, the papers examined were published after 2010, since the urban road of the future is a complex matter that changes dynamically and rapidly; prior papers were deemed ‘too old’ to be part of a body of literature underpinning a ‘future road’ narrative. “Grey literature” and conference proceedings, books, technical reports, etc. were excluded from the corpus, ensuring the quality of the existing papers (Lagorio et al., 2016). The search was conducted using Scopus.

In step 2, the keyword-based search was undertaken in January 2021 and lasted a month. Initially, the search returned a total of 3223 articles including journal articles and conference proceedings in all possible languages found in Scopus. Next, on the basis of extracting only papers written in English, we limited the number of papers to 2849. The search for journal papers written between 2010-2021, returned 1148 papers; these passed a title and abstract screening and were ‘eye-balled’ consistency and precision of the keyword search (Yigitcanlar et al., 2010). The papers with abstracts that were found relevant were only 94. The full-text of these initially screened articles were then read against the research aim. This led to a review pool consisting of 38 articles, that were re-read, reviewed, categorised and analysed. This literature selection procedure is illustrated via a PRISMA diagram (see **Figure 2**) that ensures transparent and complete reporting of the SLR process (Liberati et al., 2009).

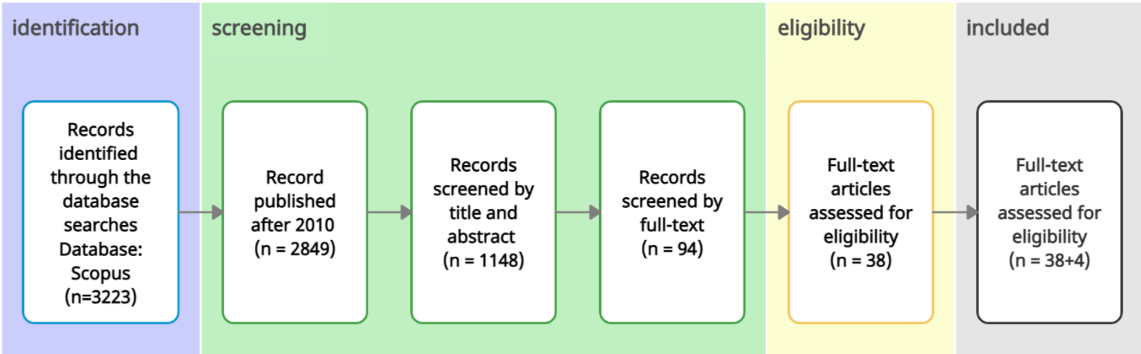


Figure 2: PRISMA workflow and number of collected papers in each step

In step 3 (reporting and concepts identification), the work focused on writing up and presenting our findings identifying the transforming concepts related to the urban road of the future. Particularly, we underwent a synthesis process, highlighting and combining different elements to formulate the concept in question. At this stage, other publications on the topic conducted by the authors were also integrated as additional supporting literature evidence to better comprehend the issue and elaborate better results. The total number of reviewed references was 42.

## 2.2 Q-method theory and background

Predicting the defining elements of the urban road of the future is a complex task that should synthesize the different views of a diverse sample of planning experts from governments and local authorities, academia, business, practice and industry. Q-method was selected as a well-established research method appropriate for elite survey purposes that combines qualitative and quantitative features. Q-method is *"a qualitative analysis assessing subjective opinions that employs the quantitative approach of a factor analysis of statements ranked by* *respondents"* (Kougias et al., 2020). Q-method builds on a relatively small sample an approach that produces reliable results that offer both breadth and depth (Wolbertus et al., 2020).

Apparently, Q-method is a fitting technique that can support and improve understanding of the diversity and plethora subjective opinions regarding a specific subject (Milakis et al., 2018b). Normally, the Q-method is not a tool designed for reaching consensus; on the contrary it is suited for stimulating heterogeneity in opinions on subjects on which a more or less mature developed debate has evolved (Watts & Stenner, 2005). This is due to its inherent feature that forces respondents to choose or/and prioritise between the opinions, they agree or disagree the most (Wolbertus et al., 2020). According to Zabala et al. (2018), the Q-method is an efficient method to address conflicts, concerns and to even identify unexpected attitudes about future directions. A difference encountered between Q and other qualitative *methods "is the ability to mitigate response biases as respondents are particularly engaged with pre-defined opinions"* (Kougias et al., 2020; Zabala et al., 2018) *"and the analysis is not affected by dominance effects"* (Kougias et al., 2020; Mukherjee et al., 2015). However, *"the Q-method proves to be less flexible for interpretation compared to more typical qualitative research methods"* (Kougias et al., 2020). Questionnaires, a possible alternative to our approach, require significantly bigger samples to yield reliable results; therefore, they do not serve the scope of a work, where the expertise parameter shrunk the pool of potential respondents significantly.

According to Davies and Hodge (2006), *"the Q-method follows pre-set steps initiating with defining a concourse that requires outlining the full range of ideas, opinions, values, preferences and knowledge, either written or spoken"*. Particularly, the Q-method works with a set of statements (Q sample) describing a certain topic. Within this framework, participants (P set) of a Q study are chosen and invited to participate in a set of these statements. They are asked to evaluate a heterogeneous set of statements in terms of agreement or disagreement (from -3 to +3) (Kougias et al., 2020). According to Brůhová Foltýnová et al (2020), *"each* *participant develops an individually sorted ranking of statements i.e. Q sort. Q sorts are statistically analysed to identify similarities in viewpoints and to obtain key shared viewpoints on the study subject, i.e. factors".* The Q-method steps are also illustrated in **Figure 1**.

# 3 Transforming Concepts

By studying the **42** selected papers (see **Figure 2**), we identified the key transforming concepts defining the dimensions of the urban road of the future that are related to 1) efficiency, 2) road safety, 3) accessibility, 4) liveability and 5) new technologies.

## 3.1 Concepts aiming to improve efficiency

The first group of concepts refers to those that aim to minimize the travel time by recommending measures that will change the balance between demand and supply. One of these concepts is the **Road Pricing**. According to Rentziou et al. (2011), road pricing schemes are an effective measure to reduce demand and therefore to decrease emissions, noise, and congestion in specific urban roads. It is also a way to promote public transportation, while municipalities raising their funds for new construction projects in the road network. Rotaris et al. (2010) have proved that in Milan, road pricing schemes can correctly consider as welfare-increasing policy, as the social benefits by implementing experimental road pricing measures overcame the costs.

Yet, the political cost seems to remain considerable due to the low social acceptance of road pricing schemes. In general car users accessing the road pricing area are less likely to accept these schemes while public transport users may be more in favour of them; acceptability is a subjective notion that differs among social groups and it may reflect inequality or extra cost considerations (Rentziou et al., 2011). Zheng et al. (2012) performed an agent-based simulation to predict the impacts of road pricing schemes and found that these have a stronger impact on non-work activities, since some agents choose to change their travel plans to avoid tolls but in general congestion problems were mitigated.

An alternative approach refers to the reallocation of the road space in order to increase the efficiency of public transport services that results in lower demand for car trips. Zheng and Gerolimnis (2013) have examined **Dynamic Road Space Allocation** in multimodal congested networks using optimization techniques. They attempted to minimize the efficiency of a multimodal transport system by making various spatiotemporal decisions, so that the available road space could not be wasted. One of their main findings was that the dynamic allocation strategy utilizes the bus lane space better during the off-peak hours, while during peak hours it serves a higher number of passengers (Zhang et al., 2018; Zheng & Geroliminis, 2013). The surface public transport network consists of **Bus Priority Lanes**, which refer to a broader range of road layout strategies and traffic management solutions (Gitelman et al., 2020). The main objective is to eliminate traffic interferences that slow down transit service and make it less efficient reliable (Novotný et al., 2016). According to Hadas and Nahum (2016), public transport road infrastructure is classified into 4 categories: mixed traffic, semi-exclusive, exclusion and grade separated.

The enchantment of multimodality in urban arterials and collectors has been discussed in a recent study of Tsigdinos et al. (2020). They introduce a new concept called **Multimodal Corridors**. According to this study, *"Multimodal Corridors are major transport facilities which accommodate automobile, bus, bicycle and pedestrian travel"*. These roads aim not only to improve the system efficiency by promoting multimodal mobility but also to provide an appropriate accessibility level for all road users (pedestrians, disabled people, elderly, children etc.) and therefore to enhance transport equity in many different metropolitan areas. A different approach is the one presented in the study of Biswas et al. (2020) who argued the introduction of **Divided Arterials**. According to their study, pedestrian movements and crossing and on-street parking manoeuvres cause capacity drop and consequently they downgrade the efficiency of the transport system. These complicated interactions are called side-frictions. Salini and

Ashalatha (2020) suggested that road designers should give special care to eliminate side-frictions as much as possible. In their study, bus stops are considered as a major side-friction, which can be faced by installing bus bays instead of curb-side stops. They recommend the construction of parking facilities to eliminate on-street parking and the segregation of pedestrian flows from motorized traffic by providing more dedicated space.

The concept of **Crosswalk Anywhere** contradicts the previously mentioned views. Indeed, it refers to a situation, where any part of the road could be considered as a crosswalk (Knoop & Daganzo, 2018). This situation could be the best both for cars and pedestrians in terms of travel delays, since in crowded urban areas, the capacity of a road section is not influenced by the total amount of pedestrian crossings, but by the flow of pedestrians per crosswalk. This Crosswalk Anywhere concept has many similarities with the **Shared Space** concept that *"refers to urban road space part of which all road users (including pedestrians, cyclists, vehicles and disabled people) are encouraged to legally occupy with little physical or visual separation"* (Karndacharuk et al., 2014; Tzouras et al., 2021). The study of Kaparias and Wang (2020) observed that shared space improves the level of service not only for pedestrians but also for vehicle traffic in some locations.

## 3.2 Concepts aiming to improve road safety

**Shared Space** also intends to create safer road environments by adding more danger. According to Hammond and Musselwhite (2013), *"shared space is based on the risk homeostasis theory, where humans shift the balance of risk according to their environment"*. Yet, in the end, this complex reality results in modifications of the behaviour both of car users and VRUs. Previous studies that collected both qualitative and quantitative data (e.g. trajectories, interviews, responses from a survey) observed that VRUs are noticeably avoiding the mixed traffic areas following traditional footways (Karndacharuk et al., 2014). Some experts think that the main assumption of shared is totally based on the "law of the jungle", and it is not sure that vulnerable social groups (e.g. elderly, children and people with special needs) have the capability to cope with all these complex interactions (Oxley et al., 2010). According to Kaparias et al (2014), *"shared space is an umbrella term that relates to a range of streetscape interventions aiming at creating a more pedestrian-friendly environment by removing the physical separations of traffic flow"*.

Yet, there are studies that consider shared space as one of the **Traffic Calming Measures**, which aim to reduce crashes with fatalities or serious injuries in urban roads (Yannis et al., 2014). Other measures with the same aim are speed humps, roundabouts, curb extensions, chicanes, raised intersections, median barriers or islands etc. Furthermore, some studies strongly connect this term with lower speed limits in particular urban areas, e.g. 30 km/h or even 15 km/h (Colonna et al., 2019). Gargoum et al. (2016) attempted to define factors related to the urban road environment that affect the driver compliance in order to set **Credible Speed Limits**. According to their research, *"the presence of median or physical separation encourages speeding and therefore increases the probability of speed limit violation"* (Gargoum et al., 2016). The low compliance rates appear mainly in collectors compared to arterial roads.

Surely, the existence of many different features in a collector road (i.e. on-street parking, median islands, bus stops, pedestrian crossing) create an inconsistent road design. **Design Consistency** as a concept aims to define operational and geometric features that are consistent with the functionality of each road segment (Colonna et al., 2019). Mono-functionality can be considered as a necessary pre-condition to develop consistent road designs with homogenous traffic speeds (Demasi et al., 2018), as multifactional roads leads to incorrect expectations and inappropriate driving behavior (Charlton et al., 2010). The last study examined the relationship between road features and drivers' expectation with the aim of creating **Self-Explaining Roads**. According to this approach, the road designer should evoke correct expectation and driving behaviour. Compared to design consistency concept, it focuses more on drivers' perceptions that in the end determine traffic speeds and behaviour than design. Nevertheless, human errors are meant to happen especially in the (complex) urban road environments. **Forgiving Roads** refers to *"designs that are resilient with respect to human errors"* (O'Hern et al., 2019). The concept attempts to minimize to zero the probability of fatal accidents (Oxley et al., 2010).

### 3.3 Concepts aiming to improve accessibility

Urban road environments are not solely destined for drivers and passengers of motor vehicles, but for other users as well. Substantial attention should be given to vulnerable road users, i.e. pedestrians, cyclists and people with disabilities, older people, children etc. Therefore, an acceptable and at the same time **Human-Oriented Road Environment** should include the proper infrastructure sustaining their needs (Villegas Flores et al., 2021). Hereby, segregated **Cycling Infrastructure** (cycling lanes or cycling tracks), **Walking Infrastructure** like sidewalks (wide and in good condition) and pedestrianized zones, as well as infrastructure destined for facilitating disabled people movement (e.g. curb ramps, tactile paving) are essential (Macmillan et al., 2014; Oxley et al., 2010), thus forming altogether an important principle of the urban road.

Place making comprises an important element of the urban roads of the future. According to Karndacharuk et al (2014), this concept suggests that urban streets *"shall provide better use of public space through a lively quality of the environment that attracts users to spend time within this place and is also reflected in a wider range of street activities"*. Two other complementary concepts, supporting the creation of a sense of place, and similar to each other in terms of speed management, are a) **Home Zones** and b) **Traffic Calming**. Lower speeds for cars support the needs of pedestrians, cyclists and micromobility users. Home zones aim to balance the needs of residents and vehicular traffic (Curl et al., 2015). In this framework, the transformation of typical residential roads into low-speed streets is suggested.

Another great concept intimately associated with the aforementioned concepts, incorporating the reconfiguration of road space, is the creation of **Superblocks**. According to Lopez et al. (2020), "*the Superblock concept can be perceived as a new model of mobility that restructures the existing urban road network; they are made up of a grid of main roads forming a polygon, with both interior and exterior components*". This tool could be supporting accessibility of pedestrians and cyclists. This is due to the potential of these models to permit in the inner street network solely "access traffic" (i.e., trips whose origins or destinations are located in the neighbourhood), while, "cut-through traffic" (i.e., car trips whose origins and destinations are both located outside the neighbourhood) is discouraged (Soret et al., 2011).

### 3.4 Concepts aiming to improve liveability

There are many concepts able to enhance liveability conditions. A characteristic feature augmenting road space is **Roadside Vegetation** that comprises *"all types of cultivated or wild-grown plant assemblages growing in road verges, medians, swales, tree pits or paving joints"* (Säumel et al., 2016). The role of roadside vegetation is essential since it contributes to mitigating environmental pressures in urban roads and also shapes conditions favourable to road users, especially pedestrians or cyclists (Li, 2012).

Liveability is firmly related to human activities and human behaviour in general (McAndrews & Marshall, 2018). In this context, two significant human activities associated with urban roads are in structured, namely: **Vitality and Diversity**. On the one hand, the concept of vitality refers *"generally to the extent to which a place feels alive or lively and can be gauged by measuring pedestrian flows and movements"* (Aral & Demirbaş, 2015). On the other hand, the notion of diversity relates to the variety of different activities happening in urban streets.

The notion of **Urban Roads as Public Space** could be one pioneering perspective that can change the way the roads function today. According to Aral and Demirbas (2015), *"the* *public character of space emerges according to particular conditions like diversification and exchange".* Specifically, it is found to evolve through the capability of spaces to bring together people from various social groups who can freely express themselves (Aral & Demirbaş, 2015; Karndacharuk et al., 2014). Herewith, spaces of vehicular and pedestrian flow could be portrayed as the most important public spaces of a city, in other words, they are its "most vital organs (Aral & Demirbaş, 2015; Vitale Brovarone et al., 2021). In general, urban roads can be considered as the means to observe and understand the city (Tsigdinos & Vlastos, 2020).

Urban culture is akin to the urban morphology and the street layout as well as the public behaviour. It can also constitute "the soul of the city" (Li, 2012). Various activities taking place in the urban streets or land uses encountered there, disclose a very meaningful cultural perspective. Therefore, according to McAndrews & Marshall (2018), *urban roads (even arterials) can be* **Cultural Assets** *and* **Social Places** *in addition to playing roles as travel corridors.*

### 3.5 Concepts aiming to make the road technologically smarter

The introduction of AVs will change the urban road environment. An expected change is the installation of **Vehicle-to-Infrastructure (V2I)** communication systems, such as smart traffic lights and signs, 5G band, HD maps etc (Vitale Brovarone et al., 2021). These systems would be future transport policy tools that will govern in real-time the circulation of AVs resulting in smoother traffic flows. For example, they propose the creation of superblocks in modern cities, where the traffic speed of AVs will be controlled by V2V connection systems ensuring safe interactions between vehicles and VRUs. **Vehicle-to-Vehicle (V2V)** communication is recommended as a solution to mitigate congestion problems by improving route planning and ensuring smaller headways (Szele & Kisgyorgy, 2018). V2V will be able to cope with complex vehicles' interactions appearing in intersections nowadays with the aim of minimizing traffic delays. If so, road signs and traffic rules will not be necessary in the future urban roads. Hence, it is expected that the focus of researchers and designers will be turned from the urban road design to the designs of smart systems.

However, the development of driverless vehicles that are capable to operate in mixed traffic environments still seems like an utopia. A future scenario of an AV urban road network that consists of **Fully Segregated AV Corridors** seems to be a more feasible solution considering the already developed systems and potentials. According to Parkin et al. (2018), in this scenario, AVs are completely separated from other road users and they operate within their own system. An alternative idea is the use of AVs only in a constrained subset of roads mainly referring to high-speed and high-volume roads with various traffic management systems (e.g. motorways, ring roads etc.). The introduction of AVs in conventional urban roads or shared space falls on many ethical dilemmas related to the complicated nature of human behaviour.

Stead et al. (2019) thinks that automation will transform the urban road environment if **Shared Autonomous Vehicles (SAVs)** dominate over private ones. The increased use of shared mobility services that will be on-demand and door-to-door will result in lower car-ownership. *"This means a considerable reduction in the land consumption for parking spaces"*, according to Stead et al. (2019). The remaining road space can be utilized to promote more attractive public spaces for people, where they can socialize, live, work and play (Stead & Vaddadi, 2019). Yet, it has to be acknowledged that a considerable amount of road space will be needed for picking and dropping off passengers. Furthermore, the same study argues that due to the upgraded capabilities of AVs compared to the conventional ones, traffic lanes in cities can become narrower, while at the same time, some of the existing transport-related hardware (e.g. safety barriers, traffic signals) can be fully removed.

Car automation may need some years of research, so that they can be functional in urban roads; yet electric mobility has already arrived and may transform urban roads. There are stakeholders that consider the installation of **Electric Vehicles' Charging Stations (EVCSs)** as a new parking policy tool, while others are not of favour of mixing these two policies (Karolemeas et al., 2021). EVCSs provide vehicle-to-grid (V2G) charging in plug-in electric vehicles. According to the last study, policy makers are willing to invite EVs in city centres by establishing on-street EVCSs near points of city attractions. On the contrary, planners think that this policy is inappropriate since it results to congestion of electric vehicles (EVs). Van Wee et al. (2012) think that the introduction of EV privileges in central urban areas are useful in the short term, but in the long term, limitations in parking and driving an EV should be established for reasons of liveability and efficient use of road space. According to them, electric mobility infrastructure refers to corridors and parking facilities exclusively destined to electric vehicles.

To improve the driving range of EVs, some previous studies have proposed the installation of equipment that will support **Dynamic Wireless Charging** of vehicles. This will result in additional slow-speed lanes in urban arterials or highways that will allow suitable charging (García-Vázquez et al., 2017). Another transforming concept that is related to electric mobility is the **Photovoltaic Road**. This involves replacing the city road materials with solar panels - a renewable source of energy (Liu et al., 2019). In the last study, the impact of traffic congestion in the solar energy collection was further examined; lower congestion levels in photovoltaic roads mean higher collection of energy.

# 4 Q-method application and results

## 4.1 Statements' development (Q-set)

The first step for implementing a Q-method is the definition of a concourse delineating the major features related to the research question. Our SLR identified five areas of importance: 1) efficiency, 2) road safety, 3) accessibility, 4) liveability and 5) new technologies. The statements composing this set refer to these and the key concepts of each area. In that sense the Q-method and SLR function as a unified and sequential approach.

The concepts were converted into statements that were simple and coherent, articulating a clear meaning. It is important to ensure unambiguity in order to facilitate the respondents and to ensure valid results. Initially, a large number of statements was delineated; however, we finally narrowed it down to set forth 40 well-targeted statements.  This specific number of statements lies within the range indicated by best practice literature.

The structure of the final developed Q-set and the connection with the transforming concepts is presented in **Table 1**. More specifically, each of the 40 statements relates to one or more of the 28 identified concepts appearing in the last column of the table. We attempted to integrate some of the most noticeable dilemmas appearing in the literature; some of the 40 statements were provocative and contribute to distinguishing the various perspectives later in the analysis. Besides, Q-method assumes that participants will agree and disagree with some statements; therefore, keeping the right balance between positive and negative statement was a significant challenge we had to address.

Table 1: Q-set structure

| ID | Order number | Statements | Transforming Concept(s) |
|---|---|---|---|
| E | | Efficiency | |
| E.1 | 12 | Enhancement of multimodality in urban arterials and collectors will decisively contribute to the improvement of transport system efficiency. | Multimodal Corridors |
| E.2 | 19 | High flow arterials should still prioritize automobile traffic over other means of transport. | Road Space Allocation; Divided Arterials |
| E.3 | 1 | To enhance their reliability, public transport modes should not operate in mixed traffic urban environments with complex interactions. | Divided Arterials; Bus Priority Lanes |
| E.4 | 28 | Permanent bus lanes in urban arterials downgrade the efficiency of the transport system. | Bus Priority Lanes |
| E.5 | 22 | Future urban roads should dedicate space to mobility hubs offering shared mobility and public transport services. | Road Space Allocation; Multimodal Corridors |
| E.6 | 18 | Irregular road user behaviour (e.g. illegal pedestrian crossing movements) and traffic blocking activities (e.g. parking manoeuvring) should be banned in urban streets as they cause speed reductions. | Divided Arterials; Crosswalk Anywhere |
| E.7 | 36 | Congestion problems in cities can effectively be mitigated through road pricing schemes. | Congestion Road Pricing |
| E.8 | 33 | It is impossible to accommodate adequately all transport modes in European Cities due to space limitations. | Road space allocation |
| E.9 | 7 | On-street parking should be radically restricted in future urban roads. | Divided Arterials |
| E.10 | 24 | Public transport should not pass by pedestrianised streets in central city areas (efficiency). | Bus Priority Lanes |
| E.11 | 25 | Road pricing could result in high accessibility inequalities in European cities (efficiency). | Congestion Road Pricing |
| S | | Safety | |
| S.1 | 17 | Speed limits of 30 km/h can now be established in all residential streets without any design intervention. | Speed Limits Credibility; Traffic Calming Measures |

| | | | |
|---|---|---|---|
| S.2 | 29 | Speed limits are not necessary in urban roads as interactions among road users using automated means of mobility (e.g. AVs and automated buses) can self-regulate traffic speeds. (technology) | Speed Limits Credibility; Crosswalk Anywhere |
| S.3 | 9 | Medians should exist in unidirectional urban roads as they eliminate dangerous overtaking manoeuvres and boost pedestrian safety. | Forgiving Roads; Design Consistency |
| S.4 | 32 | It is essential to eliminate traffic conflicts in junctions by constructing roundabouts in cities. | Forgiving Roads; Design Consistency |
| S.5 | 40 | Urban road design ought to evoke correct expectations and driving behaviour from road users. | Self-Explaining Roads |
| S.6 | 14 | Shared space can critically undermine traffic safety by creating more mixed traffic interactions and thus increased collision danger. | Shared Space |
| A | | Accessibility | |
| A.1 | 39 | Traffic calming measures should be preferred over pedestrianised streets or car-free areas as they do not restrict any transport mode. | Traffic Calming Measures |
| A.2 | 35 | Accessibility of vulnerable road users will be downgraded by implementing shared space. | Shared Space; Human Oriented Road Environment |
| A.3 | 2 | Roads within a superblock should not be exclusively destined to active modes and micro-mobility. | Superblocks; Place Making; Home Zones |
| A.4 | 16 | Arterials should also be redesigned to enhance pedestrian and cycling presence. | Human Oriented Road Environment; Walking/Cycling Infrastructure |
| A.5 | 4 | Future urban road design cannot possibly consider all the different travel needs of road users (i.e. older car drivers, people with special needs, etc.). | Place Making; Human Oriented Road; Forgiving Roads |
| A.6 | 23 | A superblock is the most complete measure for diverting traffic volumes away city centres. | Superblocks |

| | | | |
|---|---|---|---|
| A.7 | 26 | It will be necessary to fully restrict the use of AVs in some areas as their dominance will result in a dystopic environment. | Human Oriented Road Environment |
| A.8 | 37 | Exclusive cycling infrastructure (i.e. bike lanes and bike sharing schemes) is the only proper way to promote cycling trips. (accessibility) | Walking/Cycling Infrastructure |
| L | | Liveability | |
| L.1 | 15 | Cities should implement tram systems as a tool for urban regeneration projects. | Urban Road as Public Space |
| L.2 | 38 | It is not so significant to create urban road environments that attract users to spend more time. | Social Places |
| L.3 | 8 | Cities should fully focus on the aesthetics of the urban road environment since urban roads are means to observe and understand the city. | Roadside Vegetation; Urban Road as Public Space; Vitality and Diversity |
| L.4 | 20 | Urban roads can be neighbourhood cultural assets in addition to their travel corridor role. | Streets as Cultural Assets |
| L.5 | 30 | Roadside vegetation is the only counter measure to maintain the urban environment quality, which will be caused by an intense use of private AVs. | Roadside Vegetation |
| L.6 | 10 | Shared space interventions cannot increase daily social and physical activities in urban areas. (liveability) | Social Places; Shared Space |
| L.7 | 3 | Lane numbers should be designed not only based on traffic flows but also based on noise pollution considerations. | Home Zones; Vitality and Diversity |
| T | | Technology | |
| T.1 | 34 | Cities ought to increase the use of EVs in city centres through deploying EV charging points in central streets. | Electric Vehicles' Charging Stations |
| T.2 | 11 | The deployment of Electric Vehicle (EV) charging points should be preferred in off-street parking facilities. | Electric Vehicles' Charging Stations |

| | | | |
|---|---|---|---|
| T.3 | 21 | Urban roads can promote sustainable energy policies through the establishment of wireless changing equipment and the creation of photovoltaic roads. | Photovoltaic roads; Dynamic Wireless Charging |
| T.4 | 5 | Road signs and traffic lights will be replaced by Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) technologies that will guide Autonomous Vehicles (AVs). | V2I and V2V Communication Systems |
| T.5 | 27 | It is necessary to plan exclusive AV corridors accompanied with V2I sensors in European Cities. | Fully Segregated AV Road |
| T.6 | 31 | SAVs will have a decisive role in urban roads as they will free up parking spaces in city centres. | Shared Autonomous Vehicles |
| T.7 | 6 | Shared Autonomous Vehicles (SAVs) should not be designed to operate in complex road environments including those providing shared space. | Shared Autonomous Vehicles |
| T.8 | 13 | Future interventions in (physical) road infrastructure will not be necessary, since connected AVs will solve traffic congestion and safety problems. | V2I and V2V Communication Systems; Shared Autonomous Vehicles |

## 4.2 Sample of experts (P-set)

The next step ensuing the development of Q set is the P set meaning the group of respondents, i.e. experts that would rank the Q-set statements. We followed the typical practice regarding the selection of respondents encountered in Q studies and therefore formulated a non-random sample. We built a diverse sample of experts related to urban road space issues, having renown experience in the transport field.

Firstly, each author developed a list of potential respondents; our purposive strategy included respondents that are experienced academics or researchers, stakeholders, policy makers, consultants, etc., in (at least one of the aspects of) the topic. It should be noted that certain attention was given to invite respondents who represent different disciplines so that the P-set is as ‘diverse’ as possible. Snowball sampling approach was not preferred in this study;

therefore, the experiment was fully controlled.  At the end, the final pool of potential respondents contained 95 specialists. Afterwards, a standard email was prepared.  The survey form in xlsx format along with detailed instructions were developed and distributed to potential respondents, too

At the end, fifty (50) stakeholders participated in this study (i.e. response rate was 52.6%), specifically: science and knowledge institutes, academia (28); – policy-makers, international organisations, local or regional governance and regulatory authorities (15) and consultants and entrepreneurs, project installers etc. (7). The sample consists of people with scientific background in transport who are mainly engineers or planners, however, there are also people coming from social research (e.g. sociology, economists), or sciences (e.g. mathematicians), thus ensuring the purposed heterogeneity. In addition, the respondents are based on the following 12 European countries: Greece (17), UK (13), the Netherlands (9), Belgium (3), Switzerland (1), Czech Republic (1), Portugal (1), Norway (1), Finland (1), Malta (1), Ireland (1) and Italy (1). The 50 participating experts come from 36 different organizations.

### 4.3 Development of survey form

Respondents assigned each statement a ranking respecting a quasi-normal distribution ranging from prohibitive (-3) to imperative (+3). In the survey form, the normal distribution was fixed for each respondent. The fixed distribution defines the exact number of statements that can be rank in each level, i.e. 2 spaces for prohibitive (+3) and imperative (-3), 4 spaces for strongly disagree (-2) and strongly agree (+2), 8 spaces for disagree (-1) and agree (+1) and 12 spaces for neutral (0). In practice, the previously described configuration makes our survey form an inverted symmetrical “pyramid” that is shown in **Figure 3**.

The Q-survey was developed in xslx format. It was distributed via personal emails to experts added in the sample from April to May 2021. Respondents saved the file with the completed form and forward it back to us. We also provided in each email detailed survey completion instructions to help respondents fill in the pyramid and a clear rationale behind the project.

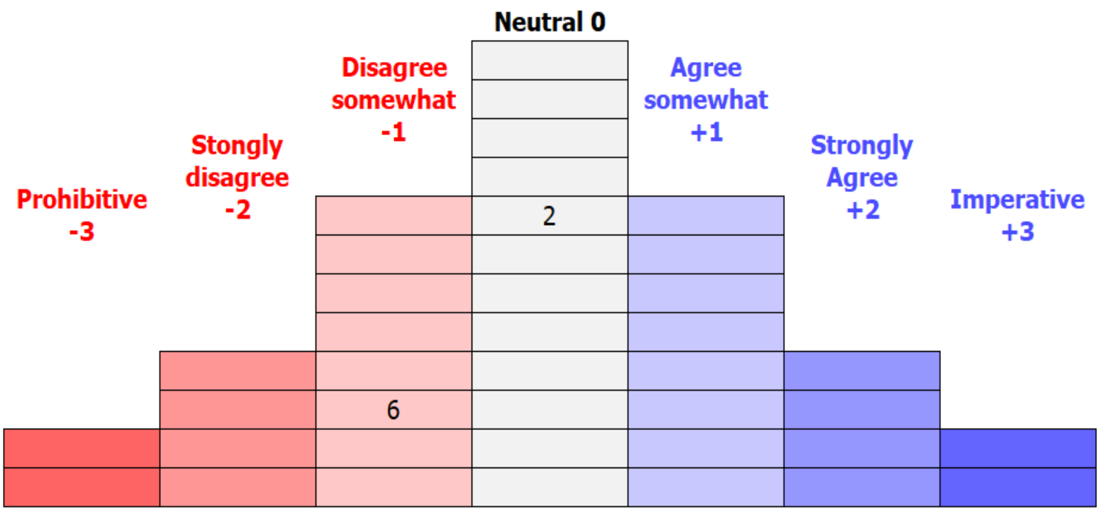


Figure 3: Inverted symmetrical pyramid of statements (Q grid).

### 4.4 Data processing and outputs

To process the collected Q-sorts, the “qmethod” package developed by Zabala (2014) was utilized in R. This package performed the Q-pattern analysis that allowed us to highlight existing perspectives regarding the future configuration of the ideal urban road. The Q-pattern analysis is based on the calculation of the correlation matrix among the collected Q-sorts. *“Q sorts with high intercorrelations can potentially create one underlying variable i.e. one factor”* (Kougias et al., 2020; Zabala & Pascual, 2016). In this study, the Principal Component Analysis (PCA) was used to extract the main factors that form the leading perspectives. To make the data structure clearer and improve interpretation, the extracted factors were rotated using the varimax method; it is a common technique used in some previous relevant studies.

To select the number of extracted factors, two rules of thumb were followed. Firstly, the eigenvalue of each factor should be greater than 1 and secondly, at least two Q-sorts should significantly load upon each factor (Curry et al., 2013; Kougias et al., 2020). Moreover, the main challenge was to select a relative low number of factors which would be still capable of describing the maximum possible variance. In qualitative terms, the identified factors forming a perspective should have a clear meaning. At the end, four factors in total were extracted from this analysis; the eigenvalues and the relative statistics are shown below in **Table 2.**

Table 2: Eigenvalues of the unrotated factor matrix

| | **Factor I** | **Factor II** | **Factor III** | **Factor IV** |
|---|---|---|---|---|
| **Eigenvalues** | 8.51 | 7.00 | 5.24 | 3.85 |
| **Number of loading Q-sorts** | 16.00 | 11.00 | 8.00 | 7.00 |
| **Explained Variance (%)** | 17.02 | 14.01 | 10.47 | 7.70 |
| **Composite reliability** | 0.98 | 0.98 | 0.97 | 0.97 |
| **Standard error of factor scores** | 0.12 | 0.15 | 0.17 | 0.17 |

To estimate the factor loadings, the automatic pre-flagging process was chosen. According to Zabala and Pascual (2016), this process is based on two criteria: a) the loading is considerably high and b) the square factor loading is greater than the sum of the square loading for all the other factors. However, some Q-sorts may confound in more than one factors. By analysing the data, we found that 8 out of 50 respondents seem to not belong to a specific perspective. Sixteen individuals were significantly loaded in Factor I, which explains the 17.02% of the variance. Factor II, III and IV add 32.18% of the explained variance. As it is shown in both **Table 2** and **Table 3**, no large differences were observed in terms of factor loadings. Thus, there is balance on how experts are divided into factors.

**Table 4** shows the relationship between factors and statements; a positive relationship (i.e. positive sign) indicates agreement, while a negative one refers to disagreement (Zabala & Pascual, 2016). The statements' scores can be estimated by ordering the z scores per factor and considering the scale (for -3 to +3) used in the survey form. By examining the z-scores, we were able to find distinguishing statements, i.e. statements that distinguish one factor from the other. **Figure 4, Figure** 5**, Figure** 6**, and Figure** 7 show the distinguishing statements of Factor I, II, III and IV, respectively. The plotted Radar Charts were also a valuable input in the process of identifying leading perspectives.

Table 3: Matrix of factor loadings

| Expert (P-set) | Factor I | Factor II | Factor III | Factor IV | Expert (P-set) | Factor I | Factor II | Factor III | Factor IV |
|---|---|---|---|---|---|---|---|---|---|
| **1** | -0.15 | -0.01 | 0.82* | 0.04 | **26** | 0.38* | 0.26 | -0.27 | -0.05 |
| **2** | 0.45 | 0.19 | 0.42 | -0.14 | **27** | 0.27 | 0.54 | -0.3 | 0.45 |
| **3** | 0.05 | -0.07 | 0.27 | 0.53* | **28** | 0.39 | 0.68* | 0.27 | 0.03 |
| **4** | -0.04 | 0.02 | 0.35 | 0.38* | **29** | 0.48 | 0.48 | 0.11 | 0.1 |
| **5** | 0.62* | 0.06 | 0.3 | 0.07 | **30** | 0.01 | 0.54* | 0.32 | 0.09 |
| **6** | 0.65* | -0.02 | 0.12 | 0.11 | **31** | 0.25 | 0.42 | -0.29 | 0.25 |
| **7** | 0.5 | 0.49 | 0.44 | -0.02 | **32** | 0.21 | 0.28 | 0.14 | 0.51* |
| **8** | 0.3 | 0.55* | 0.15 | -0.2 | **33** | 0.38 | 0.35 | 0.56* | 0.05 |
| **9** | -0.25 | 0.3 | 0.41* | -0.05 | **34** | 0.48* | -0.07 | -0.19 | 0.35 |
| **10** | 0.26 | 0.31 | 0.52* | 0.16 | **35** | 0.62* | 0.08 | 0.13 | 0.31 |
| **11** | 0.51* | 0.06 | 0.4 | 0.17 | **36** | 0.53* | 0.08 | 0.01 | -0.13 |
| **12** | -0.31 | 0.38 | 0.34 | 0.45 | **37** | 0.64* | 0.36 | 0.28 | 0.14 |
| **13** | 0.17 | 0.43 | 0.16 | 0.56* | **38** | 0.23 | 0.23 | 0.54* | 0.14 |
| **14** | 0.6* | 0.21 | 0.34 | 0.15 | **39** | -0.17 | 0.57* | 0.02 | 0.34 |
| **15** | 0.05 | -0.02 | 0.03 | 0.51* | **40** | 0.41* | 0.03 | -0.09 | 0.1 |
| **16** | 0.32 | 0.18 | 0.56* | 0.06 | **41** | 0.39 | 0.37 | -0.06 | 0.43 |
| **17** | -0.03 | 0.68* | 0.16 | 0.3 | **42** | 0.22 | 0.41 | 0.64* | 0.2 |
| **18** | 0.61* | 0.34 | 0.48 | 0.16 | **43** | 0.33 | 0.67* | 0.09 | 0.15 |
| **19** | 0.13 | 0.56* | 0.39 | 0.32 | **44** | 0.09 | 0.55* | 0.11 | -0.26 |
| **20** | 0.58* | 0.19 | 0.24 | 0.29 | **45** | 0.66* | 0.09 | 0.36 | 0.17 |
| **21** | 0.26 | 0.19 | -0.03 | 0.63* | **46** | 0.73* | -0.2 | -0.14 | 0.05 |
| **22** | 0.17 | -0.15 | 0.46* | -0.13 | **47** | 0.39 | 0.56* | 0.18 | 0.21 |
| **23** | 0.78* | 0.34 | -0.02 | -0.1 | **48** | 0.44 | 0.55* | 0.19 | -0.04 |
| **24** | 0.43 | 0.3 | -0.18 | 0.36 | **49** | -0.05 | 0.72* | -0.03 | -0.02 |
| **25** | -0.14 | 0.29 | 0.29 | -0.46* | **50** | 0.69* | 0.26 | 0.23 | 0.28 |

Table 4: Rounded statements' scores and z-scores in parenthesis for each factor

| Statement (Q-set) | Factor I | Factor II | Factor III | Factor IV | Statement (Q-set) | Factor I | Factor II | Factor III | Factor IV |
|---|---|---|---|---|---|---|---|---|---|
| **1** | -2 (-1.23) | 2 (1.28) | 0 (0.5) | 0 (-0.25) | **21** | 1 (0.64) | 1 (0.83) | 0 (0.25) | 2 (1.33) |
| **2** | -1 (-0.46) | -2 (-1.22) | -1 (-0.73) | 1 (0.48) | **22** | 3 (1.88) | 3 (1.92) | 1 (0.95) | 2 (1.50) |
| **3** | 1 (0.54) | 1 (0.69) | 1 (0.54) | -2 (-1.21) | **23** | 0 (0.00) | 2 (1.05) | 0 (0.18) | -1 (-0.48) |
| **4** | -3 (-1.93) | -2 (-1.36) | 0 (0.33) | -2 (-1.56) | **24** | 0 (-0.42) | 0 (0.11) | 1 (0.69) | 0 (-0.05) |
| **5** | 1 (0.97) | -1 (-1.09) | 1 (0.76) | -1 (-1.09) | **25** | 1 (0.69) | 0 (0.41) | 2 (1.41) | 0 (0.34) |
| **6** | -2 (-1.17) | 0 (0.43) | -1 (-1.2) | -1 (-0.64) | **26** | 0 (-0.31) | 0 (0.27) | 3 (1.50) | 0 (0.29) |
| **7** | 0 (0.32) | 3 (1.59) | 2 (1.28) | -2 (-1.78) | **27** | 1 (0.74) | -1 (-0.80) | -2 (-1.38) | -1 (-0.40) |
| **8** | 0 (0.28) | 0 (0.57) | 0 (0.24) | 0 (0.14) | **28** | -1 (-1.15) | -1 (-0.86) | -1 (-0.70) | -3 (-1.80) |
| **9** | 0 (0.50) | -1 (-0.52) | 0 (0.1) | 0 (-0.22) | **29** | -1 (-0.67) | -3 (-1.92) | 1 (0.62) | -1 (-0.56) |
| **10** | -2 (-1.59) | -2 (-1.56) | -2 (-1.38) | -1 (-0.5) | **30** | -1 (-0.44) | -1 (-0.64) | -1 (-0.57) | 0 (0.02) |
| **11** | 0 (0.11) | 1 (0.65) | 0 (0.52) | 0 (0.02) | **31** | 1 (0.84) | -1 (-0.67) | 0 (0.42) | 1 (0.36) |
| **12** | 3 (1.75) | 2 (1.13) | 3 (1.46) | 1 (0.49) | **32** | 1 (0.70) | 1 (0.65) | 0 (-0.09) | 0 (-0.24) |
| **13** | -1 (-0.7) | -3 (-1.98) | -3 (-1.88) | -3 (-1.90) | **33** | -2 (-1.92) | 0 (0.54) | 2 (1.29) | 1 (0.72) |
| **14** | -1 (-0.68) | 0 (-0.39) | -3 (-1.95) | 0 (-0.28) | **34** | 2 (0.98) | 0 (-0.29) | 0 (-0.25) | 2 (1.83) |
| **15** | 1 (0.76) | 1 (0.61) | 0 (0.03) | 1 (0.38) | **35** | -1 (-0.85) | -1 (-1.09) | -1 (-0.77) | -2 (-1.11) |
| **16** | 2 (1.3) | 1 (0.8) | 2 (1.27) | 0 (0.27) | **36** | 0 (0.42) | 0 (0.20) | -1 (-0.73) | 1 (0.83) |
| **17** | 0 (0.1) | -2 (-1.15) | -1 (-0.87) | 0 (0.28) | **37** | 0 (0.14) | 0 (-0.27) | 0 (-0.04) | 3 (2.22) |
| **18** | 0 (0.34) | 0 (0.46) | -2 (-1.56) | -1 (-0.99) | **38** | -3 (-1.99) | -1 (-0.97) | -1 (-1.11) | -1 (-0.31) |
| **19** | -1 (-0.59) | 1 (0.81) | -2 (-1.58) | 1 (0.39) | **39** | 0 (-0.42) | 0 (-0.50) | 1 (0.73) | 1 (0.51) |
| **20** | 2 (1.37) | 1 (0.87) | 1 (0.71) | 2 (0.95) | **40** | 2 (1.15) | 2 (1.41) | 1 (1.02) | 3 (2.01) |

## 4.5 Interpretation of Q-method outputs

The four factors determined unveil four leading perspectives which can be deemed as four discrete views on the "configuration" of the urban road of the future. Each of these perspectives does not represent individual thoughts and beliefs; on the contrary, it stands as a shared view among the participants related to each factor (Curry et al., 2013). Among the groups of experts, there was a high level of agreement regarding the role of aesthetics in the quality of the urban road environment (statement 8). Experts also agreed on the creation of mobility hubs for shared mobility services in the urban roads (statement 22). Lastly, apart from experts who belong in factor 1, all the others consider future interventions in the road environment necessary, since automation will not solve all the issue appearing in urban roads (statement 13).

### *4.5.1 Factor 1: People-first Techno-centrists*

The first leading perspective imagines a future where technologically advanced vehicles and humans will coexist on the urban roads. More specifically, it consists of respondents who believe that there is enough road public space to accommodate all transport modes including pedestrians and cyclists (statement 33). They also think that SAVs will decrease vehicle ownership in cities and therefore the parking space needs (statement 31). Apparently, multimodality and SAVs will free up road space (statement 12) that can be used to create urban road environments that attract people to spend more time and socialize (statement 38). Furthermore, AVs should be designed to cope with complex interactions (statement 6), which will appear as a result of co-existence in streets with access function. Yet, in some particular corridors with significant flow function, this factor highlights that it is necessary to prioritise the use of autonomous vehicle by constructing exclusive infrastructure (statement 27). These respondents are in favour of establishing electric charging points in central road segments (statement 34). In general, they are not positive to any restriction applied in technologically advanced transport modes (statement 27).

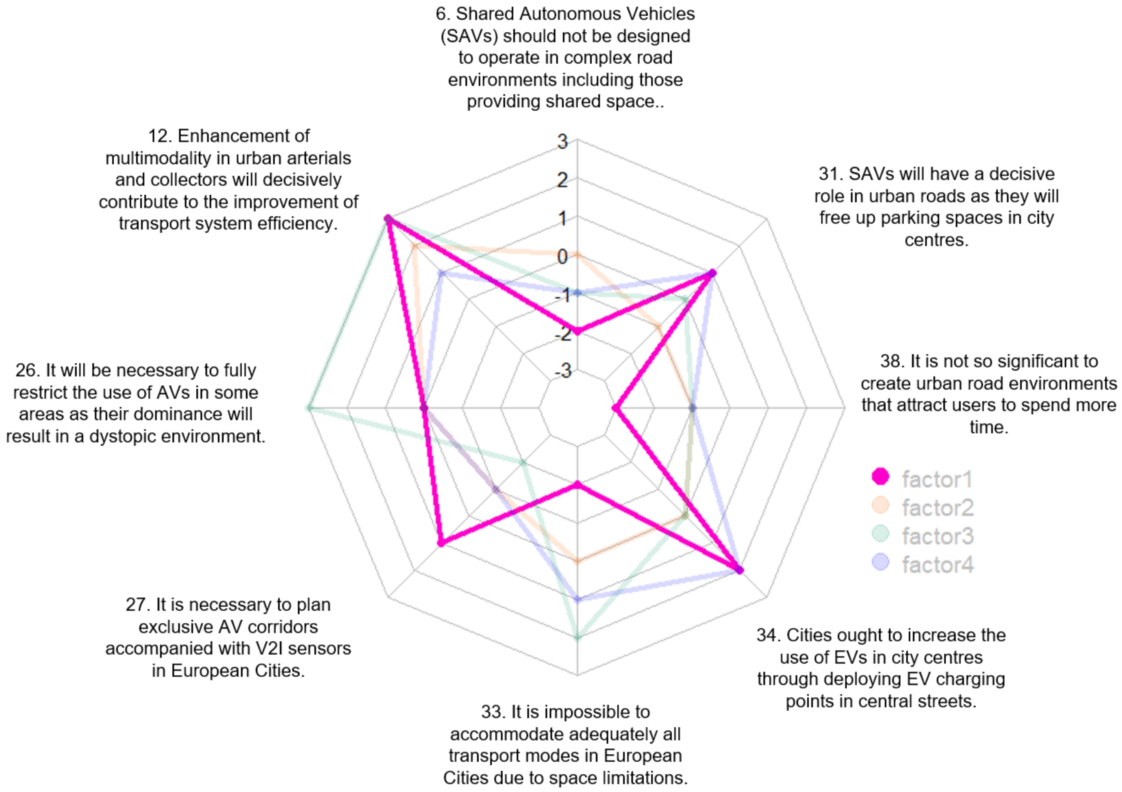

Figure 4: Radar chart of rounded statements scores for distinguishing statements of factor I

### *4.5.2 Factor 2: AV-sceptisists*

This perspective deals with a very significant issue that will play a central role in the transport systems of the future, i.e. AVs. AVs are gradually drawing even more the attention of researchers, planners, stakeholders and consultants, not only for their technical and operational characteristics but mainly for their impacts on the urban environment. This factor embedded a noteworthy scepticism over this kind of vehicles (statement 31) and at the same time highlighted the key role of active mobility, arterials' redesign and creating superblocks (statement 16 and 23). The scepticism is based on their belief that car automation and especially SAVs will never solve complicated safety issues arising in the urban road environments today (statement 1 and 6). Respondents belonging to this factor completely oppose the framework which implies that engineers will focus more on the design of systems than roads in the future (statement 5 and 29). According to them, the coexistence of humans and AVs in the same road environment cannot be considered as a potential future scenario (statement 2).

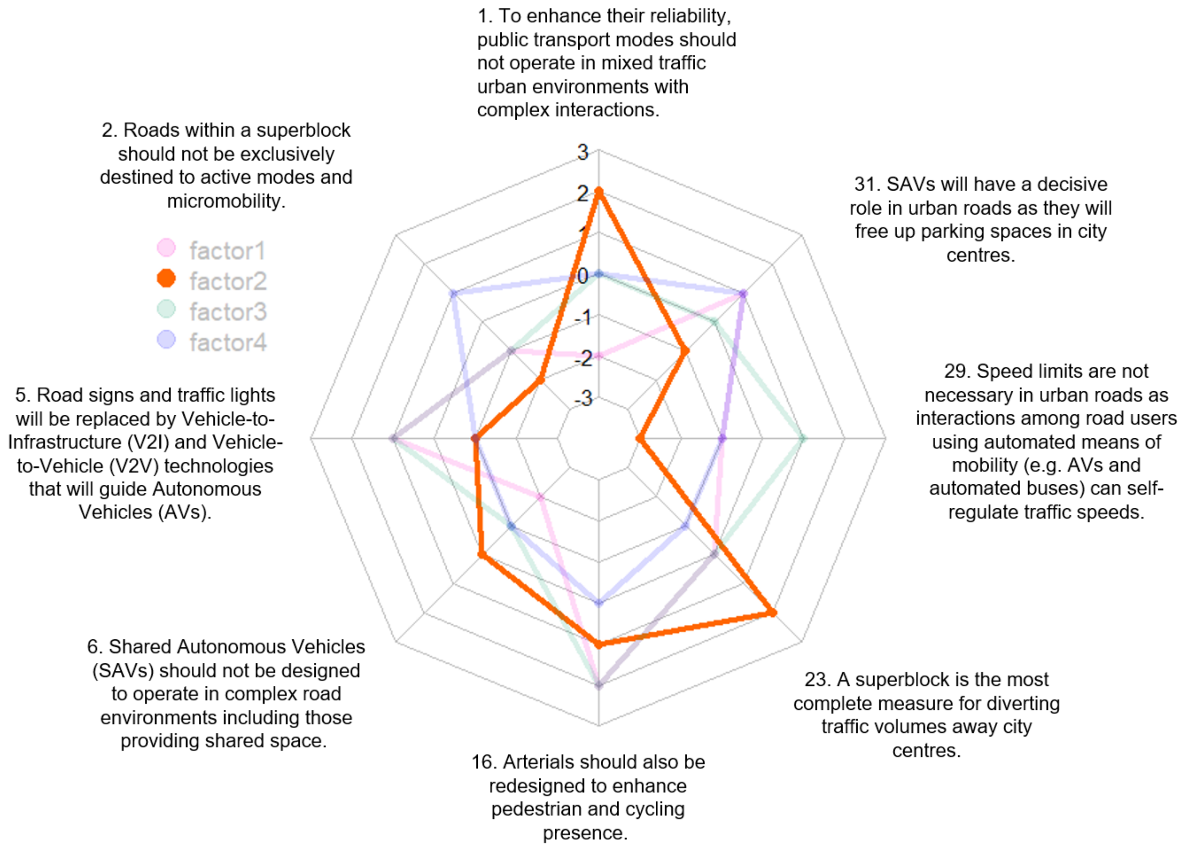

Figure 5: Radar chart of rounded statements scores for distinguishing statements of factor II

### 4.5.3 *Perspective 3: Unconventionalists*

The third perspective arising introduces a brand-new direction regarding the form of the urban road space. The respondents associated with this factor can be nominated as "Unconventionalists" since they support some particularly radical measures and especially the mix of road users. In this framework, they consider shared space as a pivotal intervention to mitigate traffic safety problems in the urban road of the future (statement 14). They think that it is impossible to accommodate all transport modes in European cities (statement 33). Tellingly that is the main reason why they propose a scheme to free the urban road space from traffic regulations (statement 25, 29 and 36) and create a shared environment based on interactions and mutual understanding (statement 18). This scheme does not depend on technological advancements, but it is more a new way of thinking. These experts note that urban road space should gradually leave behind the typical condition of prioritising automobiles (statement 19) over the rest modes even in the upcoming years of car automation (statement 27).

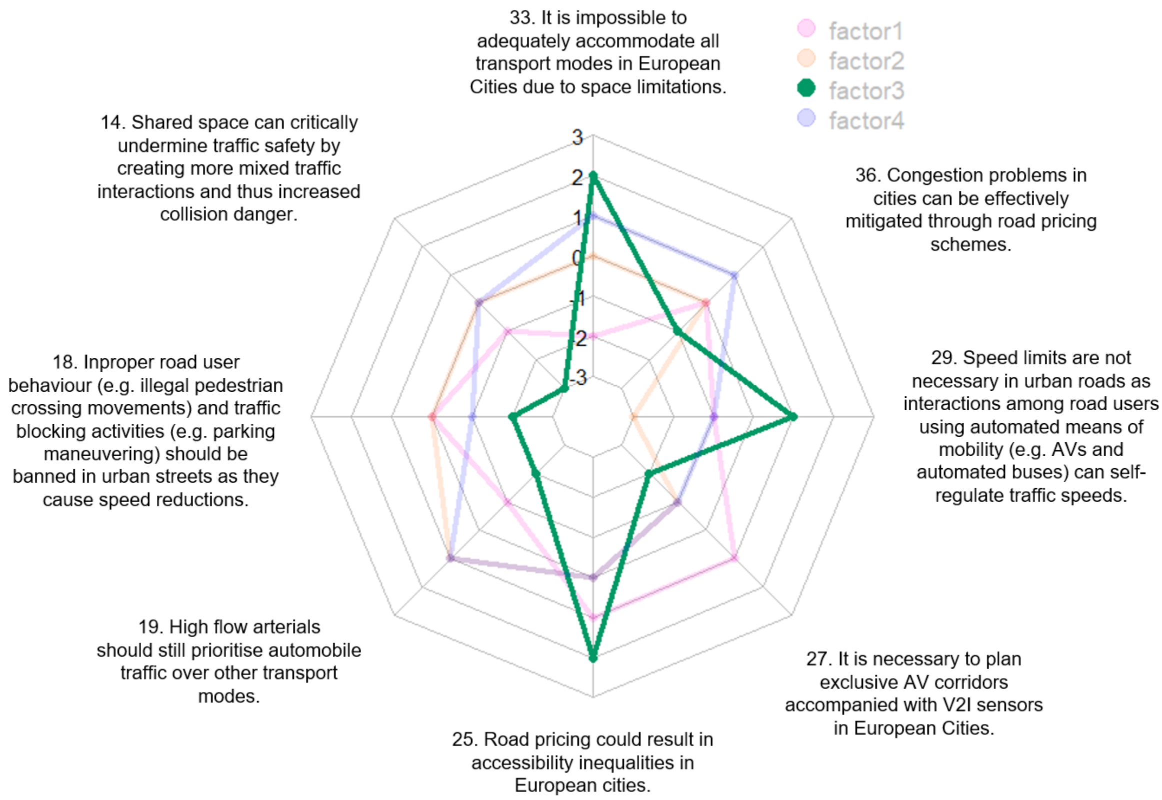

Figure 6: Radar chart of rounded statements scores for distinguishing statements of factor III

### *4.5.4 Perspective 4: Infrastructurists*

The last factor signifying a discrete perspective related to the urban road of the future consists of respondents that can be considered as “Infrastructurists”. In general, this term can explain a tendency of some respondents to support a key role of interventions in shaping the urban road. In this viewpoint, engineers are fully responsible to design urban roads that will inspire the correct expectations ensuring better driving behaviour (statement 40). In other words, they converge that the form of urban road should be influenced by a coherent set of exclusive infrastructure such as exclusive cycling infrastructure (statement 37), bus lanes (statement 28), roadside vegetation (statement 30), EV charging points (statement 34), etc. This viewpoint prioritises safety and congestion problems over those related to liveability and accessibility of urban roads (statement 3 and 2). Last, they seem to look positively road pricing schemes with the aim to mitigate congestion in central roads (statement 36).

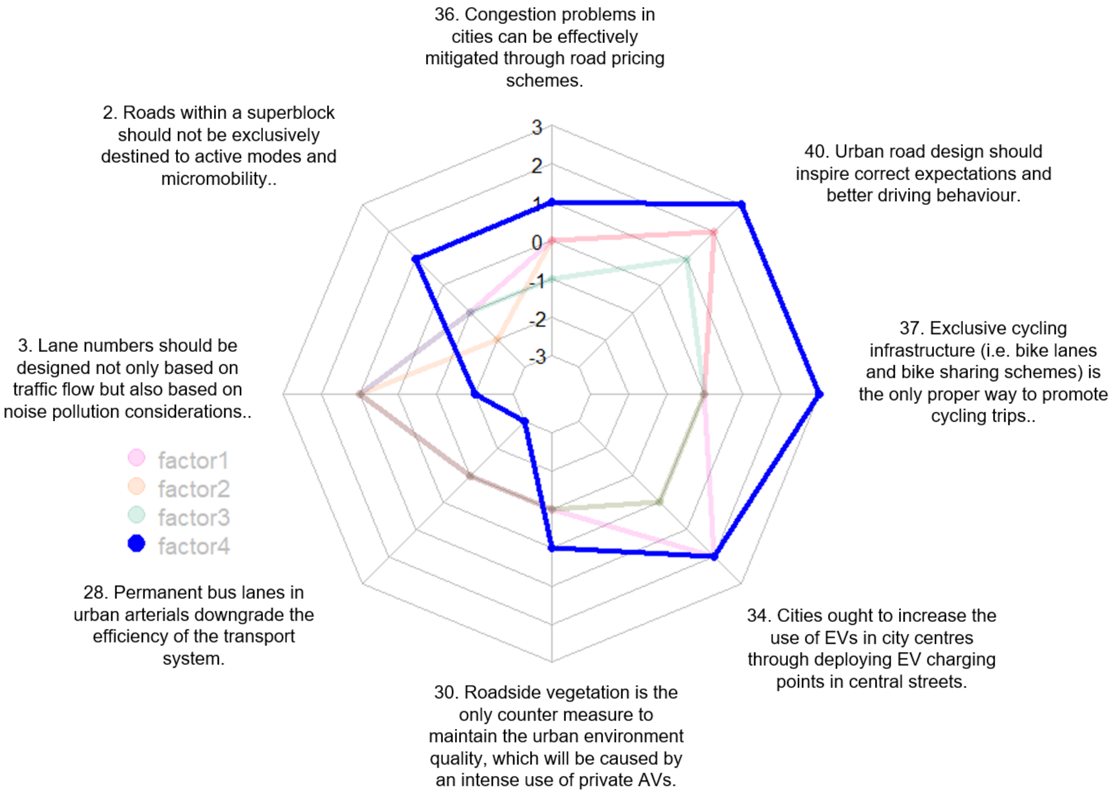

Figure 7: Radar chart of rounded statements scores for distinguishing statements of factor IV

## 5 Discussion

This paper attempts to define the dimensions and dilemmas of the urban road of the future by identifying concepts and perspectives in a rather complex and uncertain reality. This study can be deemed as a "vessel" for identifying new urban road rationales as well as for generating new research questions about the way planners should go forward. In that regard, the principal task of this paper is to contextualise directions towards the future and particularly to distinguish not only consensus, but also dilemmas.

A pivotal issue puzzling researchers is "priority" matters. Will the future urban road prioritise human movement or will automobile dependency and dominance prevail? According to Creutzig et al. (2020), the prioritisation of the slowest modes (i.e. pedestrians, cyclists) contributes to the fair and efficient allocation of space. This tendency to re-allocate more fairly and efficiently the available space emerges as a common belief among survey respondents too. The answer to the "space problem" in modern cities is particularly complex according to Zheng and Geroliminis (2013). All different perspectives identified, support different strategies and solutions. For instance, the unconventionalists suggest that shared space will be an efficient and innovative practice to address urban mobility needs and mainly limited space constraints. This reflects a balanced situation where every mode tries to take its place into a common ground. However, a balanced approach is also preferred by others. Infrastructurists also consider that human movement and vehicles should use the urban road equally, but their key measures are multimodal corridors, bus priority lanes and congestion pricing. Therefore, they believe that the human aspect is critical, but cannot overtake motor vehicles completely. On the other side, AV-sceptisists, put active modes at the first place of the mobility pyramid, thus recognizing human as the leader in some urban roads. Within this framework, they propose an extended implementation of superblocks schemes, home zones and traffic calming measures, thus enhancing active mobility. Additionally, re-design of arterials is also a key feature of this perspective.

Another dilemma, directly related to the previous one, is to share or to segregate. This is a problem illustrating mainly infrastructure and regulation strategies. Hammond and Musselwhite (2013) consider shared space as a key concept that disrupts the lethargy, which is seen by road users in a segregated space by creating a more pedestrian-friendly road environment. Unconventionalists agree with the last view by proposing a mixed flow scheme where shared space dominates, cross-walking can take place anywhere in the street segment and active mobility has a leading character. This approach imagines a future urban road where anyone can move freely under limited or even absent of restrictions. On the contrary, AV-scepticists and Infrastructurists suggest corridors and generally segregated road design approaches, with discrete identity, capable of being self-explained. This root problem, can also be extended into a wider dilemma, which is to regulate or not. This dilemma is also related to the social acceptance problem of congestion pricing measures (Rentziou et al., 2011; Rotaris et al., 2010). In this debate, Infrastructurists underline the effectiveness of these measures as well as the necessity of speed limits in urban roads.

Moving into the final dilemma, we may address an issue that has principally emerged during the last decades. Is the urban road subject to new design approaches and more specifically should we design systems or roads? Vitale Brovarone et al. (2021) think that urban and transport planning strategies will still be necessary, since they can reduce the negative impacts of the transition to AVs and exploit positive opportunities. Accordingly, People-first Techno-centrists and to a lesser degree Infrastructurists, are enthusiast to new technologies and approaches tending to invest on a future road that automation and smart infrastructures will take the lead. On the contrary, others seem to be in favour of traditional measures and approaches and at the same time being quite sceptical about the role and most of all about the impacts that these new modes and infrastructures will generate. AV-scepticists do not warrant the adoption of SAVs or similar smart solutions. They instead prefer active mobility prioritization. In the same direction, but not so sceptical, Unconventionalists, underscore that automation and smart mobility solutions could contribute to the urban road of the future; however, they do not acknowledge this as an urgent issue. They think that these kind of new modes and strategies should gradually integrate in the urban road system in an organic manner.

All of the aforementioned dilemmas statements, may pose a preliminary interest on exploring the urban road of the future. The "exact and ideal configuration" of the future urban road can be "drawn" by just answering them. Nevertheless, it is significant that we tried to set the directions and key elements of this dialogue and not answer directly; there are no fixed solutions for the future we believe.

As any study based on a survey-based data collection and analysis this has its limitations that refer to human biases. In the P-Set, we included experts from different European Countries and with various perspectives. Yet, as it happened in previous relevant studies (Kougias et al., 2020; Wolbertus et al., 2020), a bigger sample was not reached; therefore, some subversive views may be missed at the end. Another major restraint is the uncertainty of the future; there are no fixes and disruptions could occur. Tellingly, this research was conducted under the effect of COVID-19, meaning that some of the corpus of the literature studied, the approaches undertaken and the respondents participating in the survey were (even slightly) influenced by these circumstances. Also, the rapid technological advances that can be a gamechanger related to a series of urban road issues may force a change of direction and cause re-prioritization. For instance, AVs are coming into our cities gradually, but 20 years before, there were considered as an almost “fictitious” solution.  Different cultures will also be a limitation of the current study, since the produced outcomes will not apply in all circumstances. For example, European countries differ significantly from Asian or African ones. Also, there are considerable differences within the European continent, as Haustein and Nielsen (2016) have pointed out. Hence, this research could be a stimulus for carrying out more studies addressing a wide variety of cultures, approaches and principles.

Apparently, both the findings and the limitations of this work, lead to several useful recommendations for the future. In this context, new research works should aspire to answer some of the dilemmas described in this paper. For instance, it would be beneficial to examine the acceptance of some concepts and the rationale behind the acceptance conditions. This is a rather continuous process that can either address existing literature works or prepare new studies related to concepts unexplored until today. Moreover, the use of simulation tools either traditional or advanced like agent-based models and Land Use and Transport Interaction models would be a significant contribution towards the prediction of the impacts of each identified concept (Tzouras et al., 2021). Finally, interdisciplinary approaches that consider roads, vehicles, operating systems and people as a unified feature shall be promoted. An exemplar approach is that of the Safe System Approach that addresses via an integrated manner speeds, people, vehicles and roads (Bambach & Mitchell, 2015; Oxley et al., 2010).

# 6 Conclusions

The aim of the research was twofold. Firstly, to identify the transforming concepts related to the urban road of the future and secondly, to identify leading perspectives among experts. To this end, we used a sequential mix of SLR and Q-method. Similar studies have already utilised these methods, however, there is no relevant attempt in the corpus that combines these two into the same paper. Transforming concepts were identified through SLR and leading perspectives through Q-method.

Our SLR indicates that the transforming concepts referring to the urban road of the future differ and belong to a wide variety of urban, transport, economic, social and environmental aspects. In this study, 28 concepts which aim to transform the urban road were identified via the study of 42 papers. This signifies that the urban road of the future has a multitude of diverse elements. For better interpretation, this identified concepts were classified into five different approaches, i.e. concepts aiming to improve efficiency, road safety, accessibility, liveability and make the road technologically smarter.

Using Q-method, 50 experts coming from 12 different European countries and 36 organizations “imagined” the future urban road by filling in the Q survey. The findings show that four main factors and therefore four leading perspectives were determined. Techno-centrists, AV-scepticists, Unconventionalists and Infrastructurists emerge, all with different priorities and concerns.

These four perspectives can be considered as the new directions related to the urban road in the path towards the future. They are expected to influence the form and configuration of the urban street space and therefore, they should be taken into account by theoretical or practical schemes. The main dilemmas arising are the following: a) prioritisation of modes? Human first or not? b) Share or segregate and therefore to regulate or not and c) design systems or roads? These main concerns shall be considered as different paths in the quest for the future urban road.

The value of this research is certainly important, since it generates a critical debate that has been understudied thus far from the literature. Furthermore, except from the theoretical value of the paper, this study endeavours to influence the planning process through highlighting tendencies towards the future. Forthcoming studies or projects can benefit substantially from this study, paving the way for the making of cities providing high-quality life to their residents and sustaining the (urban) environment.

## CRediT authorship contribution statement

**Stefanos Tsigdinos**: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, **Panagiotis G. Tzouras**: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, **Efthimios Bakogiannis**: Supervision, Writing - review & editing, **Konstantinos Kepaptsoglou**: Supervision, Writing - review & editing, **Alexandros Nikitas**: Conceptualization, Methodology, Investigation, Validation, Supervision, Writing - review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References

Alyavina, E., Nikitas, A., & Tchouamou Njoya, E. (2020). Mobility as a service and sustainable travel behaviour: A thematic analysis study. *Transportation Research Part F: Traffic Psychology and Behaviour, 73,* 362–381. https://doi.org/10.1016/j.trf.2020.07.004

Aral, E. A., & Demirbaş, Ö. O. (2015). Pedestrians' perception of sub-spaces along urban roads as public spaces-case of Eskişehir road in Ankara. *Metu Journal of the Faculty of*

*Architecture*, *32*(1), 45–64. https://doi.org/10.4305/METU.JFA.2015.1.3

Bambach, M. R., & Mitchell, R. J. (2015). Safe system approach to reducing serious injury risk in motorcyclist collisions with fixed hazards. *Accident Analysis and Prevention*, *74*, 290–296. https://doi.org/10.1016/j.aap.2014.06.002

Bask, A., & Rajahonka, M. (2017). The role of environmental sustainability in the freight transport mode choice. In *International Journal of Physical Distribution & Logistics Management* (Vol. 47, Issue 7, pp. 560–602). https://doi.org/10.1108/ijpdlm-03-2017-0127

Biswas, S., Chandra, S., & Ghosh, I. (2020). Side friction parameters and their influences on capacity of Indian undivided urban streets. *International Journal of Transportation Science and Technology*. https://doi.org/10.1016/j.ijtst.2020.03.007

Booth, A., Sutton, A., & Papaioannou, D. (2016). *Systematic approaches to a successful literature review*. SAGE Publications Ltd.

Brůhová Foltýnová, H., Vejchodská, E., Rybová, K., & Květoň, V. (2020). Sustainable urban mobility: One definition, different stakeholders' opinions. *Transportation Research Part D: Transport and Environment*, *87*(August), 102465. https://doi.org/10.1016/j.trd.2020.102465

Charlton, S. G., Mackie, H. W., Baas, P. H., Hay, K., Menezes, M., & Dixon, C. (2010). Using endemic road features to create self-explaining roads and reduce vehicle speeds. *Accident Analysis and Prevention*, *42*(6), 1989–1998. https://doi.org/10.1016/j.aap.2010.06.006

Colonna, P., Intini, P., Berloco, N., Fedele, V., Masi, G., & Ranieri, V. (2019). An Integrated Design Framework for Safety Interventions on Existing Urban Roads—Development and Case Study Application. *Safety*, *5*(1), 13. https://doi.org/10.3390/safety5010013

Creutzig, F., Javaid, A., Soomauroo, Z., Lohrey, S., Milojevic-Dupont, N., Ramakrishnan, A., Sethi, M., Liu, L., Niamir, L., Bren d'Amour, C., Weddige, U., Lenzi, D., Kowarsch, M., Arndt, L., Baumann, L., Betzien, J., Fonkwa, L., Huber, B., Mendez, E., … Zausch, J. M. (2020). Fair street space allocation: ethical principles and empirical insights. *Transport Reviews*, *40*(6), 711–733. https://doi.org/10.1080/01441647.2020.1762795

Curl, A., Ward Thompson, C., & Aspinall, P. (2015). The effectiveness of "shared space" residential street interventions on self-reported activity levels and quality of life for older people. *Landscape and Urban Planning*, *139*, 117–125. https://doi.org/10.1016/j.landurbplan.2015.02.019

Curry, R., Barry, J., & McClenaghan, A. (2013). Northern Visions? Applying Q methodology to understand stakeholder views on the environmental and resource dimensions of sustainability. *Journal of Environmental Planning and Management*, *56*(5), 624–649. https://doi.org/10.1080/09640568.2012.693453

Davies, B. B., & Hodge, I. D. (2006). Farmers' preferences for new environmental policy instruments: Determining the acceptability of cross compliance for biodiversity benefits. *Journal of Agricultural Economics*, *57*(3), 393–414. https://doi.org/10.1111/j.1477-9552.2006.00057.x

Davis, J., Mengersen, K., Bennett, S., & Mazerolle, L. (2014). Viewing systematic reviews and meta-analysis in social research through different lenses. *SpringerPlus*, *3*(1), 1–9. https://doi.org/10.1186/2193-1801-3-511

Dekker, R., & Bekkers, V. (2015). The contingency of governments' responsiveness to the virtual public sphere: A systematic literature review and meta-synthesis. *Government Information Quarterly, 32*(4), 496–505. https://doi.org/10.1016/j.giq.2015.09.007

Demasi, F., Loprencipe, G., & Moretti, L. (2018). Road Safety Analysis of Urban Roads: Case Study of an Italian Municipality. *Safety, 4*, 58. https://doi.org/10.3390/safety4040058

Domenichini, L., Branzi, V., & Meocci, M. (2018). Virtual testing of speed reduction schemes on urban collector roads. *Accident Analysis and Prevention, 110*, 38–51. https://doi.org/10.1016/j.aap.2017.09.020

García-Vázquez, C. A., Llorens-Iborra, F., Fernández-Ramírez, L. M., Sánchez-Sainz, H., & Jurado, F. (2017). Comparative study of dynamic wireless charging of electric vehicles in motorway, highway and urban stretches. *Energy*, *137*(2017), 42–57. https://doi.org/10.1016/j.energy.2017.07.016

Gargoum, S. A., El-Basyouny, K., & Kim, A. (2016). Towards setting credible speed limits: Identifying factors that affect driver compliance on urban roads. *Accident Analysis & Prevention*, *95*, 138–148. https://doi.org/10.1016/j.aap.2016.07.001

Gitelman, V., Korchatov, A., & Elias, W. (2020). An Examination of the Safety Impacts of Bus Priority Routes in Major Israeli Cities. *Sustainability*, *12*(20), 8617. https://doi.org/10.3390/su12208617

Hadas, Y., & Nahum, O. E. (2016). Urban bus network of priority lanes: A combined multi-objective, multi-criteria and group decision-making approach. *Transport Policy*, *52*, 186–196. https://doi.org/10.1016/j.tranpol.2016.08.006

Hammond, V., & Musselwhite, C. (2013). The Attitudes, Perceptions and Concerns of Pedestrians and Vulnerable Road Users to Shared Space: A Case Study from the UK. *Journal of Urban Design*, *18*(1), 78–97. https://doi.org/10.1080/13574809.2012.739549

Haustein, S., & Nielsen, T. A. S. (2016). European mobility cultures: A survey-based cluster analysis across 28 European countries. *Journal of Transport Geography*, *54*, 173–180. https://doi.org/10.1016/j.jtrangeo.2016.05.014

Holden, E., Banister, D., Gössling, S., Gilpin, G., & Linnerud, K. (2020). Grand Narratives for sustainable mobility: A conceptual review. *Energy Research and Social Science*, *65*, 1–10. https://doi.org/10.1016/j.erss.2020.101454

Iclodean, C., Cordos, N., & Varga, B. O. (2020). Autonomous shuttle bus for public transportation: A review. *Energies*, *13*(11). https://doi.org/10.3390/en13112917

Kaparias, I., & Wang, R. (2020). Vehicle and pedestrian level of service in street designs with elements of shared space. *Transportation Research Record*, *2674*(9), 1–13. https://doi.org/10.1177/0361198120933627

Karndacharuk, A., Wilson, D. J., & Dunn, R. C. M. (2014). Analysis of Pedestrian Performance in Shared-Space Environments. *Transportation Research Record: Journal of the Transportation Research Board*, *2393*(1), 1–11. https://doi.org/10.3141/2393-01

Karolemeas, C., Tsigdinos, S., Tzouras, P. G., Nikitas, A., & Bakogiannis, E. (2021). Determining Electric Vehicle Charging Station Location Suitability: A Qualitative Study of Greek Stakeholders Employing Thematic Analysis and Analytical Hierarchy Process. *Sustainability (Switzerland)*, *13*, 2298. https://doi.org/10.3390/su13042298

Katrakazas, C., Michelaraki, E., Sekadakis, M., & Yannis, G. (2020). A descriptive analysis of the effect of the COVID-19 pandemic on driving behavior and road safety. *Transportation Research Interdisciplinary Perspectives*, *7*, 100186. https://doi.org/10.1016/j.trip.2020.100186

Knoop, V. L., & Daganzo, C. F. (2018). The effect of crosswalks on traffic flow. *European Journal of Transport and Infrastructure Research*, *18*(2), 145–157. https://doi.org/10.18757/ejtir.2018.18.2.3227

Kougias, I., Nikitas, A., Thiel, C., & Szabó, S. (2020). Clean energy and transport pathways for islands: A stakeholder analysis using Q method. *Transportation Research Part D: Transport and Environment*, *78*(December 2019), 102180. https://doi.org/10.1016/j.trd.2019.11.009

Lagorio, A., Pinto, R., & Golini, R. (2016). Research in urban logistics: a systematic literature review. *International Journal of Physical Distribution & Logistics Management*, *46*(10), 908–931. https://doi.org/10.1108/IJPDLM-01-2016-0008

Li, Y. (2012). Enhancing the Image of Urban Space, Promoting Urban History and Culture: A Case Study of the Urban Design of Wangjiang Avenue. *Nature Environment and Pollution Technology*, *11*(4), 601–606.

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *Journal of Clinical Epidemiology*, *62*, e1–e34. https://doi.org/10.1016/j.jclinepi.2009.06.006

Liu, Z., Yang, A., Gao, M., Jiang, H., Kang, Y., Zhang, F., & Fei, T. (2019). Towards feasibility of photovoltaic road for urban traffic-solar energy estimation using street view image. *Journal of Cleaner Production*, *228*, 303–318. https://doi.org/10.1016/j.jclepro.2019.04.262

Loorbach, D., & Shiroyama, H. (2016). *The Challenge of Sustainable Urban Development and Transforming Cities* (pp. 3–12). https://doi.org/10.1007/978-4-431-55426-4_1

López, I., Ortega, J., & Pardo, M. (2020). Mobility infrastructures in cities and climate change: An analysis through the superblocks in Barcelona. *Atmosphere*, *11*(4). https://doi.org/10.3390/ATMOS11040410

Lyons, G., & Davidson, C. (2016). Guidance for transport planning and policymaking in the face of an uncertain future. *Transportation Research Part A: Policy and Practice*, *88*, 104–116. https://doi.org/10.1016/j.tra.2016.03.012

Macmillan, A., Connor, J., Witten, K., Kearns, R., Rees, D., & Woodward, A. (2014). The Societal Costs and Benefits of Commuter Bicycling: Simulating the Effects of Specific Policies Using System Dynamics Modeling. *Environmental Health Perspectives*, *122*(4), 335–344. https://doi.org/10.1289/ehp.1307250

McAndrews, C., & Marshall, W. (2018). Livable Streets, Livable Arterials? Characteristics of Commercial Arterial Roads Associated With Neighborhood Livability. *Journal of the American Planning Association*, *84*(1), 33–44. https://doi.org/10.1080/01944363.2017.1405737

Milakis, D., Kroesen, M., & van Wee, B. (2018a). Implications of automated vehicles for accessibility and location choices: Evidence from an expert-based experiment. *Journal of Transport Geography*, *68*(March), 142–148. https://doi.org/10.1016/j.jtrangeo.2018.03.010

Milakis, D., Kroesen, M., & van Wee, B. (2018b). Implications of automated vehicles for accessibility and location choices: Evidence from an expert-based experiment. *Journal of Transport Geography*, *68*, 142–148. https://doi.org/10.1016/j.jtrangeo.2018.03.010

Miller, E. J., Farooq, B., Chingcuanco, F., & Wang, D. (2011). Historical validation of integrated transport-land use model system. *Transportation Research Record*, *2255*, 91–99. https://doi.org/10.3141/2255-10

Mukherjee, N., Hugé, J., Sutherland, W. J., Mcneill, J., Van Opstal, M., Dahdouh-Guebas, F., & Koedam, N. (2015). The Delphi technique in ecology and biological conservation: Applications and guidelines. *Methods in Ecology and Evolution*, *6*(9), 1097–1109. https://doi.org/10.1111/2041-210X.12387

Nikitas, A., Kougias, I., Alyavina, E., & Njoya Tchouamou, E. (2017). How Can Autonomous and Connected Vehicles, Electromobility, BRT, Hyperloop, Shared Use Mobility and Mobility-As-A-Service Shape Transport Futures for the Context of Smart Cities? *Urban Science*, *1*(4), 36. https://doi.org/10.3390/urbansci1040036

Nikitas, A., Michalakopoulou, K., Njoya, E. T., & Karampatzakis, D. (2020). Artificial intelligence, transport and the smart city: Definitions and dimensions of a new mobility era. *Sustainability (Switzerland)*, *12*(7), 1–19. https://doi.org/10.3390/su12072789

Nikitas, A., Tsigdinos, S., Karolemeas, C., Kourmpa, E., & Bakogiannis, E. (2021). Cycling in the era of covid-19: Lessons learnt and best practice policy recommendations for a more bike-centric future. *Sustainability (Switzerland)*, *13*(9). https://doi.org/10.3390/su13094620

Novotný, V., Kočárková, D., Havlena, O., & Jacura, M. (2016). Detailed analysis of public bus vehicle ride on urban roads. *Transport Problems*, *11*(4), 43–55. https://doi.org/10.20858/tp.2016.11.4.5

Nurse, A., & Dunning, R. (2020). Is COVID-19 a turning point for active travel in cities? *Cities & Health*, *00*(00), 1–3. https://doi.org/10.1080/23748834.2020.1788769

O'Hern, S., Stephan, K., Qiu, J., & Oxley, J. (2019). A simulator study of driving behavior and mental workload in mixed-use arterial road environments. *Traffic Injury Prevention*, *20*(6), 648–654. https://doi.org/10.1080/15389588.2019.1632443

Oliveira, C., Albergaria De Mello Bandeira, R., Vasconcelos Goes, G., Schmitz Gonçalves, D., & D'Agosto, M. (2017). Sustainable Vehicles-Based Alternatives in Last Mile Distribution of Urban Freight Transport: A Systematic Literature Review. *Sustainability*, *9*(8), 1324. https://doi.org/10.3390/su9081324

Oxley, J., Langford, J., & Charlton, J. (2010). The safe mobility of older drivers: a challenge for urban road designers. *Journal of Transport Geography*, *18*(5), 642–648. https://doi.org/10.1016/j.jtrangeo.2010.04.005

Parkin, J., Ricci, M., Parkhurst, G., Clark, B., & Clayton, W. (2018). Autonomous vehicle interactions in the urban street environment: a research agenda. *Proceedings of the Institution of Civil Engineers: Municipal Engineer*, *171*(2013), 15–25. https://doi.org/10.1680/jmuen.16.00062

Rentziou, A., Milioti, C., Gkritza, K., & Karlaftis, M. G. (2011). Urban Road Pricing: Modeling Public Acceptance. *Journal of Urban Planning and Development*, *137*(1), 56–64. https://doi.org/10.1061/(asce)up.1943-5444.0000041

Rotaris, L., Danielis, R., Marcucci, E., & Massiani, J. (2010). The urban road pricing scheme to curb pollution in Milan, Italy: Description, impacts and preliminary cost-benefit analysis assessment. *Transportation Research Part A: Policy and Practice*, *44*(5), 359–375. https://doi.org/10.1016/j.tra.2010.03.008

Rowley, J., & Slack, F. (2004). Conducting a literature review. *Management Research News*, *27*(6), 31–39. https://doi.org/10.1108/01409170410784185

Salini, S., & Ashalatha, R. (2020). Analysis of traffic characteristics of urban roads under the influence of roadside frictions. *Case Studies on Transport Policy*, *8*(1), 94–100. https://doi.org/10.1016/j.cstp.2018.06.008

Säumel, I., Weber, F., & Kowarik, I. (2016). Toward livable and healthy urban streets: Roadside vegetation provides ecosystem services where people live and move. *Environmental Science & Policy*, *62*, 24–33. https://doi.org/10.1016/j.envsci.2015.11.012

Sharifi, A., & Khavarian-Garmsir, A. R. (2020). The COVID-19 pandemic: Impacts on cities and major lessons for urban planning, design, and management. *Science of the Total Environment*, *749*, 1–3. https://doi.org/10.1016/j.scitotenv.2020.142391

Sheller, M., & Urry, J. (2016). Mobilizing the new mobilities paradigm. *Applied Mobilities*, *1*(1), 10–25. https://doi.org/10.1080/23800127.2016.1151216

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Soret, A., Jimenez-Guerrero, P., & Baldasano, J. M. (2011). Comprehensive air quality planning for the Barcelona Metropolitan Area through traffic management. *Atmospheric Pollution Research*, *2*(3), 255–266. https://doi.org/10.5094/APR.2011.032

Stead, D., & Vaddadi, B. (2019). Automated vehicles and how they may affect urban form: A review of recent scenario studies. *Cities*, *92*(April), 125–133. https://doi.org/10.1016/j.cities.2019.03.020

Szele, A., & Kisgyorgy, L. (2018). Autonomous vehicles in sustainable cities: more questions than answers. *Sustainable Development and Planning*, *217*(10), 725–734. https://doi.org/10.2495/SDP180611

Tsigdinos, S., Nikitas, A., & Bakogiannis, E. (2020). Multimodal Corridor Development As A Way Of Supporting Sustainable Mobility In Athens. *Case Studies on Transport Policy*. https://doi.org/10.1016/j.cstp.2020.11.004

Tsigdinos, S., & Vlastos, T. (2020). Exploring ways to determine an alternative strategic road network in a metropolitan city: A multi-criteria analysis approach. *IATSS Research*. https://doi.org/10.1016/j.iatssr.2020.06.002

Tumlin, J. (2012). *Sustainable transportation planning: Tools for Creating Vibrant, Healthy and Resilient Communities* (Wiley (ed.)).

Tzouras, P. G., Karolemeas, C., Bakogiannis, E., & Kepaptsoglou, K. (2021). A Concept Agent-Based Simulation Model to Evaluate the Impacts of a Shared Space Network. *Procedia*

*Computer Science*, *184*(C), 680–685.

van Wee, B. (2012). How suitable is CBA for the ex-ante evaluation of transport projects and policies? A discussion from the perspective of ethics. *Transport Policy*, *19*(1), 1–7. https://doi.org/10.1016/j.tranpol.2011.07.001

Villegas Flores, N., Cruz Salvador, L. C., Parapinski dos Santos, A. C., & Madero, Y. S. (2021). A proposal to compare urban infrastructure using multi-criteria analysis. *Land Use Policy*, *101*, 105173. https://doi.org/10.1016/j.landusepol.2020.105173

Vitale Brovarone, E., Scudellari, J., & Staricco, L. (2021). Planning the transition to autonomous driving: A policy pathway towards urban liveability. *Cities*, *108*, 102996. https://doi.org/10.1016/j.cities.2020.102996

von Schönfeld, K. C., & Bertolini, L. (2017). Urban streets: Epitomes of planning challenges and opportunities at the interface of public space and mobility. *Cities*, *68*, 48–55. https://doi.org/10.1016/j.cities.2017.04.012

Watts, S., & Stenner, P. (2005). Doing Q methodology: Theory, method and interpretation. *Qualitative Research in Psychology*, *2*(1), 67–91. https://doi.org/10.1191/1478088705qp022oa

Wolbertus, R., Jansen, S., & Kroesen, M. (2020). Stakeholders' perspectives on future electric vehicle charging infrastructure developments. *Futures*, *123*(June), 102610. https://doi.org/10.1016/j.futures.2020.102610

Yigitcanlar, T., & Cugurullo, F. (2020). The sustainability of artificial intelligence: an urbanistic viewpoint from the lens of smart and sustainable cities. *Sustainability (Switzerland)*, *12*(20), 1–24. https://doi.org/10.3390/su12208548

Yigitcanlar, T., Kamruzzaman, M., Foth, M., Sabatini-Marques, J., da Costa, E., & Ioppolo, G. (2019). Can cities become smart without being sustainable? A systematic review of the literature. *Sustainable Cities and Society*, *45*, 348–365. https://doi.org/10.1016/j.scs.2018.11.033

Yigitcanlar, T., Rashid, K., & Dur, F. (2010). Sustainable Urban and Transport Development for Transportation Disadvantaged: A Review~!2009-09-21~!2009-12-15~!2010-03-16~! *The Open Transportation Journal*, *4*(1), 1–8. https://doi.org/10.2174/1874447801004010001

Zabala, A. (2014). Qmethod: A package to explore human perspectives using Q methodology. *R Journal*, *6*(2), 163–173. https://doi.org/10.32614/rj-2014-032

Zabala, A., & Pascual, U. (2016). Bootstrapping Q Methodology to Improve the Understanding of Human Perspectives. *PLoS ONE*, *11*(2), 1–19. https://doi.org/10.1371/journal.pone.0148087

Zabala, A., Sandbrook, C., & Mukherjee, N. (2018). When and how to use Q methodology to understand perspectives in conservation research. *Conservation Biology*, *32*(5), 1185–1194. https://doi.org/10.1111/cobi.13123

Zhang, F., Zheng, N., Yang, H., & Geroliminis, N. (2018). A systematic analysis of multimodal transport systems with road space distribution and responsive bus service. *Transportation Research Part C: Emerging Technologies*, *96*, 208–230. https://doi.org/10.1016/j.trc.2018.09.009

Zheng, N., & Geroliminis, N. (2013). On the distribution of urban road space for multimodal congested networks. *Transportation Research Part B: Methodological*, *57*, 326–341. https://doi.org/10.1016/j.trb.2013.06.003

Zheng, N., Waraich, R. A., Axhausen, K. W., & Geroliminis, N. (2012). A dynamic cordon pricing scheme combining the Macroscopic Fundamental Diagram and an agent-based traffic model. *Transportation Research Part A: Policy and Practice*, *46*(8), 1291–1303. https://doi.org/10.1016/j.tra.2012.05.006