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# The 15-Minute City Concept: An Operations Research Perspective and a Research Agenda

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**Abstract.** The 15-minute city is an urban planning model where residents can access essential services within a 15-minute walk or bike ride. The idea is centered on reconsidering urban planning paradigms through the lens of proximity and accessibility. This paper explores how the concept can be operationalized using tools from operations research. While much of the existing literature has focused on defining and measuring accessibility in proximity-based cities, this work shifts the emphasis toward operational strategies and optimization-based methodologies to implement and manage such urban environments. We survey relevant operations research literature, identify thematic overlaps with urban planning goals, and propose a research agenda that includes facility location, mobility systems, shared transportation services, and integrated governance models.

**Keywords**: Proximity-based city, 15-minute city, X-minute city, smart and connected communities, operations research, transportation, logistics



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## 1. Introduction

The concept of the 15-minute city, and more broadly, proximity-based or X-minute cities, envisions urban environments where residents can access essential services such as work, education, healthcare, shopping, and recreation within a short walk or bike ride from their homes. This concept aims to enhance livability, improve mobility, reduce dependence on cars, and promote sustainable urban development. While researchers have made considerable progress in defining 15-minute cities and developing indicators to measure proximity and accessibility, limited attention has been paid to how such cities can be designed or how existing urban environments can be transformed to achieve proximity goals. This paper addresses this gap by discussing perspectives on the use of operations research (OR) techniques to support strategic, tactical, and operational decisions in the development of 15-minute cities.

Around 4.4 billion individuals accounting for 56% of the global population reside in cities (World Bank, 2024) and this number is expected to increase to six billion by 2045. Approximately 1.1 billion of city dwellers reside in urban slums or slum-like conditions as of 2022, and this number is also expected to increase by two billion in the next three decades (United Nations, Department of Economic and Social Affairs, 2024). Cities must therefore act swiftly to strategize for expansion and ensure the provision of fundamental services and infrastructure for their growing populations. Governments across the world are prioritizing and investigating opportunities in sustainable cities to serve as a solution for the growing problem. To this end, "Make cities and human settlements inclusive, safe, resilient and sustainable" is one of the Sustainable Development Goals of the United Nations. Another major initiative is the C40, which is a global network of mayors of nearly 100 world leading cities formed to confront the climate crisis (C40 Cities, 2024).

Khavarian-Garmsir et al. (2023) provide a historical view of neighborhood planning from the "garden city" of the 1890s to the smart city and the 15-minute city in the 2010s. The 15-minute city concept is an evolution of earlier urban planning models. It draws on the principles of garden cities introduced in the early 20th century, which emphasized self-sufficient, green communities. This idea was further developed through the neighborhood unit model of the 1920s, aimed at creating self-contained districts in response to increasing urbanization. It also shares a common ground with the compact city model of the 1970s, which advocates for higher density, mixed land use, and reduced car dependency. The smart city paradigm, which gained prominence in the early 2000s, emphasizes the integration of digital technologies such as sensors, data analytics, and Internet of Things devices to optimize urban systems and services. In contrast, the 15-minute city, introduced by Moreno (2016), advocates urban designs where residents can access essential services within a 15-minute walk or bike ride, emphasizing proximity, walkability, and human-scale development. The 15-minute city and smart city concepts, while distinct in origin and focus, have increasingly converged in contemporary urban planning to promote sustainable, efficient, and equitable urban environments. Chronologically, the smart city concept laid the technological foundation that the 15-minute city model builds upon to achieve its goals of localized living and reduced car dependency. The integration of smart technologies into the 15-minute city framework represents an evolution in urban planning, where digital technologies supports the creation of more livable and sustainable neighborhoods.

### 1.1. Objective of the paper

Interestingly, while the 15-minute city is mainly related to transportation and location science, scant effort has been spent towards linking these two fields to the 15-minute city concept. Our goal is to bridge the gap between these fields. The emphasis in the literature has been on defining what it is rather than on the ways to achieve the goals. This paper deals with the question of "how" to transform cities into 15-minute cities, rather than "what" they are. Several topics have been covered in the OR literature that can potentially offer solutions to problems arising in the 15-minute city concept. In this paper, we present related problems and we discuss related methodological tools to solve them. Finally, we also present research directions that can address some new challenges in the OR field that may potentially introduce interesting problems.

### 1.2. Literature review

We now review the 15-minute city literature to identify papers at the intersection of 15-minute city and OR fields. We have mainly used the Web of Science database (Web of Science, 2025) and searched for documents written in English using the following keywords: "*minute* cit*" OR "*minute* neigh*" OR "*proximity*based* cit*" OR "*proximity*based* neigh*". These keywords cover several core concepts linked to 15-minute cities, such as "15-minute city", "15-minute cities", "20-minute city", "20-minute cities", "X-minute city", "X-minute cities", "proximity-based city", and “proximity-based cities”. This search led to 407 documents. We then refined the search by filtering the following document types: “Article”, “Patent”, “Dissertation Thesis”, “Other”, “Review Article”, “Early Access”, “Preprint”, “Editorial Material”, “Correction”, and “Unspecified”. We also considered publications after 2016, when the term was first introduced. This filtering yielded 316 documents.

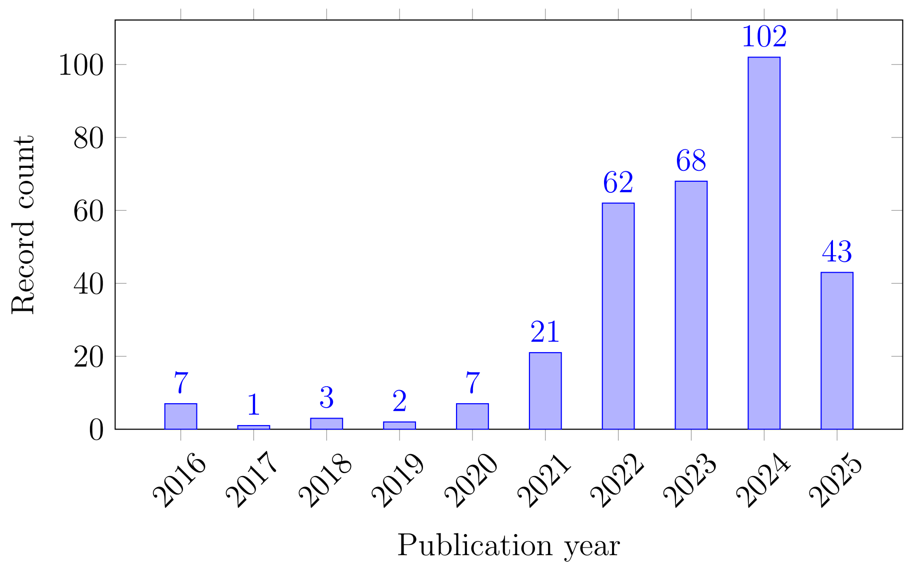


Figure 1: Record counts of publications related to 15-minute city or related terms by year from its inception in 2016 to June 2025.

Figure 1 shows the number of documents per year from 2016 to June 2025. We observe that the interest in the 15-minute city is increasing. Frequency counts related to 15-minute city research in journals with at least three published papers are reported in Table 1. As shown the table, most of the journals publishing on the 15-minute city focus on urban planning, sustainability, or transportation policy, and there is little representation from core OR journals. This reflects a qualitative and policy-oriented emphasis in the literature, rather than the optimization and decision-analytic perspectives typical of OR.

We have carefully investigated the titles and abstracts of these 316 documents and identified 11 review papers about 15-minute cities in general, and 27 research papers that may potentially involve an OR method. We now review the research papers to pinpoint methods used in these studies.

Table 1: Journal frequency counts related to 15-minute city research with at least three papers published

| Order | Publication/Source Titles | Count |
|---|---|---|
| 1 | Cities | 25 |
| 2 | Sustainability | 16 |
| 3 | Journal of Urban Mobility | 12 |
| 4 | Transportation Research Part A: Policy and Practice | 11 |
| 5 | Journal of Transport Geography | 8 |
| 6 | Smart Cities | 8 |
| 7 | Land | 7 |
| 8 | Sustainable Cities and Society | 7 |
| 9 | Tema Journal of Land Use Mobility and Environment | 7 |
| 10 | ISPRS International Journal of Geo Information | 6 |
| 11 | arXiv | 5 |
| 12 | Preprints | 5 |
| 13 | Energies | 4 |
| 14 | European Transport Trasporti Europei | 4 |
| 15 | Transportation Research Interdisciplinary Perspectives | 4 |
| 16 | Transportation Research Part D: Transport and Environment | 4 |
| 17 | Travel Behaviour and Society | 4 |
| 18 | Urban Science | 4 |
| 19 | Applied Geography | 3 |
| 20 | Nature Human Behaviour | 3 |
| 21 | Networks Spatial Economics | 3 |
| 22 | Urban Policy and Research | 3 |
| | Others sources with less than one or two documents | 163 |

Subsequently, we review the survey articles.

Among the research papers, we identified seven studies that incorporate a mathematical model or an optimization method. Mihailova and Vance (2024) use a single-constraint econometric model to choose transportation modes for the users, which is solved by Lagrangian relaxation. The remaining six studies are related to location optimization. Song et al. (2022) use a capacitated $p$-median problem and presented a mathematical model. Wang, J. et al. (2024) present a set covering location model. Bartzokas-Tsiompras and Bakogiannis (2023) apply multi-criteria decision making to score cities. While Abouhassan et al. (2024) mention optimization as a tool to design cities, they provide no model. Lima et al. (2022) also mention explicitly optimization, but build a decision-support tool to design the layout of urban fabrics and the location of amenities in a neighborhood using a mix of heuristics, which they refer to as grammar-based optimization. Jafari et al. (2023) develop an iterative multi-step heuristic to locate facilities.

Among the 11 survey papers, Sepehri and Sharifi (2025) review the literature with the goal of identifying the most important resources in the field of X-minute cities, and discuss major thematic areas. The paper does not review any quantitative method. Megahed et al. (2024) review the literature to identify the proximity measures within the context of X-minute cities. The authors identify six approaches: (1) grid-based/origin destination approach, (2) point of interest (POI) catchment area approach, (3) building catchment area, (4) mixed approach, (5) network-based method/graph representation method, and (6) indicator/index-based method. These approaches basically describe the 'demand'. The first takes the demand as trips (e.g., between origin-destination pairs), while the second and third ones take the demand as fixed points. The fourth approach is a mix, the fifth one models the demand on networks, and the last one is a multi-criteria approach to evaluate a city. We discuss a more detailed modeling of the demand in Section 1.3.1 of this paper. The next survey paper by Rojas-Rueda et al. (2024) focuses on the health benefits of 15-minute cities. Lu and Diab (2023), on the other hand, analyze different X-minute city policies by 15 cities in North America and Australia. The study argues that different transportation modes, parameters and goals are used in different use cases, and explores how cities operationalized the concept. Vizmpa et al. (2023) focus on the use of micromobility in the context of 15-minute cities. Khavarian-Garmsir et al. (2023) compare six major neighborhood planning movements in the history from proximity, density, diversity, mixed-use, modularity, adaptability, flexibility, human-scale design, connectivity and digitalization perspectives. Giles-Corti et al. (2023) focus on the lessons drawn from COVID-19 and how the ideas extend to 15-minute cities. They mention planning policies and interventions that may be used to operationalize 15-minute cities, without giving details of each intervention type. Wolański (2023) investigates the role of public transportation and railways in enabling 15-minute cities. This study is noteworthy because the authors observe that the main idea of the 15-minute city does not involve commute, and focus mostly on local services, but the majority will still commute outside of the neighborhood for work. In addition to the Moreno's original 15-minute city idea, the paper presents as alternatives the "Transit-Oriented Development (TOD)/TOD-Based 15-Minute Cities (which provides a variety of services in a neighborhood around a local center or public transport node) and an "ideal 15-minute city", which considers dispersion of workplaces to the neighborhoods. The paper does not analyze the results, but leaves this to be investigated. Boulanger (2022) compares the evolution of the concept and the trends before and after COVID-19 pandemic. Nieuwenhuijsen (2021) reviews the urban models including 15-minute city, and discusses common principles among these models. Finally, Teixeira et al.

(2024) identify 414 practices connected to 98 case studies worldwide that are either being implemented or are planned to be implemented to move cities towards 15-minute city goals. The authors presents different practices within the concept into four key areas of action (KA): (KA1) sustainable urban mobility, (KA2) people-centered urban spaces and planning, (KA3) smart urban logistics, production and service sites, and (KA4) urban governance for mobility transition. Observe that these four KAs mainly involve location optimization and mobility and transportation optimization. We adopt a very similar classification in Section 2.

### *1.3. A generic problem description*

The 15-minute city is an urban planning idea focused on ensuring that essential services (such as work, shopping, healthcare, education, and recreation) are within a 15-minute walk or bike ride from any neighborhood. The concept aims to minimize car dependency, encourage walking and cycling, and enhance residents' quality of life by creating more self-sustaining local communities. Given this broad description, any attempt to attain this goal may be considered within the field of 15-minute city. In this section, we present a list of useful parameters, objective functions and constraints of the problems in this context. This description is intentionally left imprecise to allow flexibility to accommodate different perspectives on the ways to reach the broad goals of 15-minute cities. This diversity is also reflected in the 414 practices connected to 98 case studies worldwide (Teixeira et al., 2024).

#### *1.3.1. Problem parameters*

The 15-minute concept in its inception included six essential functions that residents should access within a 15-minute journey from their home (Moreno et al., 2021): (1) living, (2) working, (3) commerce, (4) healthcare, (5) education, and (6) entertainment. Graells-Garrido et al. (2021) revise the list and include the following amenity categories: education, entertainment, finance, food, government facilities, health facilities, professional services, recreational areas, religion venues, retail, and public transport (Knap et al., 2023). In Table 2, we enumerate the urban amenities by extending the Graells-Garrido et al. (2021) list. In particular, we add residential areas, workplaces, industrial zones, emergency services, and utilities infrastructure, which represent other essential service areas in a city.

These amenities can be represented as nodes in a graph, with arcs representing travel between the nodes. Since walking and biking are the two

Table 2: A selection of urban amenities considered in 15-minute city design

| # | Amenity name | Examples |
|---|---|---|
| 1 | Residential areas | Houses, apartments, condominiums |
| 2* | Education | Primary schools, high schools, universities |
| 3* | Healthcare facilities | Hospitals, clinics, urgent care centers |
| 4* | Shopping centers | Malls, markets, retail strips |
| 5 | Workplaces | Offices, plazas, business parks |
| 6 | Industrial zones | Factories, warehouses, utilities |
| 7* | Finance centers | Banks |
| 8* | Green spaces | Parks, gardens, nature reserves |
| 9* | Sports and recreation areas | Gyms, stadiums, playgrounds |
| 10 | Public gathering spaces | Plazas, town squares |
| 11 | Hospitality and dining | Restaurants, hotels, cafés |
| 12* | Cultural and civic institutions | Museums, libraries, theaters, community centers |
| 13* | Government and administrative buildings | City hall, courthouses, post offices |
| 14* | Religious buildings and spiritual centers | Temples, churches, mosques, synagogues |
| 15 | Emergency services | Fire stations, police stations |
| 16* | Transportation infrastructure | Roads, bike lanes, bus stops, metro stations, bike stations |
| 17 | Utilities infrastructure | Waste management, water treatment, energy stations |

* indicates that the amenity is included in Graells-Garrido et al. (2021) list.

primary modes of transport emphasized in 15-minute city applications, multiple arcs can be added between the same pairs of nodes to represent different modes, resulting in a multigraph. While there exists a rich body of literature on network centrality measures such as degree, betweenness, closeness, and eigenvector centrality, their application to multigraphs remains relatively underexplored. Although centrality measures developed for simple graphs can be extended to multigraphs, such extensions require careful consideration. Furthermore, representing distances using the 1-norm (Manhattan distance) or the 2-norm (Euclidean distance) can lead to significant inaccuracies in estimating actual travel time, especially in urban areas with short distances and various natural barriers such as rivers or mountains, and man-made barriers such as highways or large buildings. Therefore, actual travel time is the most appropriate metric to use for arc costs in such contexts.

Demand in the context of the 15-minute city can be modeled in various forms. First, point-based demand can be represented by individual nodes, particularly those corresponding to residential areas, where each node reflects localized demand. Second, origin-destination (O-D) pair-based demand captures commuting behavior, where trips between specific origins and destinations constitute the demand. Some studies treat both point-based and O-D pair-based demands separately, especially in models that account for dynamic demand relocation throughout the day (e.g., Muffak and Arslan, 2023). Dynamic facility location models also provide valuable insights for handling time-dependent demand changes over planning horizons (e.g., Wesolowsky, 1973; Jena et al., 2016). Third, a more generalized and complex form is activity-based or tour-based demand, similar to the household activity pattern problem (HAPP) introduced by Recker (1995). In this approach, demand is represented as a sequence of activities (e.g., dropping off children, going to work, shopping), akin to a traveling salesman problem. This type of demand accounts not only for locations but also for the order and frequency of visits, highlighting the difference in trip frequency between, for instance, visiting a bank and going to a shopping center.

*1.3.2. Measures and objective functions*

Moreno et al. (2021) identifies four dimensions: (1) density, (2) proximity, (3) diversity, and (4) digitalization. We now focus on the first three measures, and leave out digitilization, as it is mostly related to information technologies.

The first dimension, the *density* in the context of 15-minute cities, refers to the number of people per square kilometer. While Moreno et al. (2021) mention an "*optimal number of people that a given area can comfortably sustain in terms of urban service delivery and resource consumption*", no number is explicitly mentioned. As an example, Cervero and Kockelman (1997) provide an average of 18.20 as the population per developed acre and an average of 5.96 as the employment per developed acre for 50 neighborhoods in the San Francisco Bay Area. Density is an important measure that may be considered in the problem either as an objective (to minimize deviations from a certain target) or as a constraint (to be within a certain range of values).

Proximity is the second dimension of the 15-minute city and is described by Moreno et al. (2021) in both temporal and spatial terms. The emphasis is generally on travel time in a 15-minute city context. Nevertheless, when evaluating neighborhoods within a 15-minute city framework, distance measures such as the Jaccard distance (Jaccard, 1901), the Hamming distance (Hamming, 1950) or the Gini index (Ceriani and Verme, 2012) can also provide valuable insights into the similarity or disparity in amenity access across different areas. By representing each neighborhood as a set or binary vector of accessible services, these measures allow for the quantification of similarity or disparity in functional accessibility. This can be especially useful for assessing equality among neighborhoods, revealing gaps where some areas may lack essential services within walking or biking distance. Such analysis supports data-driven urban planning aimed at ensuring equitable access and guiding targeted interventions to bring underserved neighborhoods closer to the ideal 15-minute city. We note that such measures are not studied in the context of 15-minute cities.

The third key dimension is diversity. Moreno et al. (2021) describe diversity in two main aspects: (1) the functional mix of land use, combining residential, commercial, and entertainment components within the same neighborhood, and (2) social diversity, referring to cultural and demographic variety among residents. Similar to proximity, functional diversity can be quantitatively assessed in OR models by evaluating the distribution and colocation of different types of amenities and land uses across neighborhoods. In contrast, social diversity is more difficult to enforce directly through modeling. It can only be influenced indirectly through planning incentives or policies. Therefore, while OR models can incorporate and optimize for functional diversity, promoting social diversity typically requires broader socio-political strategies beyond optimization frameworks.

Considering these three dimensions (density, proximity, and diversity) provides a foundation for developing meaningful objective functions in OR models of the 15-minute city. These dimensions bear not only on the decision variables and constraints, but also on the prioritization of goals such as accessibility, equity, and sustainability. By embedding these urban design principles into formal models, researchers and planners can better evaluate trade-offs between competing objectives and design interventions that are both efficient and socially inclusive.

### *1.4. Constraints*

A mathematical model supporting the decision-making in 15-minute city must incorporate a comprehensive set of constraints, which ensure that the solutions are not only theoretically sound but also feasible, equitable, and aligned with broader urban planning objectives. We investigate them under three different groups as (1) fundamental constraints, (2) regulatory and equity constraints, and (3) urban form and behavioral constraints.

#### *1.4.1. Fundamental constraints*

Budget, capacity and accessibility constraints are among the most fundamental. *Budget constraints* limit the extent of new infrastructure investments, facility upgrades, and expansions of transport or service networks. These constraints typically reflect restrictions in public funding, land acquisition costs, and long-term maintenance obligations. *Accessibility constraints* take the form of distance or travel time thresholds, ensuring that all residents can access key amenities within a 15-minute walk or bike ride. They may be formulated as hard or soft constraints. *Capacity constraints* ensure that facilities and services are not overwhelmed by the demand. These constraints are especially important in dense urban environments, where overuse can degrade service quality.

### *1.4.2. Regulatory and equity constraints*

*Land use and zoning regulations* represent another class of constraints, which restrict the types and intensity of development in specific areas. For instance, some districts may be protected from densification due to heritage, environmental, or political reasons. Zoning also affects functional diversity. *Environmental constraints* also play an important role in planning. These may prohibit development in ecologically sensitive areas such as flood zones, or conservation lands. Additionally, emissions, green space requirements, and climate adaptation measures may be embeded into the models. In transportation-oriented problems, environmental goals often translate into modal shift constraints or limits on the total vehicular emissions. *Equity constraints* are essential to ensure fair access across the population. These constraints guarantee a minimum level of service coverage in all neighborhoods or for specific demographic groups (for example, low-income, elderly, or disabled populations).

### *1.4.3. Urban form and behavioral constraints*

Controlling urban sprawl is another important consideration. *Sprawl control constraints* help create compact urban form and prevent inefficient land utilization. By imposing spatial limits on where development can occur, the model can encourage compact urban forms and reduce long-term infrastructure and transportation costs. *Affordability constraints* address the socio-economic implications of increasing accessibility. As high-access neighborhoods become more desirable, property values may rise, risking gentrification and displacement. Constraints may be added to ensure a share of affordable housing or to limit average rent levels within high-access zones. *Behavioral constraints* may be relevant in models that incorporate detailed travel patterns or household behavior. For example, trip chaining and activity sequencing, common in household activity pattern problems, introduce temporal and spatial logic constraints that reflect realistic behavior.

In summary, the constraints in 15-minute city models serve not only to enforce technical feasibility but also to encode policy goals, legal obligations, and ethical commitments. A model may combine such measures to balance between efficiency, equity, and environmental sustainability.

## 2. Themes of the 15-Minute City and Related OR Problems

In this section, we investigate the overlapping research streams between OR and 15-minute city fields and identify key problems and papers. Our aim is not to provide a comprehensive literature review but rather to raise awareness of the potential synergies between these two fields. We follow the classification of Teixeira et al. (2024), who identified the 414 practices worldwide into four key areas of action (KA): (KA1) sustainable urban mobility, (KA2) people-centered urban spaces and planning, (KA3) smart urban logistics, production and service sites, and (KA4) urban governance for mobility transition. They report that 33% of the projects fall under KA1, 38% under KA2, 7% under KA3, and 22% under KA4. We now separately investigate each of these themes of the 15-minute city.

### *2.1. KA1: Sustainable urban mobility*

Mobility functions are similar to the vascular system of a human body facilitating the movement of people and freight through the veins of a city. The KA1 associated with sustainable urban mobility accounts to 33% of the 414 practices (Teixeira et al., 2024). Examples include building dedicated infrastructure for cycling, enhancing public transport services, and creating mobility hubs that integrate various sustainable transport options at a single location. We now investigate related problems in the OR literature.

#### *2.1.1. Design and management of public transport networks*

Public transportation network design and management is a complex problem (Desaulniers and Hickman, 2007), involving several line planning, fleet sizing, routing, timetabling, crew scheduling and fare pricing decisions in static settings (Farahani et al., 2013). Real-time management problems include dispatching and real-time control (Cao et al., 2019; Ibarra-Rojas et al., 2015). With the introduction of electric buses, depot charge scheduling also appeared as a new research domain (Pelletier et al., 2018; Yamín et al., 2024). Other studies also consider integration of micromobility systems with public transportation (Oeschger et al., 2020) as well as adopting public transportation to help with last-mile parcel delivery using crowdsourcing (Kızıl and Yıldız, 2023; Mohri et al., 2025).

*2.1.2. Shared mobility systems*

Shared mobility systems have flourished not only due to advances in information and communication technologies but also because of users' growing openness to shared transportation options (Laporte et al., 2015). Laporte et al. (2018) review problems arising in station location, fleet dimensioning, station inventory, rebalancing incentives, vehicle repositioning in static and dynamic cases related to shared mobility systems. They argue that these are new applications of different problems, and that there exists a wide range of methodological tools to solve most planning problems raised by shared mobility systems. Mourad et al. (2019) provide a complementary perspective by classifying shared mobility systems into two main categories: those where people share rides (ride sharing, car pooling, van pooling, carsharing, and dial-a-ride), and those that combine passenger and parcel transport (combined delivery, share-a-ride, and crowd-sourced logistics). They discuss various modeling approaches and solution techniques for such systems.

*2.1.3. Shared micromobility systems*

The bike sharing is the most common form of shared micromobility, and the literature largely focuses on the bikes as form of micromobility. Zhou et al. (2022) review the literature and classify the topics into three categories: (1) development, operation mode and lessons learned, (2) bike sharing system static rebalancing problem, and (3) spatiotemporal characteristics and demand prediction. In the OR literature, determining the the inventory levels in bike sharing systems (Datner et al., 2019), and static (Liu et al., 2024) and dynamic (Liang et al., 2024) rebalancing optimization have been widely studied. Shared micromobility also applies to other means of transport such as scooters. Effective system management requires routinely repositioning, recharging, or sourcing of units to prevent stockouts or surplus inventory at locations experiencing imbalanced flows. Crowdsourcing is used to this end for vehicle rebalancing (Jin et al., 2023) or system management (Akturk et al., 2024).

*2.1.4. Bike lane network design*

The bike lane network design problem (Mesbah et al., 2012; Mauttone et al., 2017) deals with the design of lanes to be used by cyclists by considering their trips in the road network. Several aspects have been considered in this problem including discontinuity of the bike lane segments, the total design budget and the impact of the bike lanes over car regular vehicle traffic. Liu et al. (2022) consider the cyclists' route choices and a bilevel program using a multinomial logit model. Their study investigates the trade-off between the coverage of bike trips and continuity of bike lanes. Wiedemann et al. (2025), on the other hand, evaluate the trade-off between bike and car travel times with Pareto frontiers. Chan et al. (2022) acknowledge the fact that a large number of cyclists (followers on a bilevel model) are present, considers a sampled subset of them and develops a machine learning model to estimate the objective values of unsampled followers.

The integrated bike station location and bike lane design problem has also been explored (García-Palomares et al., 2012; Song et al., 2024), typically in the context of dock-based bike sharing systems. However, it is important to note that in many regions, the majority of cyclists use privately owned bikes rather than shared ones. For example, a study by Statista (2024) found that 81% of Polish households have access to a bicycle, while only 9% use bike sharing services. In contrast, some Chinese cities exhibit the opposite trend, where 44% of users rely on shared bikes compared to 41% who own one. In modeling settings that account for both private and shared bike users, the hub location problem and its extensions (Alumur and Kara, 2008; Alumur et al., 2021) offer a natural framework for designing shared infrastructure across user types.

*2.1.5. Mobility-as-a-service systems*

Mobility-as-a-Service (MaaS) is a business model that integrates various transportation services such as public transit, ride-sharing, and bike rentals into a single, user-centric interface for trip planning, managed by an online platform. Wong et al. (2020) presents a MaaS framework for urban mobility that emphasizes modal efficiency and sustainable transport integration. While several papers study the shared mobility services from a single shared mobility service perspective, the focus on the development of a joint mode choice model among modes, such as bike sharing, carsharing and ride hailing services is scarce (Narayanan and Antoniou, 2023). To this end, van den Berg et al. (2022) study different business models and test their affects on prices, profits, consumer surplus and welfare, and Yang et al. (2023) study integrating metros and shared autonomous vehicles.

### *2.2. KA2: People-centered urban spaces and planning*

Approximately 38% of the practices are associated with KA2. Examples include designing urban spaces by converting road space previously used by cars into public and green areas, developing buildings and spaces that serve multiple purposes, and fostering neighborhoods with diverse land use.

#### *2.2.1. Service facility location*

Farahani et al. (2019) review the urban service facility location problem applications arising in several domains including waste management systems, large-scale disasters, small-scale emergencies, general service and infrastructure, non-emergency healthcare systems, and transportation systems and their infrastructure. They point to several important directions to improve the realism of the problems solved, including making joint decisions integrated with location, sustainability aspects, uncertainty and risk modeling, dynamic models and location sharing. Location decisions in their nature are usually strategic and there exists a vast body of literature on classical as well as contemporary topics on location science (Laporte et al., 2019). In the context of the 15-minute city, such models can be leveraged to determine the optimal placement of essential services, including healthcare centers, schools, parks, local markets, mobility hubs, and administrative facilities.

#### *2.2.2. Districting*

Districting, or zoning, is a special type of location problem, which has a wide range of applications, arising when determining political districts, service regions, or areas of responsibility. In the context of the 15-minute city, zoning arises as an important application to balance residential, commercial, and green spaces. While there are models directed towards district design (Kalcsics and Ríos-Mercado, 2019), other problems such as location-allocation or location-routing (Albareda-Sambola and Rodríguez-Pereira, 2019) can also be used to determine zoning strategies. Similar to districting problems, dividing a territory fairly among several facilities or vehicles has also been studied (Carlsson, 2012; Carlsson and Devulapalli, 2013).

#### *2.2.3. Traffic mitigation strategies*

Traffic mitigation strategies in urban environments may be achieved by using different incentive or pricing schemes. One common method is declaring car-free streets or zones, which is closely linked with the districting and location optimization problems. Another effective method is congestion pricing (De Palma and Lindsey, 2011; Eliasson and Mattsson, 2006) which requires large vehicles to enter a certain region at certain times or to pay a fee. This indirectly encourages delivery companies in urban regions to employ more environmentally sustainable solutions such as walking or the use of micromobility. Additionally, rising demand from delivery services and mobility providers is straining available curb space. Managing curb space for diverse functions is vital to reducing congestion during rush hours (see, for example, Yu and Bayram, 2021; Lim and Masoud, 2024; Xu and Sun, 2024).

### *2.3. KA3: Smart urban logistics, production and service sites*

Approximately 7% of the practices are linked to KA3 (Teixeira et al., 2024). We believe that the low reported numbers are not related to the actual projects themselves, but rather to the fact that urban logistics is generally not considered a responsibility of municipalities or governments, but of private firms. In this category, examples include the development of sustainable urban logistics, such as using cargo bikes or electric vehicles (EVs) for last-mile deliveries. In some cases, only EVs and cargo bikes are permitted for last-mile distribution, while in others, deliveries within neighborhoods are exclusively conducted via cargo bikes or through designated loading zones located on the ground floors of buildings.

#### *2.3.1. Home delivery*

Home deliveries generate a significant cost on urban life. Attended home delivery is a last-mile logistics model that require the customer's presence at the time of delivery or at the service execution (Cordeau et al., 2024). These authors investigate several related problems including time-slot management, delivery pricing, and routing. Home deliveries include meal delivery problems (Reyes et al., 2018), the home healthcare routing and scheduling problem (Euchi et al., 2022), and the technician routing and scheduling problem (Castillo-Salazar et al., 2016). We refer the reader to Cordeau et al. (2024) for an updated survey of attended home delivery and service problems with a focus on applications.

#### *2.3.2. Crowdsourcing*

Carbone et al. (2017) review review 57 crowd logistics initiatives and classify them into four types: (1) crowd storage, (2) crowd local delivery,

(3) crowd freight shipping, and (4) crowd freight forwarding. Among these types, crowd local delivery and crowd storage are particularly important in 15-minute cities. The crowd local delivery is also referred to as crowdsourced delivery or crowdshipping by Alnaggar et al. (2021), who investigate different scheduling and matching mechanisms for the drivers, compensation schemes, and discuss different applications of crowdsourced delivery business. Note that, while local deliveries may potentially reduce the number of large truck deliveries, they may also increase the delivery demands leading to an undesired result from a sustainability perspective. For the crowd storage, a related business model is introduced by Wang, X. et al. (2024), who use the neighborhood structure to improve home deliveries. Lockers also help in delivery business which is presented next.

#### *2.3.3. Locker location*

Lockers are a recent innovation that delivery companies use for managing out-of-home delivery in last-mile delivery (Janinhoff et al., 2024). They provide several benefits including consolidation of deliveries, flexible route planning, reducing theft and failed deliveries, all of which serve the residents with a more lively environment due to reduced number of truck deliveries in the neighborhoods and more convenient pickup options. The essential function of 15-minute cities is to offer services within a certain proximity, and deliveries are no exception. The recipients may pickup their parcels by biking or by walking. The literature in this field is also growing by considering several characteristics of the problem such as choice models (Lin et al., 2020, 2022), mobile lockers (Kötschau et al., 2025), demand management, and compensation schemes.

#### *2.3.4. Ultra-fast delivery*

Ultra-fast delivery (also referred to as quick delivery, quick-commerce, or q-commerce) is a business model where orders are delivered significantly faster than same-day delivery, with target delivery times ranging from 15 to 45 minutes. This concept aligns well with the idea of the 15-minute city, which aims to provide services to residents within a 15-minute radius. Notably, this goal can be achieved either by citizens walking or biking to nearby service points or by services reaching customers within 15 minutes. From this perspective, ultra-fast delivery can be considered as an enabling business model for 15-minute cities. Offering such services typically requires a dense network of service points, referred to as micro-depots or dark stores

(Rai et al., 2023), from which orders are dispatched. Given that 15 minutes is an extremely tight time window, accounting for uncertainty in delivery times is crucial. In this regard, Wang, X. et al. (2023) study network design for ultra-fast delivery services using robust optimization models.

#### *2.3.5. Drone delivery*

Drone-based last-mile delivery for urban logistics is attracting significant attention from academic perspective. By facilitating quick deliveries, drones can reduce reliance on traditional vehicle transport and decrease traffic congestion and associated emissions. Garg et al. (2023) provide a comprehensive review of drone applications in last-mile delivery. Although real-world implementations are still relatively limited, early initiatives demonstrate the feasibility of drone delivery. There are early works on related problems such as urban air corridor planning for drone delivery (He et al., 2025). These initiatives align with the 15-minute city model by improving access to goods and services within a short time frame, promoting more livable and environmentally friendly urban environments.

#### *2.3.6. Electric vehicles*

Electric vehicles (EVs) play a critical role in the decarbonization of urban transport and are increasingly adopted for both private use and last-mile deliveries. Their application in urban logistics contributes to reducing greenhouse gas emissions and noise pollution, particularly in dense city centers. Recent research has focused on optimizing EV fleet operations, charging infrastructure planning, and vehicle routing problems specific to EVs, which consider battery constraints and limited charging availability (Schneider et al., 2014; Montoya et al., 2017). In the context of last-mile logistics, EVs are often used alongside cargo bikes to ensure sustainable delivery within the 15-minute city framework. Overall, electric vehicles are a cornerstone of sustainable urban mobility solutions and enablers of environmentally responsible last-mile distribution in the 15-minute city.

### *2.4. KA4: Urban governance for mobility transition*

Approximately 22% of urban governance practices fall under KA4, which emphasizes their role in facilitating the transition to a 15-minute city. Project planning requires several subproblems including project scheduling, resource allocation, risk analysis, performance evaluation, cash flow forecasting, and corrective action decision-making (Pellerin and Perrier, 2019). In this section, we discuss resource allocation, project scheduling, revenue management, and inclusive planning and equity.

*2.4.1. Resource Allocation*

The resource allocation problem aims to determine the most efficient way of distributing a limited set of resources across various activities in order to minimize the total associated costs (Katoh and Ibaraki, 1998). There exists a wealth of research on the theory and algorithms for effective resource allocation. In the 15-minute city context, the budget is limited for every municipality, and it is important to allocate the resources in the most effective way to maximize the benefits while taking into account the interactions between different projects and their expected benefits for the citizens. Korhonen and Syrjänen (2004) consider resource allocation in the context of interactions with the individual units that receive the resources to execute projects. This approach also aligns well with the inclusive aspect of the urban planning, since these units have contact with the citizens and can learn their preferences.

*2.4.2. Project scheduling*

Project scheduling problems involve the scheduling of project activities by considering the precedence and resource constraints (Herroelen, 2005). Several activities at the strategic, tactical and operational levels require technological planning, resource-capacity planning and material coordination with their associated risks, which are discussed in detail by Herroelen (2005). The resource-constrained project scheduling problem in particular attracted significant attention in the OR literature. Pellerin et al. (2020) review the good performing approximate methods to solve this problem.

*2.4.3. Revenue management*

The policy planners and executers of the 15-minute city are generally municipalities and governments. They may involve a strong inclusion of public and private companies, but the main players are public officials. Therefore, the objectives are generally not maximizing the revenues, but focusing on minimizing the costs, allocating budgets, or maximizing the benefits. When nonprofit firms needs to carry out for-profit activities and generate revenues to subsidize their activities, the organizations then face the dilemma of spending the revenue or of investing it in the projects (De Vericourt and Lobo, 2009). Berenguer and Shen (2020) discuss some strategies in managing non-profit operations by considering goals, performance metrics, relationships with stakeholders, managing grants and donations, allocation and pricing strategies and workforce management among others. All these aspects play vital roles in planning within a 15-minute city context, especially since the public is involved in the decision making process.

*2.4.4. Inclusive planning and equity*

Inclusive planning and equity practices often involve engaging the public through participatory planning processes. Insights gathered from community inputs are then used to develop plans that guide the implementation of local initiatives. The inclusive aspect of optimization is generally captured by *cooperation*. Mitchell and Nault (2007) study cooperative planning, uncertainty, and managerial control in concurrent design in companies, emphasizing upstream and downstream rework in cooperative planning. Even though the context is different, the ideas are still interesting in the 15-minute city context to avoid repetitions and reworks. Finally, Chen and Hooker (2023) review different ways to formulating fairness in an optimization model and describe various inequality measures as well as group parity metrics. Ogryczak et al. (2014) review a variety of techniques to generate fair and efficient solutions for the location problems and for the resource allocation problems. Since the 15-minute city demand and services can be described using networks, these fairness measures are also applicable to this setting as well. In line with these ideas, community-based OR (Johnson and Smilowitz, 2007) offers a framework for applying analytical methods to challenges faced by underserved or vulnerable populations in local settings. It seeks to balance economic efficiency, social equity, and administrative feasibility in solving everyday challenges, which makes it a valuable approach for guiding equitable urban governance within the 15-minute city paradigm.

## 3. Methodological Tools

The existing literature on 15-minute cities largely lacks the application of OR methods. Most studies rely on spatial and network analyses, with a primary focus on measuring accessibility (Papadopoulos et al., 2023) rather than optimizing it. In this section, we present some relevant OR methodologies that can be applied to address key decision-making problems within the 15-minute city framework.

### *3.1. Network science and graph theory*

Cities can be modeled as interconnected networks representing mobility, infrastructure, and service systems. Network science enables modeling the structural and functional properties of 15-minute cities. Graph theory can be used to model service reachability, centrality of facilities, and multimodal accessibility. Measures such as the Jaccard distance (Jaccard, 1901), the Hamming distance (Hamming, 1950) or the Gini index (Ceriani and Verme, 2012) can be leveraged and can be extended to multi-graphs, as detailed in Section 1.3.2. Additionally, small-world networks (Watts and Strogatz, 1998) and their applications in the context of 15-minute cities can prove to be a promising modeling tool to capture social dynamics and local accessibility patterns.

### *3.2. Large-scale optimization*

Mathematical programs in the form of deterministic, stochastic and robust mixed-integer linear and nonlinear models are generally used to support spatial planning, network design, facility location, resource and service allocation, and urban mobility. Decomposition methods such as Benders decomposition, branch-and-price, and Lagrangian relaxation are applied to solve large-scale instances of these models that arise often in practice. Metaheuristics, including genetic algorithms and simulated annealing, are also important tools to obtain high-quality solutions within reasonable time limits when exact methods are computationally impractical.

### *3.3. Contextual and data-driven optimization*

To integrate behavioral data and contextual realities into planning for the 15-minute city, a framework combining learning and optimization is especially useful (Sadana et al., 2025) using side information to improve the decision quality. By leveraging data from sensors, surveys, and user platforms, optimization models can incorporate real-world usage patterns, demographic trends, and service needs. Techniques such as inverse optimization and reinforcement learning are increasingly used to create adaptive models that align better with human behavior and local priorities, thus enhancing both relevance and impact.

### *3.4. Choice models and bilevel modeling*

Human-centered models are essential to account for diverse urban lifestyles, travel preferences, and perceptions of accessibility and satisfaction. Choice models such as multinomial and nested logit models help quantify individual preferences and behaviors in response to urban design and mobility options. Bilevel models are particularly suitable for capturing hierarchical decision-making, where public agencies optimize service provision while individuals respond based on their preferences. Incorporating community engagement into these models supports more inclusive and responsive planning, allowing for the design of services that reflect actual needs and reduce conflicts.

### *3.5. Multiobjective optimization*

Urban planning for 15-minute cities requires balancing multiple objectives such as cost-efficiency, accessibility, equity, sustainability, and livability. Multiobjective optimization frameworks enable the explicit modeling of trade-offs among these goals, supporting planners and policymakers in exploring Pareto-efficient solutions. Methods like the $\varepsilon$-constraint approach, goal programming, and evolutionary algorithms are commonly used to generate and evaluate efficient solution frontiers.

## 4. Potential research directions

There exist numerous research opportunities in last-mile delivery, integration of freight transport with public transit, ultra-fast delivery systems, and autonomous vehicles. These areas, however, belong to well-established streams within transportation research. In contrast, service offerings in the context of 15-minute cities remain relatively underexplored. This motivates our focus on this domain, where we outline several potential research directions that leverage OR methodologies to support the planning and delivery of accessible, efficient, and equitable urban services.

### *4.1. Land use, urban design and decentralization*

The 15-minute city concept involves reshaping existing cities to improve the proximity to services. There are two means of achieving such a goal. Either the residents visit the services, which is the most common one or the services may be delivered to the residents. The latter case is mainly covered in Section 2.3.4. Regarding the residents visiting the services, the existing spatial distribution of the facilities cannot be radically changed. Therefore, the principles of mixed-use must be emphasized, and particularly sharing opportunities must be investigated. In particular, deconsolidation is a key concept to be investigated in this context. The opportunities offered by sharing office capacities among multiple services will be thoroughly studied, which can be achieved by disintegrating large offices into small but functional units that can be distributed across the cities. Temporal and physical exchanges of office places between independent agencies may offer enlarging the service region as well as more flexibility for the workers. In other words, this may also allow people to get closer to their workplaces since the spatial distribution of such offices will follow residential housing patterns. Furthermore, one of the main barriers of 15-minute cities is the daily commute. Nevertheless, with the growth in work-from-home since the COVID-19 pandemic, people may often not reside in the same vicinity or even in the same city as their actual workplace. Such business models and their impacts on individuals as well as livelihood of the neighborhoods will be thoroughly investigated. By fostering the creation of 15-minute cities, spatial distribution ultimately aims to reshape urban landscapes into more livable, resilient, and interconnected communities, and by enabling greater coordination and cooperation among independent agencies, it seeks to unlock untapped potentials in urban planning and management.

### *4.2. Community-run service points and crowdsourcing in service offerings*

Community-run service points are vital hubs that provide essential services to residents. Examples include health clinics and senior wellness centers, where volunteers and professionals collaboratively provide healthcare services to those in need, promoting preventive care, and fostering community engagement. Similarly, community gardens and urban farms not only provide access to fresh, healthy food but also promote environmental sustainability, education about gardening and agriculture, and community bonding through shared spaces. The spatial design of these service points plays a crucial role in ensuring accessibility and efficiency. Location optimization and service planning involves strategically placing these points within neighborhoods or areas with high demand and limited access to services. Factors such as population density, transportation infrastructure, and proximity to other community resources should be carefully considered in the planning process. Furthermore, effective management is essential for the smooth operation of these service points. This includes staffing considerations (particularly crowdsourcing) to ensure the availability of qualified personnel, scheduling to accommodate varying service demands, and revenue management to sustain operations. Volunteers may supplement professional staff, fostering a sense of community ownership and engagement. Overall, community-run service points serve as lifelines for underserved communities, requiring thoughtful spatial design and management to maximize their impact and reach.

### *4.3. Repurposing parking spaces*

Parking is a significant problem in cities, not only due to the space it occupies, but also because the search for parking spots adds to the traffic congestion. Autonomous vehicles (AVs) need less parking space due to their higher level of utilization, which will have a great impact on the real estate sector in cities. For example, the parking spots occupy large spaces reaching up to 42 percent of the total land in the central districts of major U.S. cities (Bloomberg, 2023). Even though the real estate sector is much larger than the transportation sector, it is generally shaped up by the strategic decisions made in the transportation sector. One major change the AVs bring along is their reduced parking space requirements mainly due to their higher utilization rate than conventional vehicles. Whenever AVs need to be parked, they can drive themselves out of the dense urban regions. This implies that large parking areas in heavily populated urban areas may then be used for different purposes. However, the price of land in urban areas changes nonlinearly with the size of the land (Colwell and Sirmans, 1980). Therefore, the policy to transform these parking spaces into other functional units entails the question of whether individual parking spaces must be transformed completely, or whether they must be reduced in size.

### *4.4. Integrated and multi-period planning under uncertainty*

Urban planning for 15-minute cities involves several problems due to the interdependent nature of mobility, land use, logistics, and service provision. Therefore, integrated modeling approaches capturing these interdependencies are essential. Another critical distinction lies between single-period rolling models versus multi-period planning frameworks. While single-period models offer flexibility for real-time adjustments, multi-period models are more suitable for long-term strategic decisions, capturing evolving demand patterns, infrastructure development, and policy changes. Additionally, 15-minute city planning is inherently subject to uncertainty, including fluctuations in demand, disruptions in mobility, and changes in socio-demographic trends. This necessitates the use of stochastic programming and robust optimization to develop resilient strategies that perform well across a range of plausible scenarios.

## 5. Conclusion

Proximity-based urban planning represents a shift towards more livable, sustainable, and inclusive cities. However, realizing this vision requires rigorous analytical tools that support informed decision making. This paper provides a foundational operations research topics for the design, transformation, and management of proximity-based cities. We emphasize a data-driven approach integrating network models, large-scale optimization, and contextual analytics. By bridging urban planning and operations research, we aim to unlock new potentials for shaping cities that bring services, people, and opportunities closer together. Additionally, this paper presents an ambitious, yet realistic research agenda aimed at assisting decision makers in improving proximity-based city analytics. The research agenda encompasses a wide variety of intriguing problems.

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